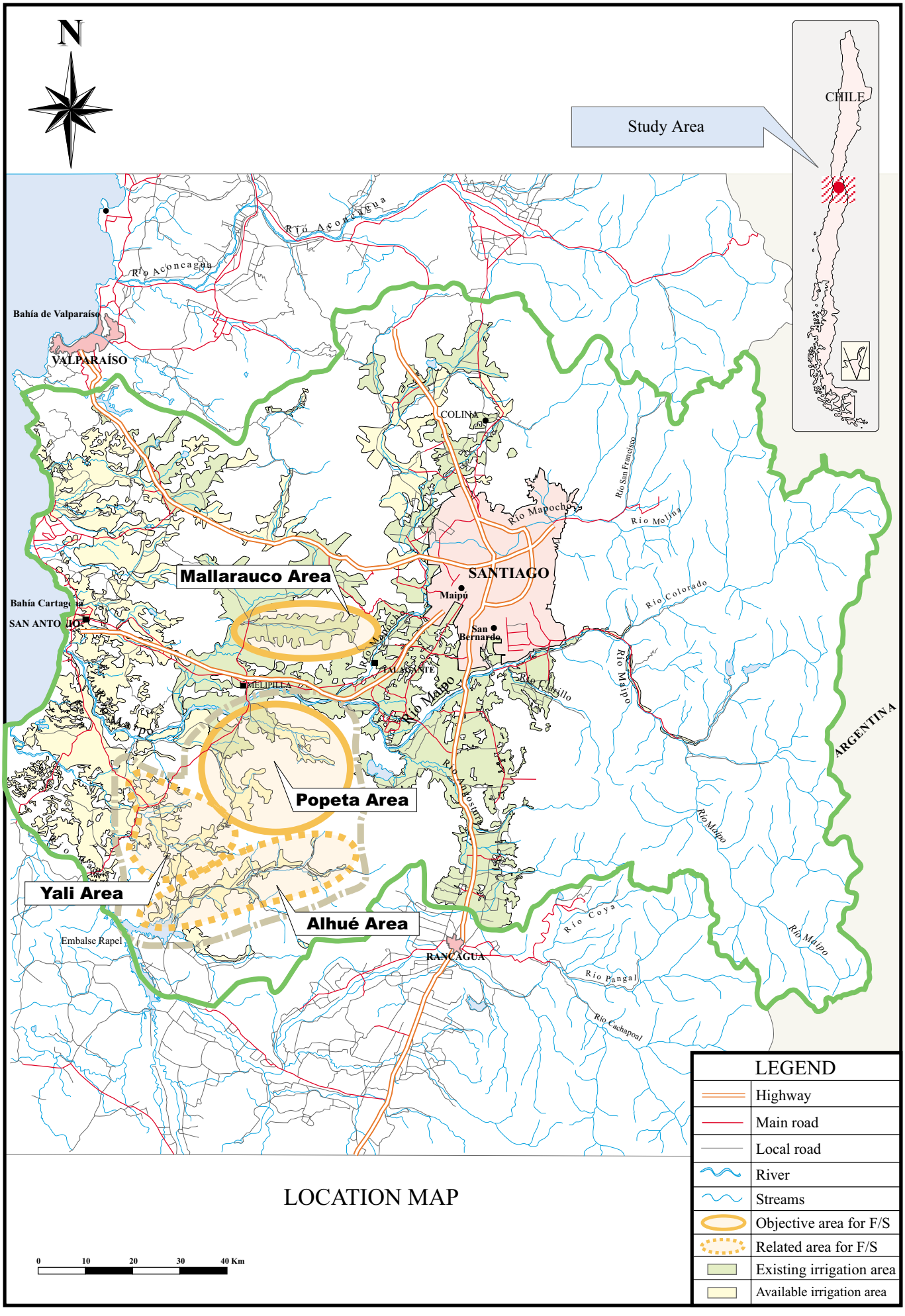
Part II Feasibility Study



LOCATION MAP

AGRICULTURAL DEVELOPMENT AND WATER MANEGEMENT IN METROPOLITAN AREA, CHILE

FEASIBILITY STUDY

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CHAPTER 1

AGRICULTURAL DEVELOPMENT PROJECT IN POPETA AREA

1 AGRICULTURAL DEVELOPMENT PROJECT IN POPETA AREA

1.1 Present Situation of Popeta Area

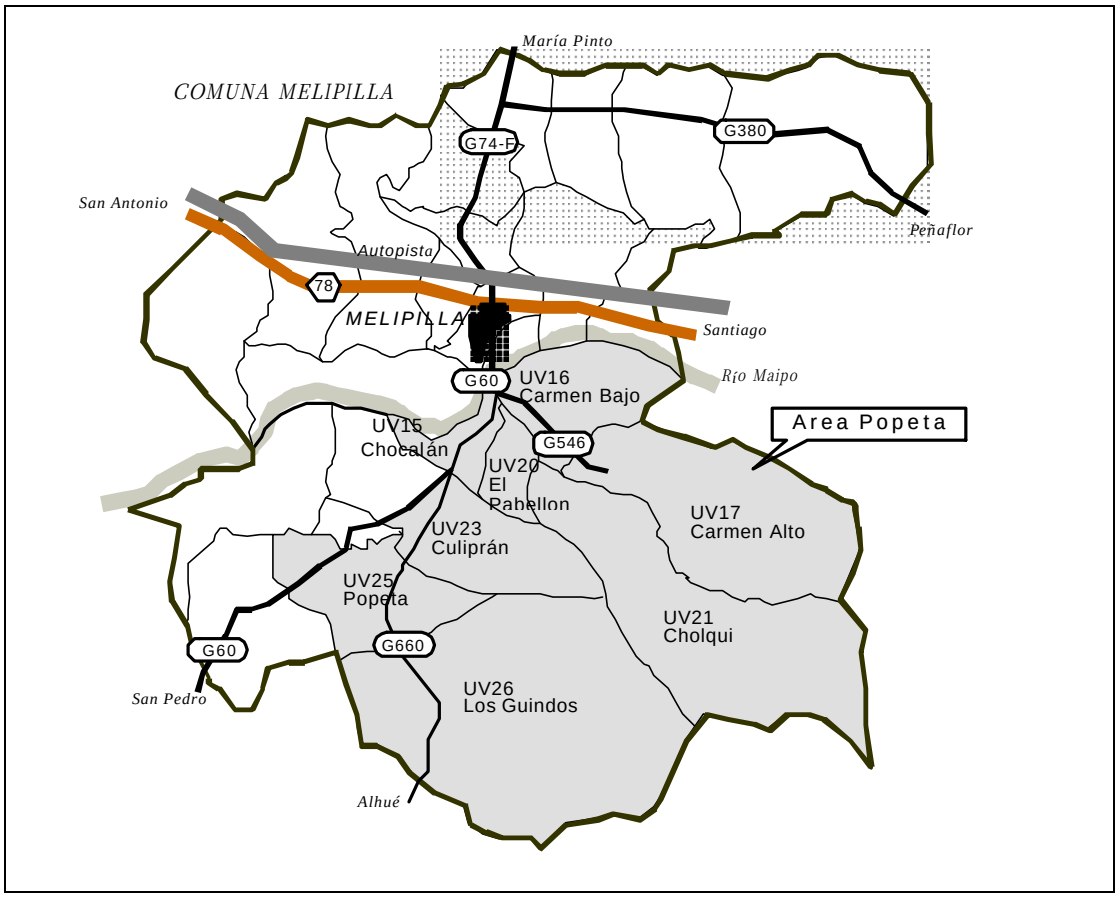
1.1.1 Present Social Situation

(1) Administrative organizations

Popeta area where is the objective area of Feasibility Study belongs to *Comuna* Melipilla and is located in the southern part of the Maipo river. Administratively, Popeta area consists of eight (8) *Unidad Vecinal* (United community: hereinafter referred to as the UV), and each *UV* consists of several *Junta de Vecinos* (Council of community: hereinafter referred to as the JJVV). UV and JJVV are defined as organizations which approved their right of self-governance legally and promote decentralization. Constitutions of the area are as follows;

Area	No.	UV	No. of Council of community
Popeta area	UV15	Chocalán	2
	UV16	Carmen Bajo	3
	UV17	Carmen Alto	2
	UV20	El Pabellon	1
	UV21	Cholqui	3
	UV23	Culiprán	4
	UV25	Popeta	2
	UV26	Los Guindos	2

Distribution of UV in Popeta area is as following figure.



(2) Population

Population of Popeta area is 8,447 persons, according to the Census '92. Population of each UV are as follows;

Area	*Unidad Vecinal*		Household	Total	Male	Female
Popeta area	UV15	Chocalán	177	687	341	346
	UV16	Carmen Bajo	285	1,125	595	530
	UV17	Carmen Alto	217	849	453	396
	UV20	El Pabellon	344	1,211	651	560
	UV21	Cholqui	240	915	484	431
	UV23	Culiprán	413	1,736	923	813
	UV25	Popeta	321	1,309	690	619
	UV26	Los Guindos	107	615	399	216
	Total		2,104	8,447	4,536	3,911

Source : Melipilla - SECPLAC

Age composition in the study area represents almost same shape with national average. Yet, the ratio of economically inactive population (0-15 years old and older than 65 years old) is higher, 32% while the main population of economic production activities (from 31 to 50 years old) is lower than national average. This might be caused by following reasons; the principal industry in the area is agriculture and the area is a pure farm area where most of inhabitants engage in agriculture; a part of economically active population demand job opportunities out of region because it is relatively close to the metropolitan area of Santiago.

(3) Rural society

About 84% of constituents of rural society in Popeta area are farmers. Among them, small scale farmers occupies about 90%. Breakdown of constituents is as follows.

Area	*UV*		Household	Farmer	Small scale	Medium scale	Large scale
Popeta area	UV15	Chocalán	177	115	98	12	5
	UV16	Carmen Bajo	285	198	145	45	8
	UV17	Carmen Alto	217	206	186	15	5
	UV20	El Pabellon	344	224	207	13	4
	UV21	Cholqui	240	216	185	24	7
	UV23	Culiprán	413	392	373	14	5
	UV25	Popeta	321	305	278	21	6
	UV26	Los Guindos	107	99	83	13	3
Total			2,104	1,755	1,555	157	43

Source : REA-CIREN 95

Among the constituents of UV mentioned above, most of medium and large scale farmers carry out enterprise type of farm management. They do not live in the area and has become absentee landowners. Therefore, operation of UV is undertaken by small scale farmers who settle down in the area.

The smallest unit as a group is JJVV in the area. It is possible to consider that the JJVV is an unit of community because it is organized based on territorially related connection. Hereafter, when the Report says "community," it refers to JJVV. The communities in the area are extended into both sides of main roads and shape row communities. There are few concentrated communities and dense communities. This is because farmland was divided at right angle along with roads and distributed with long and narrow shaped. So, farm households constructed their houses along with roads, and then this shape was formed. Consequently, farmland and houses are located in the same lots. It is hard to form the centers of communities because communities shape row but the places where public facilities such as churches and schools are

located are regarded as the centers of the communities. Distance between communities is ranged approximately from 1 to 4 km.

(4) Rural organizations

UV is a core of rural society. As the other associations that form the rural society, there are Council of community (*JJVV*), Center of Mother (*Centro de Madres*), Sports club (*Clubes Deportivos*), Aid committee (*Comités Allegados*), Young man's association (*Grupos Juveniles*), Culture club (*Centros Culturales*), and so on. Through activities of these associations, inhabitants of the area promote the activities of self-governance in the area with deepening solidarity by enhancing mutual friendship and help.

The fundamental of each organization is JJVV, and its integrated unit is UV. So, basically JJVV is established in each organization.

Establishing JJVV, the mother bodies are often territorially related groups. The membership is the inhabitant who is older than 18 years old. President, director general, and secretary are selected by mutual vote. JJVV have to submit a members' list to *Comuna*, hold general meeting, and make an annual report. Each JJVV holds monthly meetings and discusses the present facing problems, the direction of regional operation, project plans, and so on.

Distribution of each inhabitants' organization in the area is as follows;

Area	*UV*		Juntas de Vecinos	Centro de Madres	Clubes Deportivos	Comités Allegados	Grupos Juveniles	Centros Culturales
Popeta	UV15	Chocalán	2	1	2	1	-	-
	UV16	Carmen Bajo	3	1	3	1	-	1
	UV17	Carmen Alto	2	1	2	1	-	-
	UV20	El Pabellon	1	1	1	1	-	-
	UV21	Cholqui	3	1	3	1	-	-
	UV23	Culiprán	3	1	3	1	1	1
	UV25	Popeta	2	1	2	1	-	-
	UV26	Los Guindos	2	1	2	1	-	-
Total			18	8	18	8	1	2
Comuna Melipilla			100	50	84	42	2	21

(5) Gender

According to the data of MIDEPLAN-CASEN 96 (Socio-economic Characterization Survey), the effect of economic growth and social policy is shown at the national level, for example, the percentage of poor and extremely poor households got about halved, compared with 1987. Nevertheless, income disparity has not shrunken but relatively expanded.

The ratio of the extremely poor in *Comuna* Melipilla is high, compared to that in whole the Metropolitan Region. Yet, the ration is 3.4% and is about 60% of national average. That of the poor is also low, 17.5% and 76% of national average. The other indicators also tend to be more improved, compared with the national average. Nevertheless, illiteracy rate is 1.5 times as much as national average and 2.7 times as much as the Metropolitan Region's one, or 7.2%. The improvement of educational environment can be said the problem. Indicators in *Comuna* Melipilla are summarized as follows;

Index			*Comuna*	Metropolitan	Nation wide
Illiteracy rate	Total	%	7.2	2.7	4.9
Poverty line	The extremely poor	%	3.4	2.7	5.7
	Non extremely poor	%	13.3	12.1	17.5
	Not extremely poor	%	83.3	85.2	76.8

Source; Casen96, MIDEPLAN

In many cases, the women's share of works in Popeta area is also limited to housework and bringing up children as well as other rural areas. The concept that men work outside and women protect houses takes root. Therefore, women are isolated from the activities of JJVV and economic activities. The reason of this situation is that there are not enough training and education of skills for economic independence and of organized activities for women.

Dealing with this, INDAP promotes the support program for rural women's independence (PRODEMU) under the cooperation with National Service of Women (SERNAM, set up within MIDEPLAN in 1991). PRODEMU promotes participation of women on the field of green house cultivation and agricultural processing as the main activity. There is one organizations (*Taller Tierra Verde*) which is working with acquisition of skills for economic independence through establishing producers' organizations by women in Popeta area. Producers' organizations by rural women are also working in El Bajo area and San José area which are located around Popeta area.

Accordingly, the activities for improving rural women's status are taking root, gradually. So as to establish this tendency more effectively, establishing organizations of women in community level is needed. For this, improvement and construction of the base facilities for interchange among rural women and the support system for establishing organization are indispensable. It is also important to establish the system that each producers' organization by rural women can interchange about experience of establishing organization and management method, problems from now on and, so on. Interchanging between the existing organizations and rural women encourages the rural women who want to establish organizations greatly, and will be a motive power to promote independence of rural women. Therefore, careful systematization as mentioned above is an important problem for SECPLAC which promotes decentralization.

1.1.2 Natural Resources

(1) Geology

Popeta basin consists of a plain where old riverbed deposit and terrace deposit of Quaternary age cover the valley formed by impervious bed rock. However, the surface layer is a tableland composed by Alluvial pumice volcanic ash. The existing rivers flow and erode these tableland. Diluvium aquifers are overlain by the volcanic ash deposit, and development of alluvial deposit along the existing rivers is poor. Pumiceous volcanic ash deposit is not distributed at Yali and Alhué areas. Deposits of Diluvium and Alluvium accumulates continuously and forms terraces ranging from 2 to 5m high along the existing river bed. Groundwater is taken from deep Diluvium layer for agriculture and from shallow Alluvium layer for drinking water at present. The former is superior on the amount of pumping discharge than that of latter.

(2) Climate

Popeta area is located in the south-west of the objective area. Melipilla meteorological station represents the climatic factors in the south-west of the area. The station is located in the coastal mountainous areas and being observed the items to estimate the crop evapo-transpiration. Study on the meteorological items concerning

the priority development area will be made using the observed value at the Melipilla station. General climatic features of the Melipilla station are as follows;

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Temperature (ºC)													
Max.	32.2	32.4	31.1	29.0	25.2	21.8	21.9	23.8	26.8	28.4	31.1	32.5	28.0
Min.	7.4	7.2	5.3	2.9	1.2	0.4	0.0	0.2	1.4	2.7	4.4	6.3	3.3
Mean	19.1	18.9	17.7	15.1	12.6	10.7	10.1	11.0	12.6	14.5	16.5	18.4	14.8
Precipitation (mm)													
	0.1	0.2	3.0	17.8	76.1	94.7	107.4	57.6	25.4	10.9	6.0	1.3	400.6
Evaporation (mm)													
	206.3	165.9	124.9	70.7	34.9	20.1	21.8	36.2	62.2	112.5	154.8	202.0	1212.4
Relative Humidity (%)													
	60.1	62.5	66.3	70.9	77.5	80.7	80.1	77.1	72.9	67.2	62.5	58.7	69.7
Sunshine Hours (Hr)													
	10.5	9.6	7.7	6.1	4.2	3.4	3.6	5.0	5.8	8.0	8.9	9.9	6.9
Wind Velocity (km/month)													
	1599.5	1158.1	877.9	508.1	526.5	693.6	845.6	751.2	900.3	1158.6	1381.8	1641.8	1003.6

(3) Soils and land use

According to the data of REA, the total area of the objective area is summarized as follows. Present land use in Popeta area shown in Figure 1.1.1.

Unit: ha

Area	*UV*		Total area	Farmland	Others
Popeta	UV15	Chocalán	1,577.8	915.1	662.7
	UV16	Carmen Bajo	4,502.1	1,620.8	2,881.3
	UV17	Carmen Alto	9,886.3	3,262.5	6,623.8
	UV20	El Pabellon	1,408.7	1,098.8	309.9
	UV21	Cholqui	12,924.7	3,101.9	9,822.8
	UV23	Culiprán	5,291.0	2,910.1	2,381.0
	UV25	Popeta	5,470.6	2,625.9	2,844.7
	UV26	Los Guindos	19,764.8	7,708.3	12,056.5
		Total	60,826.0	23,243.3	37,582.7

Crop cultivation suitability of soils in the new irrigation area are clarified using the soil series derived from the soil survey results of CNR as well as the land productivity classification drawn up by REA. Beneficial farmers in the new irrigation area are clarified by the orthophoto and the classification code of REA on the beneficial area are fixed. As for approximately 1,000 ha of beneficial area where are not classified in the data of REA and CNR, their classification code are assumed by their neighbor land. The land productivity classification of the project area are as follows.

Land productivity classification		Area by REA (ha)
I	(No limitation for cultivation)	0.0
II	(A little limitation)	479.0
III	(Necessary to select crops)	647.0
IV	(Serious limitation for cultivation)	2,393.3
V	(Difficult for farmland)	0.0
VI	(Impossible excluding pasture land)	1,436.0
VII	(Impossible for farmland)	336.8
VIII	(Impossible for whole land use)	34.8
	Total	5,326.9

According to the above table, the farmland which belong to until class VI of the land productivity classification is approximately 5,000 ha in Popeta area. The farmland classified as class VI used to be defined as unsuitable land for permanent cultivation located at sloping area mainly. However, the fruit cultivation is now being progressed in the farmland classified as class VI and high potential of cultivation is recognized among the farmers. Moreover, orchards are reclaim at the farmland

classified as class VII in Cholgui and los Guindos area out of Popeta area.

The fruit growing method at sloping area is promoting rapidly. For example, the soil permeability is enhanced by plowing to replace surface soil with subsoil before opening the orchard and the orchard is protected from soil erosion. The fruit growing has been possible by this method at land of cheep cost. Moreover, a preferable changes of quality and productivity on fruits growing are brought by the evasion of frostbite using the air temperature of an inversion layer.

(4) Water resources

1) Surface water

The Popeta-Yali-Alhué irrigation system is taken water from the third section of Maipo river. Cabimbao observatory is available as the long term discharge observatory. Monthly average discharge and its 85% exceedance probability at Cabimbao observatory are as follows;

Item	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cabimbao														
Average	m^3/s	112.2	76.1	62.6	72.6	107.6	151.1	193.1	181.4	115.0	77.4	100.7	130.1	
	MCM	300.39	184.00	167.73	188.08	288.09	391.77	517.25	485.73	298.14	207.4	261.09	348.38	3638.1
85%	m^3/s	25.94	15.70	22.07	39.15	62.78	76.46	95.65	83.04	47.42	27.13	35.81	38.38	
	MCM	69.48	37.98	59.11	101.48	168.15	198.18	256.19	222.41	122.91	72.66	92.82	102.80	1504.2

2) Groundwater

Popeta area where is the target area of irrigation development extends between *Estero* Cholqui and its branch of *Estero* Carmen, and *Estero* Popeta and its branch of *Estero* Tantehue. The areas concerned with the irrigation development are Yali and Alhué. Yali area locates at upper stream of *Estero* Yali, and Alhué area locates at upper stream of *Estero* Alhué which is branch of *Estero* Rapel. According to data of DGA and CNR, average permeability coefficient is 5×10^{-4} m/sec in the objective area. Percolation coefficient is from 2 to 5 l/s/m in a part of Alhué and less than 2 l/s/m in the others areas. Coefficient of specific capacity of 2 to 5 l/s/m means 20 to 50 l/sec of pumping discharge volume when the water level of pumping is dropped by 10 m.

a) Distribution and the number of wells

There is the survey results on the distribution of wells in Popeta area (Carmen Alto and Cholqui) by DGA in 1998. In the study, the inventory survey is carried out regarding the distribution of wells, purpose of its use, and so on in Yali and Alhué basins (including a part of Popeta). Distribution of wells based on the data described above are as follows.

Area	*Estero*	Number	For agriculture	For domestic water	others
Popeta	Cholqui	38	16	5	17 (15)
	Popeta	31	16	2	13 (5)
Sub-total		69	32	7	30 (20)
Yali	Yali	104	67	6	31 (3)
Alhué	Alhué	61	26	3	32 (21)
Total		234	125	16	93 (44)

( ) has been dug as well for irrigation but the well is not utilized at present.

Total number of wells is 234. Out of which 125 wells are used for irrigation and 16 for domestic utilization. The others include the wells for the purpose of poultry, hog raising, mining and is not clear. However, the actual situation of their use is not clear. The number of wells in the study carried out in 1999 shows 2.8 times increase, or from 84 to 234, compared

to that in 1984.

b) The number of wells for agriculture and its irrigation area

According to the results of field survey and the well registration of DGA, the number of well and its irrigation area are summarized as follows.

Area	Popeta	Yali	Alhué	Total
No. of well for agriculture	32	67	26	125
Irrigation area (ha)	Well register 16 x 30 = 480 ha Field survey 16 wells, 544 ha	Field survey 67 wells 1,850ha	Field survey 26 wells 758ha	
Total (ha)	1,024	1,850	758	3,632

The irrigation area of wells which irrigation area is not clear is assumed by the average irrigation area (30ha / well). There are 125 wells for irrigation and total irrigation area is 3,632 ha.

c) Pumping situation of groundwater

Monthly pumping volume of wells for agriculture that was studied by the field survey is estimated by unit pumping discharge as follows.

Area	No. of wells for agriculture (wells)	Irrigation area (ha)	Unit pumping volume (l /sec)	Monthly pumping volume (m^3/Month)
Popeta	16	543.6	506.2	1,312,070
Yali	67	1,850	1384.8	3,589,402
Alhué	26	758	890.4	2,307,917
Total	109	3,151.6	2,781.4	7,209,389

On the table above, the volume of monthly pumping discharge shows the maximum volume because it is assumed that a well pumps up for 24 hours per day and for 30days per month continuously by the unit pumping discharge. When a well pumps up for 8 hours per day on average, the volume of monthly pumping discharge would be approximately 2,403,100 m^3. On the other hand, the volume of pumping discharge on 16 wells in Popeta area which are registered in the well register of DGA is about 248,800m^3. Thus, the monthly volume of pumping discharge in Popeta, Yali, and Alhué areas is estimated approximately 2.7MCM.

d) Fluctuation of groundwater level

Fluctuation of groundwater level has been observed at Cholqui and Popeta for long time. According to the data of wells which are relatively good, groundwater level of each basin tends to be reduced, or has the possibility to be reduced in the future. It can be supposed that deep wells in Yali and Alhué basins also have same tendency due to the situation of distribution. It is judged that the large scaled development of groundwater for irrigation is impossible in any areas in the future.

1.1.3 Agriculture

(1) Farming scale

Farmers in the project area are classified by scale of landholding according to the data of REA. The class consists of three groups, small scale farmers of 0.5～15ha, medium scale farmers of 15.1～100ha and large scale farmers of over 100ha. The land

belongs basically to an individual farmer in the data of REA , however at the time of the agrarian reform, there are some cases of the registration that several owners' land belongs to one owner. The table below shows farming scales modified these cases.

Land Holding Size		No. of Farmers	Total Area (ha)	Average Farming Area (ha)
Small scale	0.5 – 15	172	506.8	3.0
Medium Scale	15.1 – 100	54	2,285.6	42.3
Large Scale	Over 100.1	8	2,534.5	316.8
Total		234	5,326.9	22.8

Approximately thirty percent (30%) of total area, 5,326ha, belongs to class IV of the land productivity classification. Small scale farmers are usually situated in high productive farmland of the lower land except a few cases.

(2) Present cropping system, agricultural production and income of farm household

Medium and large scale farmers in the irrigated area of Popeta are in generally high technical level. Fruit growing area in Melipilla Province has increased by 12.4 % in the last four years. On the other hand, its cultivation is decreased by 9.7 % in the same period in the Metropolitan Region. Popeta area is included in a part of the increased areas. Recently in Popeta area, enterprises implement agricultural development projects for fruits and forage crop cultivation. Most of the projects are carried out with irrigation by using groundwater and surface flow of small streams in the farmland which belongs to class IV and VI of the land productivity classification. Those areas of the projects reach 1,000ha. However, a problem of reducing groundwater which is the water source is raised in those projects.

There are two significant facts on wine production in the area. The first one is that vineyard and winery established by a French family after the agrarian reform in the beginning of this century in Tantehue area although there is no operation at present. The second one is that very effective winery whose production capacity is 1,000,000 liters has been constructed in a small vineyard (72ha), San Juan de Popeta, recently. The wine produced in this winery is called "*Aurelio Montes*." It passed only two years after it began to be produced, but it has achieved prestige as one of export wines and recorded good sale. This suggests a possibility of further expansion of vine cultivation. Popeta area has the similar climate characteristics to Alhué area where is one of the most promising areas for expanding wine production in the country.

Other important crop in Popeta area is vegetable cultivation by small and large scale farmers. The most of crops, such as pumpkins, melons, watermelons, tomatoes, green beans and others, belongs to the category of irrigation by using surface flow. However, the area has cultivated lettuces and other regulated vegetables by using groundwater and sold them very successfully in the Santiago market. According to the Master Agricultural Survey of INE, 24 % of farmland, in case of small scale farmers, had been utilized for vegetable production before the Cholera outbreak which caused the prohibition of vegetable cultivation by surface flow in the Metropolitan Region. These facts indicate a possibility of expansion of vegetable production in the area.

Forage crop cultivation shares an important portion in Popeta area although all dairy farmers in the area have left. The products are sold mainly as dried feed to other regions. Seed production is also important even though the produced area is small. Income per unit area of seed production is high. Not only soil and climatic condition but also connection with private enterprises which contract with specific farms are also important to introduce seed production. According to Agricultural Census 1997, 4 % of cultivated land is occupied by seed production in Melipilla Province and seed production is also important crop in Popeta area.

On the other hand, the present land use of the projected new irrigation area is utilized for farming minimally because there is arid area. Minimum farming means that poor cattle raising or wood collection for charcoal. Introduction of irrigation by the project is going to increase drastically its land productivity in the area. A big difference is created between incremental net benefit at present and that in the plan.

There are agricultural activities whose gross income ranges between $50,000/ha of cattle raising and $30,000/ha of charcoal in the projected irrigation area at present. However, income from these activities are so small that farmers must depend on non-agricultural income for their living. Otherwise, the present projected irrigation area exists as abandoned land because land price increase can be expected due to land use opportunities for other purposes. If irrigation is introduced, gross income from the land would increase by $1,000,000/ha on average of both high and low productive lands. In case of high productive farmland, the gross income is expected $2,000,000/ha. The present gross income is approximately $10,000/ha on average, which is 1% of irrigated farmland. Even in the most profitable land, it is less than 5 % of that.

(3) Agro-processing

Agro-processing in the new irrigation area needs to consider that Popeta area is located in 65～80 km from Santiago and roads to Santiago are improved. In Santiago, many fields of agro-processing are operated. Different field activities of Santiago are also operating in the suburbs of Santiago such as Paine, Pirque, Linderos, Lampa, Isla de Maipo and Talagante. Any of those areas are located within 90 km from Popeta area and some of them are within 25 km. In *Comuna* of Melipilla Province where the project area is located, there are food processing facilities shown in a following table.

Type of processing facility	No. of Facility	Capacity
Fruits Dehydration Facility	1	45,000 kg/day
Nuts Processing Facility	1	7,500 kg/day
Freezing Facility	12	25,000m^3
Packing Facility	46	500,000 kg/day
Sterilizing Facility	19	318,000 kg/day
Winery	2	3,000,000lt
Horse Slaughter	1	-

1.1.4 Agricultural Support and Farmers' Organizations

(1) Agricultural support

Agricultural support in Chile is principally conducted through INDAP. The INDAP's local office which covers Melipilla Province is established in the Melipilla city. Therefore in the Project, agricultural support is to be provided by the INDAP-Melipilla.

In order to utilize the service of INDAP, farmers are required to establish organization by themselves. This was a big bottle neck on extension of INDAP services. Area Advisory Services (SAL), Project Advisory Services (SAP) and Specialized Advisory Services (SAE) were newly established in 1997 so as to promote and expand INDAP's services for conducting works step by step including establishing organizations.

It becomes easier than before to newly receive INDAP services through establishing the systems of SAL, SAP and SAE. However, a problem of how to build up organizations at the initial stage still remains. Therefore, a certain system of intermediation for establishing organization is required. It is also required to strengthen the function of SECPLAC which set up in each *Comuna*. It is practical to

arrange establishing organizations through having advisors who are closely related to the area.

At present, agricultural supports are not provided by NGOs at all in the project area. On the contrary, private agricultural consultants and private agricultural extension workers are utilized as advisers. These advisers are employed by specific farmers' organizations. They establish and implement project plans, improvement of farm management plan, and operate and management plans. Moreover, they give advice on management and operation of organizations. Especially, they give consulting services on INDAP services; establishment of organizations, application for projects, and financial procedures. Then, they also continue to give guidance on operation and management after the project. In addition, because the advisers are close to the area, they often know a lot about local information, farming condition, and so on. They contribute largely to promoting improvement of agriculture in the area.

(2) Farmers' organizations

There are five types of farmers' organizations. Beside canal associations, there are irrigation organization, milk collecting cooperatives, potato production organization and flower production organization as producers' organizations in the study area.

In Popeta area, there are seven canal associations; Canal Chocalan, Canal Carmen Alto, Canal Cholqui, Asoc. Canal Wode House, Canal Culipran, Culipran la Higuera, and Canal Basurero. These associations are working by unit of association, and mainly deal with fair distribution of irrigation water and operation and maintenance of irrigation canals. They can utilize INDAP services for rehabilitation and new construction of facilities. They also apply for services and initiate the projects by using INDAP services. So that, the canal associations employ full-time advisers, and intend to promote their duties and implement smooth operation and maintenance of facilities.

Irrigation organization (*Grupo de Riego*) as a producers' organization was established by 91 small scale farmers who lived in Culipuran and Popeta by SAL of INDAP. The irrigation organization improves irrigation technology and canals for effective use of irrigation water, and deals with increase of productivity and improvement of quality of strawberries, vegetables, and fruit trees by utilizing irrigation technology.

A milk collecting cooperative is a producer's organizations. This is a milk producers' cooperative and managed by 15 small scale dairy farmers. The bases of them are milk collection centers which equipped with a fixed temperature storing facilities by INDAP projects. Based on the centers, the cooperatives intend to control milk quality for maintaining the selling price through controlling animal raising, feed and milking of each farm. The quality is strictly controlled because the selling destination is mostly large scale milk processors. Some of the cooperatives aim at construction of dairy processing facilities of original brand through establishing an united organization of small scale milk collection centers, based on the experience of the quality control.

A flower production organization (*Taller Tierra Verde*) is managed by 8 women of farm households in Carmen Bajo area. The organization was set up by PRDEMU which is a rural women support program of INDAP. The center of its activity is carnation cultivation. It deals with production up to shipment to a central market, and promotes improvement of rural women's status and entrance into socio-economic activities.

A potato production organization (*Grupo Cultivos de Papas*) was established by 104 small scale farmers in Culpuran and Popeta through SAL of INDAP. It promotes socio-economic independence of farmers through improving productivity and establishing marketing advantage by quality control based on improvement of potato cultivation technique.

These producers' associations have finished establishing fundamental organizations and aims at next steps of development. Based on a similar idea, a farmers' organization which deals with agricultural processing is operating in San Pedro where is near the study area. This cooperative, which is invested by small and medium scale farmers, produces, grades, and collects by a quick cooling storage as a whole, and expands the market from domestic market to European markets. Due to appearance of this facility, employment opportunity is created and local employment of about 300 workers is secured. This facility contributes to stable development of the region largely through creating not only economic effects but also promoting stable production and permanent settlement of inhabitants. These experience and knowledge can be utilized as a model of agricultural development in Popeta area.

1.1.5 Agricultural Economy and Marketing

(1) Marketing of agricultural products

1) Production and distribution

Marketing of farm products in the study area can be (a) individual, in which the producer sells his/her products to an intermediary without a contract, generally obtaining low prices, but leaving the option open for good prices when market conditions turn favorable, and (b) group marketing, or through a trade association of the producers themselves, which not only improves marketing by replacing intermediaries, but permits access to credit and technical assistance.

As marketing channel, small producers in the priority study area mention intermediaries in the first place. Intermediaries bridge the gap between producers and wholesale markets in Santiago. Apparently there are two types of intermediaries: (a) those who pay before taking the products, and (b) those who combine transportation and sale services, paying the producer after selling the products, thereby making them more akin to consignees. Wholesale markets in Santiago are the main destination of most agricultural products, and serve as suppliers to regional consumption centers.

Concerning direct sale from producers to consumers, farmers who own land along a trunk road have the option of selling their produce in makeshift stands, which allow them to obtain better prices. For instance, a 5 kg tray of strawberry is sold at $2,000 to intermediaries but can fetch $4,000 if sold in 4 smaller trays at $1,000 each in roadside stands. Another direct sale channel is the popular fair, one of which operates in San Pedro during weekends. Participants in this popular fair can be one of the 68 members of a trade association that sets up the fair, or any farmer interested in selling his product. The fair sets prices at prevailing market prices, charging 10% as administrative expenses.

Another marketing option is contract production, generally involving agro-industry or packing plants. To ensure the quality of agricultural products, these firms set a number of requirements, which are not always accessible or economically justifiable for the small producer.

Collective milk marketing is becoming a required step for small producers, due to the refrigeration requirement set by the milk buyers. The price differential between non-refrigerated and refrigerated milk can be as much as 50% ($40 against $60 per liter

some time ago). A center for collective milk marketing can be set up by a group of dairy farmers who finance the necessary investments, but when there is surplus capacity it is usually open to non-members as well, paying a lower price than to members or charging around $2/liter as refrigeration service.

The purpose of quality control upon milk reception at the collective milk marketing center is to detect acidity and to prevent milk dilution with water. The milk price paid to producers is the same in some places, regardless of quality differences. However, better-organized collective milk marketing centers have all producers identified by individual codes, and their milk samples are analyzed in the laboratories of the final buyer who sets prices according to the milk quality. Milk quality requirements are defined by buyers, usually major dairy firms or local cheese factories, but small milk producers generally do not know what these requirements are.

Small collective milk marketing centers in the study area include Codigua, Culiprán, Popeta, Puerta Colorada. A recent trend is the joining of small collective milk marketing centers into associations, one of which is known as Micro-Regional Melipilla encompassing the Melipilla administrative district. This association operates with a staff that includes a manager and a veterinarian, and provides the necessary inputs, technical assistance and services such as administrative procedures.

(2) Marketing facilities

Within the priority study area, there are facilities for the marketing of perishable products. These facilities consist of packing plants and cold storage, which permit value added to the produce, either through processing or through an improved inter-temporal distribution of the product. One such example is *Agrofrutilla San Pedro SAC*, resulting from strawberry cultivation introduced by INDAP into San Pedro in 1964 and has become the main crop in the area. Up to 1988, producers sold their strawberries individually to intermediaries and wholesale markets, at low prices due to insufficient negotiation capabilities. In order to improve this situation, the Strawberry Growers Association of San Pedro was created in 1988. In 1994, a strawberry based business idea came up and appropriated by the Strawberry Growers Association of San Pedro, finally resulting in the establishment of the agro-industrial plant *Agrofrutilla San Pedro SAC* in 1997 by 63 small and medium size strawberry producers of the San Pedro district. INDAP financed 77% of investments consisting of the packing plant, offices, refrigerated truck, and strawberry platelets for its members, while the producers contribution reached 23%.

Agrofrutilla San Pedro SAC receives strawberry produced by members and non-members, providing services in marketing, processing (classification and stem removal), packaging, refrigeration, and refrigerated transportation to different markets consisting of agro-industry (70%), domestic market (20%) and exports (10%). Service fees are charged for marketing (4%), and for classification and packaging in standardized containers ($45/kg + sales tax). Buyers pay to the packing plant, which pays the producers after deducting the service fees.

The stem of the strawberry for processing is removed by hand, and the strawberry is washed with water under pressure. The clean strawberry is classified for the second time, and packaged in plastic trays that are transported to the agro-industry. The stem removal fee is charged to the agro-industry ($65 + sales tax), in addition to a 4% surcharge for the refrigerated transportation.

The business plan for the packing plant is exclusively based on strawberry production between October and May. Therefore, the key to this business is the plant utilization during the off-season. Under consideration is year-round production of strawberry in greenhouses, vegetable production (spinach, cabbage, Chinese cabbage,

cauliflower, broccoli, green peas, okra), or simply cold services for seed conservation, hibernation of plants, storage of fruit and vegetable, etc.

Future plans include marketing of farm inputs, machinery and equipment on consignment, to be sold to members and non-members, receiving a sales commission (10 to 30%).

(2) Price and quality of agricultural products

Agricultural products identified in the study area by the questionnaire survey were corn and potato were the most common crops, and occasionally onion, tomato, pumpkin, melon, cucumber, beans, sunflower, wheat, fruit like avocado and lemon, in addition to alfalfa and natural pasture for cattle.

1) Farm gate price

The farm gate price received by the small producer appears to be influenced more strongly by the harvest time, rather than by the quality of the product. In the case of strawberry, small producers lack the facilities needed to clean the strawberry, whereby they visually classify the strawberry into first class and second class, and pack it by class in 5 kg trays. By so doing, the price received for the first class strawberry early in the season in October is around $2,300 per tray, $2,000 in November and $1,800 in December. Meanwhile, the price of the second class strawberry does not change much, being sold between $1,000 and $1,200 per tray during the same period. Similarly, potato harvested in early October can be sold at around $14,000 per 80 kg bag, but the price goes down to $10,000 in November and $2,000 in December.

Month	Strawberry Price ($/5kg tray)		Potato Price ($/80kg sac)
	First Class	Second Class	
October	2,300	1,000-1,200	14,000
November	2,000	1,000-1,200	10,000
December	1,800	1,000-1,200	2,000

Farmers receive price information through 2 or 3 radio stations, and they are aware of the existence of such service. However, they argue that these radio stations broadcast price information during the morning when they need to be working in the field. The prestigious daily El Mercurio publishes an agricultural supplement on Mondays, with extensive information on prices of inputs and outputs. The Office of Studies and Agricultural Policy (ODEPA) of the Ministry of Agriculture provides price information by fax to interested farmers, and sends regional price information to the relevant local government office.

2) Wholesale price

The price recorded by ODEPA in wholesale markets specify the area where the product originates, three levels of prices (low, high, and common) by variety and quality of products, and the transaction volume per day. Price information is also available as weekly averages by variety and quality of products, and the transaction volume per week. Finally, price information is available as the monthly average between 1975 and 1998.

Wholesale price differentiation by quality of products indicates that some kind of classification takes place between the farm and the wholesale market. The tables below show examples of wholesale prices in two wholesale markets of Santiago, Lo Valledor and Mapocho, choosing the products originating in the Central Zone or in Santiago. Price differences can be noticed between the wholesale markets, prices being higher in the Mapocho market as a reflection of its convenient location in

downtown Santiago, while Lo Valledor is located in the outskirts of the city.

3) Quality standards

The National Standards Institute (INN) defines quality standards for a variety of products, including some agricultural products. Quality standards for grapes, apple, pear, avocado and lemon are set for both the domestic market and export markets. In the case of Thompson Seedless variety of grapes, and taking the bunch weight as the criterion, standards for the domestic market and the export markets differ as follows:

Class	Domestic Standard (gram/bunch)	Export Standard (gram/bunch)	
		Thompson Seedless, Cardinal, Perlette	Other Varieties
1	225	250	300
2	180	200	250
3	115		
4	115		

Source: NCh1818.Of 80, NCh1925.Of 82

The quality standards set by INN are used by Agriculture and Livestock Service (SAG) to control the quality of agricultural products for export, through its regional offices located in Melipilla and Talagante within the priority area. On the other hand, in the case of domestic market, no control seems to exist for the enforcement of quality standards set by INN. Quality standards of some agricultural products are presented as an appendix to Annex J.

4) Marketing improvement

There are favorable factors that can enable producers in the study area to improve the marketing of their products. The favorable factors are the proximity to the main consumption centers of the country, and the relative abundance of information on prices and quality of agricultural products.

The long-term price trend can give an indication on promising products. The quality standards for the promising products will indicate market requirements, and therefore, the technology that will be required in the production of such products. Once the selected products are produced, recent or short-term price information will give the pattern to decide in which market to sell.

Small producers should set up their own trade associations in order to take over the role of intermediaries. Trade associations will give their members additional advantages, such as access to technical assistance and credit offered by government institutions. A trade association can rent a sale and exhibit module in the new Santiago Wholesale Market (MERSAN), to make it possible to sell directly to consumers. If the rental fee of a sale and exhibit module in MERSAN is out of reach of a trade association, a group of trade associations can share the same space. In this case, each trade association can directly sell to consumers a specific product, which should ideally be produced successively during the year, so as to permit an efficient rotation in the use of the sale and exhibit module.

(3) Household income

The following table shows the monthly income gap between the non-poor population and the indigent population in the administrative district of Melipilla, as compared with the Metropolitan Region and the whole country. The data indicate that the 1996 monetary income gap between the non-poor population and the indigent population was 7,78 in the Melipilla district, 14,36 in the Metropolitan Region, and 10,85 at the national level, thereby indicating a relatively more equitable income

distribution in the Melipilla district.

Monthly Income ($)	Melipilla District	Metropolitan Region	Country Total
Indigent			
Autonomous income	47,158	37,935	38,992
Monetary subsidy	3,823	3,074	4,994
Monetary income	50,981	41,009	43,986
Non-Indigent Poor			
Autonomous income	84,901	108,122	98,273
Monetary subsidy	6,806	4,764	5,720
Monetary income	91,707	112,886	103,993
Non-Poor			
Autonomous income	393,538	586,463	473,995
Monetary subsidy	2,988	2,560	3,368
Monetary income	396,526	589,023	477,363
Non-Poor/Indigent Gap			
Autonomous income	8.35	15.46	12.16
Monetary subsidy	0.78	0.83	0.67
Monetary income	7.78	14.36	10.85

Source: CASEN 1996, Módulo Comunal, MIDEPLAN, Enero 1998

Results from the questionnaire survey were analyzed with reference to small farms of less than 15 ha. In the Popeta area, the survey included small farms, one medium size farm and one large farm. Small farms in the Popeta area were analyzed as a whole, and also classified into those that produce only corn and potato, and those with diversified crops. The economic results from these farms in the Popeta area, as indicated by the questionnaire survey, are presented below.

Popeta Total Small Farms

Item	Area (ha)	Income ($)	Expenses ($)	Result ($)
Farm Area	4.91			
Used Area	3.61			
Gross Farm Income		943,808		
General Expenses			265,028	
Net Farm Income				678,780
Family Labor		97,529		
Off-farm Income		313,719		
Family Expenses			757,538	
Household Income				332,490

Popeta Small Farm with Corn and Potato					Popeta Diversified Small Farms			
Item	Area (ha)	Income ($)	Expenses ($)	Result ($)	Area (ha)	Income ($)	Expenses ($)	Result ($)
Farm Area	4.75				5.11			
Used Area	3.22				4.09			
Gross Farm Income		499,571				1,506,507		
General Expenses			224,861				315,907	
Net Farm Income				274,711				1,190,600
Family Labor		136,000				48,800		
Off-farm Income		417,632				182,097		
Family Expenses			751,821				764,780	
Household Income				76,521				656,717

Item	Popeta Medium Size Farm				Popeta Large Farm			
	Area (ha)	Income ($)	Expenses ($)	Result ($)	Area (ha)	Income ($)	Expenses ($)	Result ($)
Farm Area	21.0				321.0			
Used Area	8.0				315.0			
Gross Farm Income		1,115,600				6,220,000		
General Expenses			140,000				369,000	
Net Farm Income				975,600				5,851,000
Family Labor								
Off-farm Income		720,000						
Family Expenses			1,630,000				2,440,000	
Household Income				65,600				3,411,000

Note: 8 ha of wheat completely lost

The economic results presented above indicate that the small farm is in a difficult situation, requiring off-farm income to make the farm viable. It can be seen that the small farm producing only corn and potato in the Popeta area is in the most difficult situation. The choice of corn and potato is attributed to the hope of hitting it big if market conditions turn favorable. This is because the price of a corn cob in recent years has been low at around $25 to $30 each, but sometimes it reaches $100, and it is this possibility that induce small farmers to produce corn year after year in spite of low prices. The possibility of big profit is also open to early harvests of potato and pumpkin. Despite the unfavorable economic results obtained by small farms, the positive aspect consists of small farms as employment sources for the farmer and some family members, who would be unemployed if they were not working their farms.

1.1.6 Agricultural Infrastructure

(1) Target areas for new irrigation

The area for Feasibility Study represents Popeta area, in which consists of four small basins; Carmen, Choluqui, Culiprán and Popeta. These basins belong to "Popeta-Yali-Alhué" development plan of agricultural development project through water resources utilization by using 25 m^3/sec of the unused water-rights of the Maipo river proposed in the Master Plan. Considering the location of water source in these three areas and irrigation area, the diversion weir and main canals are planned to be used in common. Accordingly, Yali and Alhué areas are also mentioned in relation with Popeta area in the study.

In the basior c plan on agricultural infrastructure of the Master Plan, Popeta new irrigation areas are the area of present unused land, the poor farming area where used for only rainy season's cultivation, the area where cultivated only during the season when surface flow of small streams is available (mostly no crop cultivation in summer), and the area where enough irrigation water cannot be obtained from existing irrigation canals. Diversion weir, a main canal, secondary and tertiary canals are planned as water supply facilities for the new irrigation areas. The plan also includes a part of existing facilities' improvement for supplemental water. Route of the main canal is planned on the slope of mountain foot in the irrigation area. The tunnels and aqueducts are also included.

(2) Irrigation and drainage condition in the new irrigation area

1) Irrigation facilities

The new irrigation area is unused land and has no organized irrigation facilities. Some small scale areas use water taken from small streams as irrigation water. Yet,

shortage of water is always happened, and so new irrigation water is desired. The situation of irrigation facilities in respective areas is described below.

- Popeta Area

Although existing irrigation areas are excluded from the proposed irrigation areas, water supplement is required because water shortage occurs constantly in 290ha of Culiprán area. There is also 420ha irrigated area by groundwater, but it is also excluded from the new irrigation areas.

- Yali Area

In Yali area, there is no irrigation system by using river flow though whole Yali river basin is the target of the project. Construction of large scale irrigation system using groundwater has increased recently. These areas are excluded from the proposed new irrigation areas because farm management of these is stable due to highly efficient water use irrigation by pumping in the area (1,850ha).

- Alhué Area

In Alhué area, the new irrigation area is spread over the Alhué river basin. At present, irrigation system taking water from tributary of the Rapel river at downstream has managed in about 1,200ha. Beside this, 760ha of irrigated areas by groundwater are scattered. These existing irrigated farmland are excluded from the proposed irrigation areas.

2) Drainage facility

The problem of poor drainage exists in a part of Yali and Alhué areas among the proposed irrigation areas; Popeta, Yali and Alhué. The cause of poor drainage is due to impervious hardpan which formed at from 1.0 to 1.5m of ground surface.

(3) Canal associations

Most part of the proposed new irrigation areas is non-irrigated land without sources of water and canal associations. Although there is some irrigated land by using surface flow of small streams in rainy season, canal associations are not organized in these areas.

1.1.7 Rural Infrastructure

(1) Present situation of basic infrastructure

Present situation of basic infrastructure in the study area is shown in the table below.

Unit: %

Area		*UV*	Electricity	Water supply	Sanitary
Popeta	UV15	Chocalán	100	100	30
	UV16	Carmen Bajo	100	100	23
	UV17	Carmen Alto	85	80	0
	UV20	El Pabellon	100	100	5
	UV21	Cholqui	100	100	12
	UV23	Culiprán	100	95	8
	UV25	Popeta	100	90	5
	UV26	Los Guindos	90	80	5
	Total		99	92	14

Source : Melpilla - SECPLAC

Regarding basic infrastructure in the study area, installation of electricity and water supply is almost completed. Electricity is supplied by an electric supply company. Drinking water is all from groundwater. Water supply facilities are constructed by the rural water supply projects of MOP with community as an unit. However, in mountainous communities, Carmen Alto and Los Guindos, the installation ratio is low and it needs to promote installation.

On the other hand, installation of sewage facilities has almost not proceeded, and there are no sewerage treatment facilities even in the communities where water supply facilities have already installed. Generally, excreta is treated by the septic tank of individual houses, and domestic sewage is directly discharged into drain canals. Therefore, contamination of agricultural water and river flows by domestic sewage is getting noticeable in some places. It is time to start examining installation of rural sewerage facilities for conservation of living environment in the rural area. However, it is economically difficult for many communities to do so due to the size of communities and their locations at present. Meanwhile, individual treatment including domestic sewage is practical. It means that discharge of untreated sewage into rivers and irrigation canals has to be banned at least, and treatment within housing lot such as penetration inlet should take priority.

(2) Road / Transportation facilities

Road network is formed by MOP managed roads and Municipality managed roads (*Municipalidad*). Trunk road system consists of MOP managed roads, and lateral roads consists of Municipality managed roads. All inter-regional roads and 60 % of the trunk roads are paved. However, all roads except inter-regional roads are dead-ended and only few roads connect between communities. Although lateral roads are not paved at all, they have already widened enough for passage of vehicles. Connection between lateral roads are very poor because most of lateral roads are arranged as comb-shape against the trunk roads. According to the road situation mentioned above, pavement of trunk roads which connect between inter-regional roads and communities, and connection between lateral roads should be promoted.

On the other hand, regarding public transportation facilities, there is a route bus service mainly on the trunk roads and connects with Melipilla city. The route busses run frequently between Melipilla city and Santiago or Valparaíso cities. It takes about 1.5 hours to Santiago city.

(3) Other facilities

Concerning educational facilities, primary education facilities are constructed mainly in each UV. High schools and colleges are established in Melipilla city. Through them, improvement of educational environment has been promoted. Distribution of primary education facilities is as follows.

Area	*Unidad Vecinal* (UV)		No. of teachers	Kindergartner	Pupil
Area Popeta	UV15	Chocalan	-	-	-
	UV16	Carmen Bajo	10	17	249
	UV17	Carmen Alto	3	0	19
	UV20	El Pabellon	12	33	321
	UV21	Cholqui	2	0	54
	UV23	Culipran	14	55	374
	UV25	Popeta	3	0	52
	UV26	Los Guindos	1	0	18
	Total		45	105	1,087

Source : Melpilla – SECPLAC

As medical facilities, a health center (*Posta Pahuilmo*) is set up in UV-20 (El Pabllon), and a health nurse is always posted. However, a medical doctor and a dentist make their rounds once a week. A clinic (*Consult. San Manuel*) is set up in San Manuel which is near the area. In the clinic, two doctors and four nurses are always posted and spread out the health activities in rural areas. Moreover, a city-owned hospital which equipped with emergency facilities and a Red Cross Hospital *(Policlinicos Cruz Roja*) are located in Melipilla city.

ENTEL (*Empresa National de Telecomunicaciones S.A.*) and CTC (*Compañia de Telecomunicaciones de Chile S.A.*) provide various types of telecommunication services in Melipilla city. Especially, significant dissemination of cellular telephone contributes largely to improvement of telecommunication environment in local cities. Regarding telecommunication in rural areas, coin type public telephones of CTC which utilize cellular telephone networks is arranged in each community and it is possible to contact with outside by dialing.

1.1.8 Environment

(1) Designated area such as natural parks

Designated areas in Popeta, Yali, and Alhué such as natural parks are shown in the table below.

Type of designation	Name of areas	Size	Place (Basin)
National Reserve	ROBLERIA DEL COBRE DE LONCHA (DECRETO No.62 1996/7/25)	5,870 ha	Est. Alhué
	ESTERO EL YALI (DECRETO No.41 1996/5/23)	520 ha	Est.Yali
Protected Area	HACIENDA TANTEHUE (DECRETO No.427 1968/8/30)	11,775 ha	Cue. Melipilla
Wild Life Protection Area	LAGUNA DE ACULEO, ALTOS DE CANTILLANA Y TANTEHUE (DECRETO No.382 1998/1/24)	156,117 ha	Cue. Melipilla, Rio Angostura, Est. Alhué y Est.Yali

ROBLERIA DEL COBRE DE LONCHA in the Caren Basin is designated as National Reserve where its original animals and plants are distributed.

ESTERO EL YALI is a marsh registered as the marsh of Ramsar Convention in December 1996, located in the mouth of the Yali river near the Vth Region, Santo Domingo. The marsh includes three lakes and the mouth and is a bait and rest area for migratory birds. It is confirmed that 115 species of birds inhabit the marsh, 71 of which are water birds. 13 birds to be preserved are registered as the table below. Cisne coscoroba and Cuervo del pantano are categorized as endangered, Bandurria, Flamenco chileno, Cisne de cuello negro, Becasina, and Gaviota garuma as Vulnerable, Garza cuca, Huairavillo, Pato gargantillo, and Pato cuchara and Nuco as Insufficiently Known.

Category	Scientific Name	Local Name
Endangered (En Peligro)	*Coscoroba coscoroba*	Cisne coscoroba
	Plegadis chihi	Cuervo del pantano
Vulnerable (Vulnerables)	*Theristicus caudatus*	Bandurria
	Phoenicopterus chilensis	Flamenco chileno
	Cygnus melancoryphus	Cisne de cuello negro
	Gallinago paraguaiae	Becasina
	Larus modestus	Gaviota garuma
Rare (Rara)	*Ardea cocoi*	Garza cuca
	Ixobrychus involucris	Huairavillo
	Anas bahamensis	Pato gargantillo
	Heteronetta articapilla	Pato rinconero

Insufficiently Known (Inadecuadamente conocida)	*Anas platalea* *Asio flammeus*	Pato cuchara Nuco

Source: RESERVA NACIONAL EL YALI, CONAF,1998.

Although 15 species of floras are found, no species to be preserved inhabit. Two species of amphibian registered as Vulnerable, 1 of amphibian as Insufficiently Known, and 3 of reptile(*Libro Rojo de los Vertebrados Terrestres de Chile, CONAF, 1988*) are found.

Hacienda Tantehue categorized into Protected Area is a supplementary area to National Reserve, located in Cajon del Rey sector. The following areas are to be designated as National Reserve: Carmen Alto-La Viluma-Cuesta El Cepillo(Melipilla); Cajon del Rey-Stream de Piche(Melipilla and Alhue); Cajon de Aculeo and Cajon del Rey sector(Melipilla); and Streams de Piche and El Membrillo sector(Alhue). LAGUNA DE ACULEO and ALTOS DE CANTILLANA Y TANTEHUE are designated as Wild Life Protection Area in order to preserve the area where the most number of wild animals inhabit over the Metropolitan Region. Main wild animals inhabiting the area are shown in the table below.

Local Name	Scientific Name
Garza cuca	*Ardea cocoi*
Torcaza	*Columba araucana*
Cisne de Cuello Negro	*Cygnus melancorypha*
Cuervo de Pantano	*Plegadis chini*
Iguana chilena	*Callopistes palluma*
Lagartos	*Pristydactilus spp*
Sapo Arriero	*Alsodes nodosus*
Zorros	*Pseudalopex spp*

Source: Decreto No 382 del 24 de Enero de 1998.

The table below shows the number of species of animals and plants to be preserved, living in LAGUNA DE ACULEO and ALTOS DE CANTILLANA.

Category	Flora	Mammal	Bird	Reptile	Amphibian
Endangered	1	2	4	-	1
Vulnerable	4	2	7	3	1
Rare	1	-	8	1	-
Insufficiently Known	-	3	4	-	1

Source: Libro Rojo de los Vertebrados Terrestres de Chile, CONAF, 1988

(2) Present condition of water contamination

The table below shows the analysis of water quality in Popeta, Yali, and Alhue.

Date		22/7	12/8	10/12	23/7	12/8	7/12	11/12	Standard			
Item	Unit	St.7	St.7	St.7	St.23	St.23	St.23	C18	SA	SB	SC	EMOS
pH	-	7.3	7.2	8.2	7.1	7.6	7.5	8.1	5.5-9.0		6.5-8.3	
BOD	mg/l	32.0	65.0	16.0	3.8	<10.0	25.0	6.2				<20
No. of Coliform Group												
	MPN/100ml	9.2E+05	9.2E+06	1.6E+04	3.5E+04	1.1E+02	3.5E+03	1.7E+05				
No. of Fecal Coliform Group												
	MPN/100ml	9.2E+04	2.8E+06	3.5E+03	3.5E+03	4.9E+01	1.4E+02	9.2E+03		1000	1000	1000
Cu^{2+}	mg/l	0.003	0.019	0.058	0.007	0.006	0.017	0.013	0.20			
$SO4^{2-}$	mg/l	390.0	351.0	350.0	980.0	515.0	410.0	300.0	250.00			
$C1^{-}$	mg/l	220.0	275.1	196.1	82.5	275.1	83.6	177.5	200			

St..7:Rio Maipo despues Río Mapocho (Haras Los Boldos), St.23:*Estero* Alhué en Quilamuta,
C:18:Canal Culiprán(en puntilla El Cerrillo)
SA:Chilian Standard for Irrigation SB:Chilian Standard for Recreation SC:Standard for growing specified Vegetables

The analyses were made three times on the point where the Maipo River joins the Mapocho River, three times on the point of the Alhue river, and once of the Canal Culipran. Compared to the standard value shown in the table above, all three points in all seasons meet the standard requirement of water for agricultural use as to pH and Cu^{2+}, while some of points meet as to Cl^{-}. Concerning $SO4^{2-}$, all points in all seasons exceed the standard value. As to fecal coliform, except for two analyses on the Alhue river, all points in all seasons exceed the standard value of water for recreation use and water for growing the specified vegetables.

(3) Water quality in Popeta area

According to the construction plan of the sewage treatment plant in Santiago by EMOS, three plants will be constructed along the Mapocho River in 2024 and then the treated water of approximately 25 m3/sec will be discharged into the Mapocho River. Consequently, water quality of the Maipo River joining the Mapocho River will be greatly improved. The table below shows the volume of water to be treated in 2010 in order to predict the quality of water for irrigation in the priority project area in the same year. Water quality to be achieved is set at 20 mg/l in BOD.

Plan	Volume of treated water (m^3/sec)	BOD (mg/l)
1 st Stage	4.7	20
2 nd Stage	5.2	20
3 rd Stage	6.4	20
Total	16.3	20

The point to predict water quality whose index is BOD is set the position to take water of the Maipo River. The table below shows the predicted value of BOD in 2010 in each of the maximum, minimum, and average flow of water selected from the average annual flow. The BOD value in 1998 is an average value of the water analysis made in the present investigation.

Point of prediction	River flow (m^3/seg)		BOD in 1998 (mg/l)	BOD in 2010 (mg/l)
Intake of Canal Mallarauco at Mapocho River	Qmax	35	64	44
	Qmin	16	64	20
	Qave	25	64	35
Up Maipo River joining Mapocho River	Qmax	96	14	12
	Qmin	29	14	12
	Qave	63	14	12
Intake at Maipo River	Qmax	131	38	20
	Qmin	45	38	15
	Qave	88	38	19

According to the table above, the BOD value at the intake water points for Popeta-Yali-Alhue will be 20 mg/l or less in 2010, that results in the water quality improvement.

1.1.9 Problems and Development Approach

Present problems on agriculture is confirmed in the Master Plan of "Agricultural Development and Water Management in Metropolitan Area, Chile." They are ; 1) difficulty of farming on small scale farmers involved in the agricultural sector and regarded as a problem on the structure of agricultural production, 2) tightness and competition of water use as a basic agricultural condition, 3) contamination of irrigation water and 4) decrease of farmland. Countermeasures to solve these problems are recognized as ; 1) agricultural promotion from inside of the sector, 2) effective use of resources as an improving condition for agricultural promotion and 3) environmental conservation.

Taking these conditions into accept, Popeta area is selected as the objective

area for the feasibility study according to the standard that development of new irrigation farmland by utilizing the unused water rights and main beneficiary is to be small scale farmers.

Following points are raised as particular problems of the area through reviewing the present situation based on the background of selection of Popeta area for the Feasibility Study.

- Existence of large number of small scale farmers

  Farm management of small scale farmers is difficult at present, and it needs the support on basic infrastructure for agricultural production, technical and financial support, and improvement of settlement condition relevant to BHN such as roads and drinking water under the present situation.

  Stable surface flow which is easy to use is not available in the area. A certain size of deep wells for using groundwater is needed for stable farming, but small scale farmers are not able to invest for such farming infrastructure. Groundwater development by a form of enterprise farms reaches the limit of available groundwater.

  Establishing farmers' organizations is recognized as a base for receiving the support service on farming improvement and reinforcement of negotiation power at markets. At present, establishing farmers' organizations is in progress among the producers of a single crop, however it is hard for small scale farmers, who do not have the farming infrastructure which ensures stable shipment and quality, to have motivation of establishing organizations.

- Agricultural development by a form of enterprise using groundwater

  The enterprises and large scale farmers, which have sufficient capital and high farming technology, carry out large scale orchard or poultry farm in the area by using climate condition which is suitable for cultivation and groundwater. This kind of groundwater use causes decreasing water level and affects small scale farmers in dry-up of shallow wells.

Based on the problems in the area mentioned above, the measurement to solve them and to promote a well-balanced rural development is recognized improvement of farming condition with small scale farmers through agricultural development which utilizes water and land resources in the area. The contents of development plan should be proposed are not only improvement of production and living infrastructure but also farming support, as a core, through using productive infrastructure. On the other hand, for large and medium scale farmers who hold land in the benefited area, implementation of the new irrigation system in the project area is to alleviates dependency on groundwater for development. Thus, it contributes to conservation of groundwater which is reaching its limit.

1.2 Agricultural Development Plan

1.2.1 Basic Concept of Development

(1) General

The Master Plan on "Agricultural Development and Water Management in Metropolitan Area" targeted at the year 2010 was established with the frames of effective use of land and water, environmental conservation and agricultural promotion

as countermeasures to solve the problems (disparity caused by landholding scale, decrease of farmland, contamination of irrigation water and tightness of water use) on agriculture in the metropolitan area. Based on the Master Plan, Popeta area, where is located in the southwest of the study area, was selected as the priority area for undertaking the Feasibility Study where will be a new irrigation area for agricultural development plan through effective water use.

Agricultural development plan for approximately 5,000ha of Popeta Area described in the Master Plan consists of agricultural infrastructure improvement establishing a new irrigation system with Yali and Alhué areas which covers about 21,000ha totally and utilize the unused water right of the Maipo river, agricultural production plan including the support system, and rural infrastructure improvement plan.

Farmland in Popeta, Yali and Alhué areas extend into the valleys formed by branches of *Estero* Popeta, *Estero* Yali and *Estero* Alhué. *Estero* Popeta finally flows in the Maipo river, but *Estero* Yali discharges into the Pacific Ocean directly and *Estero* Alhué also discharges into the Pacific Ocean after joining with the Rapel river. Farming in the area was mainly cereal crops such as wheat and livestock because available surface water is only rainfall of winter in most of the land. Yet, recently, year-round cultivation of large scale fruit trees, forage crops and maize by using groundwater increases. Many commercial poultry farms are operating in each area.

(2) Development approach

New agricultural development in Popeta area by installation of irrigation facilities aims at agricultural promotion by replenishment of water supply to the agricultural area located in the southwestern part of the Metropolitan Region. The development in the area corresponds with the development which contributes to improvement of infrastructure and supporting and strengthening of medium and small scale farmers that proposed in agricultural policy, "Strategic Agenda" by Ministry of Agriculture. Regarding the facilities relevant to new irrigation, it is planned to design organization of the facilities which realize smooth management of water use in the upstream third section of the Maipo river and stable supply of irrigation water to the downstream of the existing irrigation facilities. Through them, it is planned to contribute to future water management of the Maipo river basin as a whole from the structural aspect.

The new irrigation farmland which classified into the suitable land for irrigation by the land productivity classification extends below about elevation 210m in Popeta area and below about elevation 180m in Yali and Alhué areas. Related with the intake level required for new irrigation, the proposed new irrigation canal passes unirrigated land located in the upstream Calmen Alto, Cholqui and Culiprán, where are present irrigated areas and take water from the Maipo river. The irrigation plan includes these upstream unirrigated farmland. The most farmland of the new irrigation areas is used as pasture at present.

Farming in the new irrigation area is proposed according to the specific characteristics of the area. Small scale farmers intend the intensive crop cultivation mainly with fruits trees such as avocados and citrus kinds and cereal crops, traditional crops, forage crops and vegetables. On medium and large scale farmers, the cropping pattern whose key crop is perennial crop is proposed. The cropping pattern puts stress on fruit trees and grapevine, and includes cereal crops, forage crops, seed and nursery production, vegetables and flowers.

Water is conveyed to the new irrigation areas basically by the gravity method. The intake level of the Maipo river is about elevation 220m due to the elevation of the

new irrigation area. A new intake weir is to be constructed around the existing intake facilities of Carmen Alto. In the plan for new intake weir, integration of the existing intake facilities is planned to simplify control of water use in the third section of the Maipo river. The existing intake facilities which are to be integrated are six; Puangue, Picano, Calmen Alto, Cholqui, Chocalan and Culiprán. Integration of Puangue and Picano is planned in the right bank and the others in the left bank.

On the newly proposed irrigation canals, distributing determined amount of water by water right to the areas where enough irrigation water is not supplied due to canal losses of the existing canals is also planned. The present irrigated farmland by groundwater in the proposed area is excluded from the new irrigation plan. Small scale reservoirs are planned to impound surplus water at small valleys where canals pass through. Regulation reserves are also planned to solve the time difference between irrigation use and conveyance of water at the diversion points.

1.2.2 Agricultural Production Plan

(1) Cropping system

The cropping system is formulated based on the present cultivation crops in the project area. According to Agricultural Census in 1997, present crop cultivation in the project area is as follows,.

Crop	Cultivation Area (ha)	Cropping Rate (%)
Cereal crops	7,363.5	24.10
Traditional Crops*	1,039.6	3.40
Processing crops**	1.7	0.00
Vegetables	3,828.1	12.60
Flowers	6.7	0.02
Forage Crops	8,821.4	28.90
Fruits	6,837.1	22.40
Grape Vines	410.7	1.30
Green House	35.9	0.10
Seeds Production	1,037.8	3.40
Forest products & Others	1,089.9	3.60
Total	30,492.4	100.00

* Traditional crops such as Beans, Lentils and Peas

** Crops sold to factories for processing such as tobaccos, sunflowers, and sugar beats

The present crop cultivation reflects the conditions of agricultural production in the project area such as landholding scale, ability for investment, farming technology, opportunities of non-agricultural business and labor forces.

On the other hand, regarding the changes of farming environment by introduction of irrigation in the project area, farmers who can invest for introducing irrigation facilities in their own farmland and business enterprise type farmers who have technology and fund to buy farmland in the project area for development of highly productive agriculture will take the advantage of irrigation benefit, because productivity of agriculture is high in the project area, and especially fruit growing has high potential. For medium and large scale farmers, changes of farming environment by introduction of irrigation develop the present cultivation system more intensive in the project area. The stories mentioned above are realistic for two kinds, medium and large scale, of farmers, while small scale farmers have limitation on landholding scale and it is not realistic for them to expand landholding scale by purchasing newly irrigated farmland. Therefore, the cultivation crops of small scale farmers proposed by introduction of irrigation should be highly realistic, based on the present farming condition. Support services for small scale farmers are indispensable for realizing this objectives.

On the selection of cultivation crops, prospects on respective crops are as follow.

1) Fruit growing

To confirm the direction of change caused by the irrigation project, the trend of agricultural development carried out by private investment at present in Popeta can give a certain indication. In case of Popeta area, fruit tree growing is carried out by using groundwater in actually abandoned unirrigated land and the land classified in Class IV, VI and VII of the Land Productivity Classification. Cultivation crops are a kind of stone fruits (peaches, nectarines, plums and apricots), avocados and grape vines. Small amount of lemons and kiwis are also cultivated. A group of small scale farmers has a plan to cultivate avocados in about 600ha farmland, and a part of it includes the project area of Popeta area. This group is to produce in individual land and grade, pack and distribute at the common facility of the organization.

2) Grape vines

Although it is not comparable with Yali and Alhué areas, private sector invests to the vineyard in Popeta area. One of the reasons for this is that cost of production is relatively high due to requirement of improving soil of Popeta area. Even so, the climate condition is the same as Alhué area and very similar to Yali. Viña Santa Rita, a distinguish vineyard in the country, made a contract with small scale farmers for purchasing products from them and this contract business will expand in the future.

3) Vegetables

Vegetables have not been important for private projects util these years. This is because management of labor intensive crop cultivation was difficult in large scale farms. The exception is green peas for frozen food. This cultivation has possibility of mechanization. However in the project area, medium scale project by private sector including vegetable cultivation is planned. This seems important for small scale farmers.

4) Seed production

As alternatives of introducing crops to the new irrigation area, seed production is worth to be raised. Produced seeds are mainly two types at least; one is F1 hybrid seeds of maize and sunflower which are produced in several hundreds hectors of relatively large farms at present. Production of F1 seeds is rational and highly profitable. The other one is F1 hybrid of vegetable seeds which are produced mainly in from 5 to 10ha small farms. Vegetable F1 hybrid seed production provides extremely good benefit per ha due to very labor intensive production with skilled hand works. The former is mainly produced in Yali area at present and the latter is produced by medium scale private project in Popeta area.

5) Forage crops

Forage crops, especially Alfalfa shares 22% of crop cultivation in Melipilla Province. The purpose of cultivation is sale to other provinces after drying and consumption by a few dairy farmers who remain in the province. Small scale farmers produce for feeding their own cattle. Actually, in Popeta area, dairy farms do not remain at all. Milk produced by small scale farmers is purchased at low price by the national milk processing factory. However, in the recent years, a milk collection center is constructed by small scale farmers and contributes to improvement of selling produced milk. Anyway, forage crops are expected to gain considerable profits when they are dried, and they are important components of normal crop rotation.

6) Cereal crops

The profit of cereal crops is the lowest among cultivation crops. However, they also consist of a part of the crop rotation system. Cereal crop cultivation is easy to be managed and very easy to be mechanized. Wheat is an important self-consuming crop for small scale farmers.

7) Traditional crops

Potato is the only important traditional crop (*Chacra*) in Popeta area where beans are almost not cultivated. Popeta area is close to the Santiago among the potato production areas and very popular in rural markets.

8) Flowers and others

Flowers and so-called green-house products are expected to become more important in the future because the location of the project area is close to Santiago and the seaside resorts. Nevertheless, there is almost no importance at present.

Based on the considerations above, crop cultivation plans are formulated for four farming types classified according to landholding scale in the project area. Among the plans, two of them are for small scale farmers and the other two are for medium and large scale farmers. Number of farmers in each landholding scale is as follows.

Average landholding area	5ha	15 ha	40ha	200ha
No. of farmers	132	40	54	8

- Cultivation plan for average landholding of 5ha (small scale farmers)

  Farming area of 5ha is the majority of small scale farmers. However, it is easy for these farmers to have problems on entrance of markets, advanced farming technology, capital investment for grapevine and fruit growing, and profitable production activities for other crop cultivation in the field of capital, technology and negotiation power. Over 60 % of their farmland is uncultivated or natural grassland at present. Cultivation plan considering such situation is shown in the table below.

Crop	Cultivation Area (ha)		Share of Cultivation Area (%)	
Cereal Crops	0.65		13.0	
Wheat		0.65		13.0
Traditional Crops	0.50		10.0	
Potatoes		0.50		10.0
Vegetables	0.80		16.0	
Pumpkins		0.20		4.0
Onions		0.20		4.0
Watermelons		0.20		4.0
Green beans		0.20		4.0
Forage Crop	0.70		14.0	
Alfalfa		0.70		14.0
Fruits	1.00		20.0	
Avocados		1.00		20.0
Subtotal	3.65		73.0	
Others	1.35		27.0	
Total	5.00		100.0	

Intensive cultivation crops for this scale farmers are planned to be vegetables and fruits, relevant to the present situation. Vegetable and fruit trees share 16% (0.8ha) and 20% (avocados 1ha) of the total cultivation area,

respectively. Traditional crop shares 10% (Potatoes 0.5ha). Vegetables which have no restriction on cultivation irrigated by surface water are pumpkins, onions, watermelons and green beans. Alfalfa which shares 14 % and cereal crops which shares 13 % will provide highly productive farmland and complete rational crop rotations (vegetables-wheat-vegetables-alfalfa-vegetables) for small scale farmers. In any cases, technical, economical and marketing supports are required for implementation of the farming plan.

- Cultivation plan for average landholding of 15ha (small scale farmers)

It is relatively easy for these scale farmers to access market's entrance and technology among small scale farmers, and they have ability to get some amount of capital for investment. The farmers belonging to this class also have possibility to obtain larger farm. However, as same as 5ha landholding farmers, they have unproductive land such as uncultivated land or natural grassland. Cultivation plan considering such situation is shown in the table below.

Crop	Cultivation Area (ha)	Share of Cultivation Area (%)
Cereal Crops	1.3	9.00
Maize	1.3	9.00
Vegetables	1.0	6.66
Pumpkins	0.2	1.33
Onions	0.3	2.00
Watermelons	0.2	1.33
Green beans	0.3	2.00
Forage Crop	1.5	10.00
Alfalfa	1.5	10.00
Fruits	4.0	26.60
Avocados	4.0	26.60
Grape Vines	3.0	20.00
Seeds	0.5	3.32
Vegetable seed	0.5	3.32
Subtotal	11.3	75.3
Others	3.7	24.7
Total	15.0	100.00

As intensive cultivation, fruit trees growing is planned to share 4ha. Grapevine for wine is planned 3ha, according to the idea of selecting suitable varieties for wine and selling to wineries for final processing. The share of vegetables has been reduced, compared with fruits and grapevines. Yet, in the cultivated area, the area for vegetable seed production increases by 3.3 % and the share of intensive cultivation crop will be 49.9 %. Cereal crops and alfalfa are planned 9 % and 10 %, respectively.

- Cultivation plan for average landholding of 40ha (medium scale farmers)

This scale farmers represent the farmers who undertake medium scale and modernized farming in the area. They are easily access to markets and technology. They have restraints but can obtain capital enough for investment. Among medium scale farmers, about 10 % of cultivated land is used for natural grassland. Cultivation plan is shown in the table below.

Crop	Cultivation Area (ha)	Share of Cultivation Area (%)
Cereal Crops	5.0	12.50
Wheat	1.6	4.00
Maize	3.4	8.50

to be continued

Crop	Cultivation Area (ha)	Share of Cultivation Area (%)
Vegetables	1.6	4.00
Pumpkins	1.6	4.00
Flower	1.2	3.00
Forage Crop	6.0	15.0
Alfalfa	6.0	15.0
Fruits	14.4	36.00
Avocados	4.0	10.00
Table Vines	3.2	4.00
Peaches	5.6	14.00
Cherry	1.6	4.00
Grape Vines	5.0	12.50
Seeds	3.2	8.00
Vegetable seed	0.8	2.00
Maize	2.4	6.00
Subtotal	36.4	91.00
Others	3.6	9.00
Total	40.0	100.00

Regarding intensive cultivation crops, 14.4ha of fruit trees and 5ha of grapevine for wine are planned to be cultivated. Major fruits planted at present are kinds of stone fruits (peaches, plums, and yellow peaches), avocados and table vines. Each farmer concentrates on the different crop cultivation. Grapevine for wine is sold to winery or larger farms after harvest. On the other intensive cultivation crops, the share of vegetables, flowers, and vegetable and F1 hybrid maize seed production plan to be 4%, 3%, and 8% of the cultivated area, respectively. Flower cultivation and seed production are very suitable for medium scale farmers who have high technology. Intensive crop cultivation shares 71% of total cultivated area.

- Cultivation plan for average landholding of 200ha (large scale farmers)

Average farmers who hold 200ha represent either large scale and highly modernized farmers or farms owned by private enterprises. They hold a favorable position in relevant markets, high technology and management ability. They also have appropriate capacity for investment, and their farming is flexible on such determination of effective management scale. The reason for the selection of this holding area is that more than 200ha landholders as a large scale farmers are rare, and they contribution to the area on agricultural processing products and finance. About 10% of the cultivated land is used for unproductive purposes. Cultivation plan is as follows.

Crop	Cultivation Area (ha)	Share of Cultivation Area (%)
Cereal Crops	27.0	13.50
Maize	27.0	13.50
Vegetables	23.0	11.50
Melons	12.0	6.00
Green Beans	11.0	5.50
Forage Crop	20.0	10.00
Alfalfa	20.0	10.00
Fruits	72.0	36.00
Avocados	20.0	10.00
Table Vines	32.0	16.00
Peaches	20.0	10.00
Grape Vines	24.0	12.00
Seeds	12.0	6.00
Maize	12.0	6.00
Crop	Cultivation Area (ha)	Share of Cultivation Area (%)
Subtotal	178.0	89.00
Others	22.0	11.00
Total	200.0	100.00

The shares of fruit growing and grapevine are 36% and 12% of total cultivated land, respectively. On vegetables, the planning shares of each vegetables are as follows; green beans which are cultivated under the contract with a frozen food factory is 6%, melons which are easy to be managed due to large scale cultivation is 6 %, and seed production of F1 maize or sunflower is 6%. Intensive cultivation shares 65.5 % of the total cultivated area. Cultivation of cereals and forage crops are planned 23.5 % of the cropping pattern.

(2) Farm income

Gross income brought about the crop cultivation plans for each management scale is shown in the table below.

Small Scale Farmer(Average farming Area 5 ha)

Crops	Cultivation Area (ha)	Farm Income ($000)
Wheat	0.65	162.5
Potatoes	0.50	500.0
Pumpkins	0.20	240.0
Onions	0.20	260.0
Watermelons	0.20	280.0
Green Beans	0.20	180.0
Alfalfa	0.70	315.0
Avocados	1.00	1,000.0
Pasture	1.35	135.0
Total	5.00	3,072.5

Small Scale Farmer(Average farming Area 15 ha)

Crops	Cultivation Area (ha)	Farm Income ($000)
Maize	1.3	390
Pumpkins	0.2	240
Melons	0.3	480
Peas	0.2	300
Alfalfa	1.5	300
Avocados	4.0	750
Grapevine (Wine)	3.0	4,000
Seed Production	0.5	3,000
Pasture	3.7	370
Total	15.0	10,830

Medium Scale Farmer(Average farming Area 40 ha)

Crops	Cultivation Area (ha)	Farm Income ($000)
Wheat	1.6	480
Maize	3.4	1,360
Pumpkins	1.6	2,240
Flowers	1.2	3,600
Alfalfa	6.0	5,200
Avocados	4.0	3,520
Grapevine (Table)	3.2	11,200
Peaches	5.6	8,500
Grapevine (Wine)	5.0	2,400
Seed	0.8	1,920
Seed (Maize)	2.4	360
Pasture	3.6	42,060
Total	40.0	

Large Scale Farmer(Average farming Area 200 ha)

Crops	Cultivation Area (ha)	Farm Income ($000)
Maize	27	12,150
Melons	12	19,200
Peas	11	11,000
Alfalfa	20	12,000
Avocados	20	26,000
Grapevine (Table)	32	35,200
Peaches	20	40,000
Grapevine (Wine)	24	40,800
Seed (Maize)	12	9,600
Pasture	22	2,200
Total	200	184,150

1.2.3 Farmers' Organizations and Agricultural Support Plan

In order to promote socio-economic independence of regional agriculture, establishing organizations of farmers who are beneficiaries is indispensable. Through uniting the power of inhabitants in the area, irrigation facilities are to be constructed and improved. This leads to diversification of agricultural products and improvement of productivity. Then, the base for regional agricultural development is established. Accordingly, organizations of beneficiaries who are recipients of the Project are required to be improved in the study area for proceeding to implement projects, and utilization and promotion of effective use of improved facilities. A consensus should be obtained for improving the present situation by inhabitant's participation.

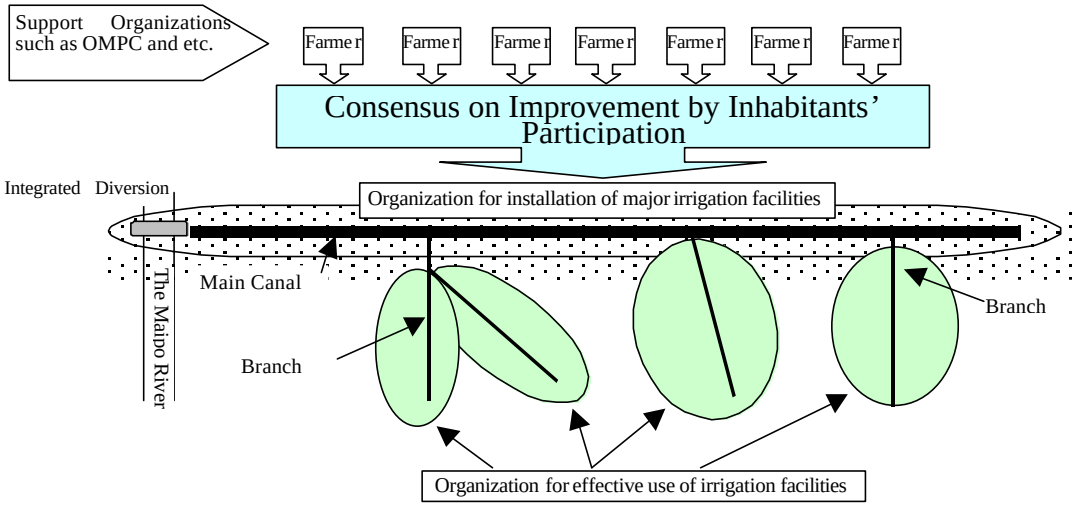
Based on the consensus for improvement of the present condition, following two systems as beneficiaries required to be established.

- Organization for installation of major irrigation facilities (according to the

Irrigation Promotion Law No. 18450)

- Organization for effective use of irrigation facilities (according to agricultural development by INDAP services and etc.)

A flow chart of the promotion system is described in the following figure.



(1) Setting of mutual consensus

The beneficiaries of the project in the study area are mostly small scale farmers according to the structure of regional society. Participation of inhabitants as democratic procedure is indispensable at every stage of the plan because the project plan directly connects with the interest of farmers. Participation of inhabitants is to be implemented in accordance with the purpose of each stage by following activities such as a conference with experts (INIA, universities, private consultants and so on), discussion among representatives of farmers, and a workshop among farmers and experts. Participation of inhabitants in these activities leads to deepening farmers' understanding against the project and promoting establishment of identity as the regional inhabitants. Moreover, this also creates derived effects such as growing regional leaders and providing accurate information for farmers.

In case of Popeta area, the present situation is to be improved through obtaining stable irrigation water and development of new irrigation farmland. Therefore, construction of the integrated diversion weir and main irrigation canals are set up as the main projects. Accordingly, mutual consensus on the project of farmers are indispensable to promote these projects. The process on setting of mutual consensus is proceeded as follows;

1) Motivating: regarded the necessity of the plan, the project system, right and duty of beneficiaries based on the present situation

2) Problem finding: finding the problems to be changed, setting the purpose of the plan, and then clarifying the problems to be struggled for solving the problems

3) Analysis of plan: analysis and appraisal of the project including alternatives to solve the problem or achieve the purpose

4) Determination of plan: based on the comparative analysis of the

alternatives, corresponding with the projects which are not main such as water use plan at the terminal, water management plan, and farming plan, determining the final plan, and then, setting of mutual consensus of beneficiaries on the project

In the procedure on setting of mutual consensus of the beneficiaries, the most important part is the first part, "motivating." Because this part has been lacking in the agricultural support plan so far, sufficient consensus has not been formed and the plan has broken down.

The agricultural support plan in the project strengthens this part. OMPC is regarded as the go-between organization between beneficiaries and the project plan. Based on the cooperation of external supporters (INIA, universities, private consultants and so on) employed by OMPC, the workshop for "motivating" will be held through JJVV and UV.

After 2) of the procedure on setting of mutual consensus, beneficiaries and external supporters mainly implement. Consulting fee is supported by OMPC and about 10% of it is paid by the beneficiaries. The burden of the beneficiaries is clarified at the stage of "Motivating."

Based on the procedure on setting of mutual consensus mentioned above, organization for installation of major irrigation facilities and the organization for effective use of irrigation facilities are to be established.

(2) Organization for installation of major irrigation facilities

Acquisition of the new water right, construction of integrated diversion weirs and new irrigation canals are planned in the Popeta area. In the third section of the Maipo river, nine canal associations which belong to Sector Sur de Melipilla are established at present. Therefore, Association of United Canals (Asoc. UCM3: Asoc. Unidad Cnalista Maipo 3ra Sección) which established by existing canal associations and canal association relevant to new irrigation canals (Canal PYA: Canal Popeta-Yali-Alhué) is required to be established for construction of an integrated weir. Asoc. Canalista PYA is established with new irrigation canals. This is the organization for proceeding to implement the projects such as distribution of the new water right.

Based on the Irrigation Promotion Law, financial support for the main facility is to be received from MOP-DOH. Asoc. UCM3 is to be the receiver of financial support service as the organization of beneficiaries.

Area	Related Project	New Organization	Implementation Body
Popeta	New Integrated Diversion Weir	Asoc. UCM3	Asoc. UCM3
	New Irrigation Main Canal	Asoc. PYA Canal association	Asoc. PYA Canal association
	Intake & Distribution of New Water right	Asoc. PYA Canal association	Asoc. PYA Canal association

(3) Organization for effective use of irrigation facilities

Construction of branch canals is necessary for irrigating in the project area by using irrigation water distributed from the main canal. Regarding financial support required for construction of branch canals, the service systems of the Irrigation Promotion Law (The Law No. 18450) and INDAP will be utilized. A recipient organization of the project is formulated by organizing canal association of terminal beneficiaries. A part of work, which can be handled by existing canal associations and irrigation organizations, is coped with by expanding the function of the association. When a new canal association or a new irrigation organization is required to be

established, application for organization is prepared by the arrangement of OMPC.

Regarding technical and financial supports against producers' groups for management of irrigation water at field level and for improving farming, INDAP service systems are to be utilized. An advisor is to be employed to promote grouping producers through arrangement of OMPC

On the promotion of the project implementation, SAL, SAP, or SAE is to be utilized according to the level of organization.

In the area introducing new irrigation facilities, although entering the existing producers' organizations should be considered, large technical gap among them can be predicted. Thus, a new organization is to be established.

Existing producers' organizations and producers' organization which can be newly established are as follows.

Organization	Name of Organization
Existing Producers' Organizations	Canal association Milk Collecting Cooperatives Potato Production Organization Flower Production Organization
New Producers' Organizations	Canal association Citrus Organization Grape Organization Avocado Organization Horticulture Organization Cereals Organization Multiple Production Organization Production Organization for Rural Women

(4) Installation of base facility for agricultural support

Many of UV in Popeta area do not have base facilities for meeting and training courses. Thus, it is impossible to communicate smoothly among inhabitants, and this leads to difficult environment for establishing fundamental organizations aiming at improvement of present agricultural situation. Thus, it is indispensable to construct the activity base facilities for vitalization of UV activities and smooth communication among regional inhabitants. This base facility is named Communication Center for UV (CECUV) and is constructed in each UV. Based on these facilities, beside promoting the activities for unity by small scale farmers, promotion of regional self-government, improvement of living environment, training and lectures on living and producing skills, and training of rural women for self-independence will be taken place. Through these activities, self-independence of UV will be promoted.

Functions of CECUV are promotion of communication, of support activities for farmers, and of independence of rural farmers. The details are as follows;

- Promotion of regional communication
    1) Improvement of rural living environment
    2) Activating communication among regional inhabitants
    3) Operate and maintenance of regional social infrastructure
    4) Participation of inhabitants in the plan for living environment improvement
    5) Providing the place for medical and health service
    6) Promotion of cultural activities for regional inhabitants and young generation
    7) Cooperation with OMPC

- Promotion of support activities for farmers
    1) Extension and enlightenment about agricultural and livestock farming's technology
    2) Extension and enlightenment about irrigation technology
    3) Promotion of uniting activities by small scale producers
    4) Providing the place for a training course of farming improvement
    5) Enlightenment about self-independence and promotion of rural women
    6) Providing an office for a producers' organization
    7) Interchange with producers' organizations in the other areas and exchange of information

Among agricultural support activities, promotion of uniting, enlightenment about and technical guidance of agricultural support activities are undertaken by advisors organized by OMPC through cooperation with external support organizations (INIA, universities, private consultants and NGOs). These advisors make their rounds and give guidance in each CECUV, *Communa*. The contents of uniting promotion, enlightenment and technical guidance provided by OMPC are summarized as follow.

Agricultural Production	Economic Activity and Management	Living Improvement
- Guidance for organization	- Guidance of farm management	- Guidance & training on house works
- Guidance of cropping	- Guidance of income generation	- Guidance of health control
- Guidance on subject of crops	- Guidance of group activity	- Guidance of group activity
- Guidance of irrigation	- Guidance on example of advanced area	
- Guidance of fertilization	- Guidance of business and finance	
- Guidance of marketing	- Guidance of merchandize	

Facilities of CECUV are as follows.

Facility	Size (m^2)
Training room	48.6
Meeting room	48.6
Administration office	12.2
Producers' group office	72.9
Store	12.2
Toilet	12.2
Total	206.7

Because Popeta UV in Popeta area has already had the Resident Center, agricultural support and living improvement is to be facilitated by using this center. Therefore, CECUVs which should be constructed are presented in the table below. Planned design of CECUV is shown in the Figure 1.2.1.

UV	Population	Household	CECUV
Chocalán	687	177	1
Carmen Bajo	1,125	285	1
Carmen Alto	849	217	1
Cholqui	1,211	344	1
El Pabellon	915	240	1
Culiprán	1,736	413	1
Popeta	1,309	321	-
Los Guindos	615	107	1

1.2.4 Agricultural Infrastructure Development Plan

(1) Area of new irrigation

A new irrigation development area in Popeta is a part of "Popeta-Yali-Alhué agricultural development plan" in the "Agricultural development plan with effective use of water resources" by unused water right (25m^3/sec) of the Maipo river proposed in the Master Plan. The diversion weir and the main canal are planned to use commonly considering a water source of three areas and the location of the irrigation area. Accordingly, the feasibility study will cover an agricultural development plan in Popeta area, determination of irrigation area and its water requirement in Yali and Alhué, and main and secondary canals.

The upper limit of the new irrigation area in Popeta-Yali-Alhué is a skirt of the mountain which the main canal passes through. As sum of irrigable land (except the areas where hold organized irrigation areas at present) in respective area is calculated, gross and net areas are 23,400ha and 21,100ha, respectively. The details are shown in the table below. Although irrigated farmlands by using groundwater are scattered in the proposed new irrigation area, the area which clarified by the data for groundwater use survey is subtracted from the proposed new irrigation area. The net irrigation area was adjusted by 10% of reduction rate to the gross area in order to subtract the area for canals and roads, and etc.

	Area		Gross Irrigation Area (ha)	Net Irrigation Area (ha)	Remark groundwater irrigation Area (ha)
1	Popeta	Carmen	540	486	60
		Choluqui	535	481	420
		Popeta	4,454	4,008	544
		Sub-Total	5,529	4,975	1,024
2	Yali		10,905	9,815	1,850
3	Alhue		6,993	6,294	758
		Total	23,427	21,084	3,632

(2) Plan for intake and conveyance of irrigation water

1) Intake weir

a) Location

There are five existing intake weirs in the left bank and three in the right bank in the upstream basin of the third section of the Maipo river. These intake facilities are functioned to supply water to Choluqui, Carmen Alto, Culiprán and Popeta areas in the left bank, and to Melipilla area in the right bank. The reconciliation organization regarding the water utilization, *Junta de Vigilancia* is not established in this section, and water utilization of the Maipo river is managed by each intake unit. Because improvement level of each intake facilities is low, headraces and intake facilities are damaged by every flood. Therefore, stable intake of water has not been achieved.

Although proposed plan of the project purposes to supply water to the new irrigation areas after taking water from the Maipo river, existing intake structures that elevation of intake could maintain and the existing canals can utilize are to be integrated with a new intake weir, because proposed weirs construct next to existing intake facilities. The results of the existing facility survey are shown in the table below.

Site	Amount of water right (m^3/sec)	Present water (m^3/sec)	Irrigation area (ha)	Canal length (km)	Action (unit)	Member (person)	Annual O/M cost (mil. Pesos)
Left Bank							
Calmen Alto	8.0	3.5	1,200	36.0	100	78	60.1
Cholqui	2.0	-	2,000*	28.0	74	-	30.0
Chocalan	5.0	2.7	2,350	9.8	1,562	-	31.3
Culiprán	5.0	3.0	1,800*	35.9	-	-	-
Codgua	4.8	2.7	-	20.0	-	-	-
Right Bank							
San Jose	5.7	3.7	-	35.0	-	-	-
Puangue	3.6	2.9	-	38.0	-	-	-
Picano	8.7	4.0	3,000	30.0	150	-	17.5

(Area of * mark is estimated from the map of 1/10,000)

As the site for the proposed integrated diversion weir, the upstream reach of the third section on the Maipo river is selected relevant to geographic condition and intake level because the main canal is planned as a canal for supplying water to three areas, Popeta–Yali–Alhué. An elevation of intake level should be maintained at more than EL 220.00m for gravity irrigation, considering the elevation of proposed irrigation area, prolongation of canal length, and canal bad gradient. The elevation of the irrigation areas is presented in the table below.

	Irrigation Area	Altitude of Irrigation Area EL (m)	Altitude of Canal EL (m)	Distance from Weir (km)
1	Popeta	220-120	220	5-59
2	Yali	200-130	200	62-73
3	Alhué	180-130	185	77

Selecting the suitable sites for constructing the weir within the area ranging between the confluence of the Maipo river and the Mapocho and the downstream 8km, they are around the Canal Calmen Alto intake in the downstream 5km and around the downstream 7km. However, the selection sites are limited from the confluence up to 5.5km downstream because a riverbed elevation is EL 205m between the confluence point and around the downstream 7km due to the intake level. Therefore, the sites are selected at the highest point as much as possible within the area ranging from EL 240m at around the confluence to EL 215m at the downstream 5.5km (C axis).

Concerning the river flow condition in the area, the river divided into several major water flows after confluence of the Mapocho river and the Maipo river, and then the major water flows discharge along with the left bank at the downstream 5km of the confluence. The tendency that the major water flows discharge along with the left bank has not changed, although the location of the water flows had been changed by flood, according to the aerial photographs of 1979 and 1992, these mapped materials, and finding by field survey. The river width is 1.9km (A axis) at the downstream 2.4km around the confluence, however the water flows are divided into several ways and changed their locations with every flood. The flows bend to the left bank and gather at the overhung hillside of Loma la toma at the Canal Calmen Alto intake point (B axis). Accordingly, the intake point of Canal Calmen Alto is desirable for the new weir site, considering stable water distribution and maintenance of the weir. The river flow condition at three points described above is summarized in the table below and location map on comparison of weir axis is shown in figure 1.2.2.

Weir site	River width (m)	Riverbed EL (m)	River flow condition			Stability of river
			Water route	Width of water route	Position of water route	
A axis	1,900	235	3	100-150	Center	Unstable
B axis	1,800	222	1	150	Left Bank	Stable
C axis	1,700	215	1	100	Left Bank	Stable

Results of reviewing three sites on river conditions on intake level of weirs and stable distribution: 1) A axis; the downstream 2.5km from the confluence of the Maipo river and the Mapocho river, 2) B axis; Bocatoma Carmen Alto and 3) C axis; downstream 500m of Bocatoma Carmen Alto are;

- Stable intake is possible because a major water flow approaches to the mountainside of the left bank by a spur of Loma la toma
- Foundation of intake structure reaches to bedrock in the left bank and durable foundation works can be constructed
- Intake level of more than EL 220m which is the essential condition for irrigation, can be secured

Considering the advantages above, B axis; Bocatoma Carmen Alto, whose construction cost is lower than the other alternatives is selected for the site of the integrated weir. The intake level of this point will maintain the elevation of 223.00m.

b) Present situation of river flow

Integrated diversion weir to be constructed in the Maipo river-course as the intake facilities of Popeta-Yali-Alhué irrigation system is planned at 6 km downstream from the confluence of the Mapocho and the Maipo rivers. There are no discharge measurement stations which continue observation on the Maipo river-course around the proposed sites of the integrated diversion facilities in the Maipo river. However, discharge observation had been made at Chiñihue located near the proposed weir site from October, 1964 to January, 1977. Those observed records can be utilized.

As the long term discharge measurement points in the Maipo river, Manzano and Obra are located in the upper stream of the proposed site, and Cabimbao is located in the lower stream of the proposed site. Based on the prescribed discharge data available and basin characteristics on each discharge measurement point, available water for the Popeta area at the site of integrated diversion weir estimates using the regression equation constructed by the correlation with the Cabimbao discharge data.

Monthly average discharge data at Cabimbao observatory are available for the duration of 57 years from 1941 to 1997. Regression equation at Chiñihue can be constructed as $y = 1.3969 \times^{0.8633}$ (y: Chiñihue, x: Cabimbao) on the basis of discharge data at Chiñihue and the discharge data on same period at Cabimbao observatory.

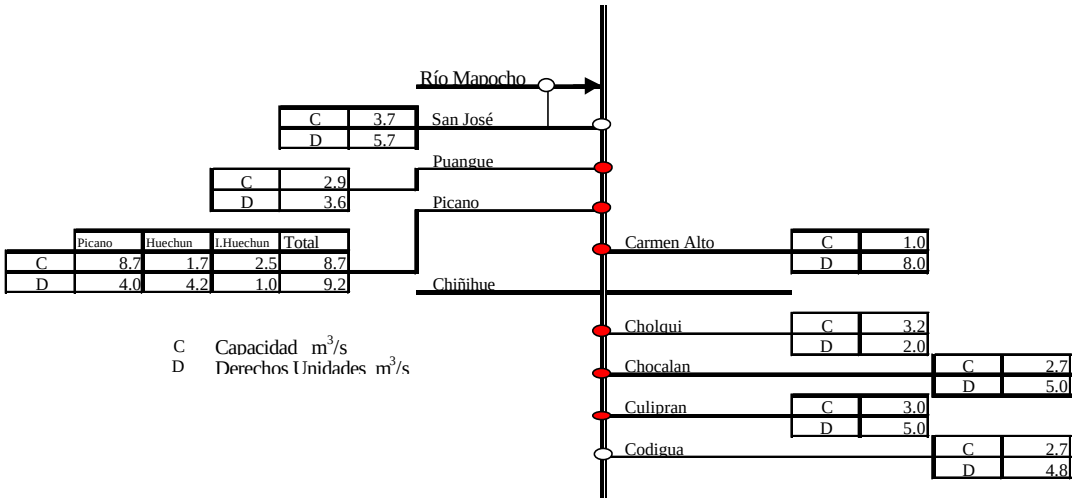
Discharge on average monthly and 85% exceedance probability at Cabimbao observatory and the proposed site of integrated diversion weir (Chiñihue) are as follows;

Item	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cabimbao														
Average	m^3/s	112.2	76.1	62.6	72.6	107.6	151.1	193.1	181.4	115.0	77.4	100.7	130.1	
	MCM	300.39	184.00	167.73	188.08	288.09	391.77	517.25	485.73	298.14	207.4	261.09	348.38	3638.1
85%	m^3/s	25.94	15.70	22.07	39.15	62.78	76.46	95.65	83.04	47.42	27.13	35.81	38.38	
	MCM	69.48	37.98	59.11	101.48	168.15	198.18	256.19	222.41	122.91	72.66	92.82	102.80	1504.2
Chiñihue														
Average	m^3/s	117.7	74.8	47.3	45.8	70.0	101.7	131.4	118.2	54.2	42.6	90.9	132.8	
	MCM	315.11	181.36	126.65	118.61	187.55	263.63	352.06	316.58	142.36	114.14	235.47	355.68	2709.2
85%	m^3/s	31.83	18.29	18.31	22.98	43.28	49.47	66.99	54.04	33.51	25.28	33.42	35.25	
	MCM	85.25	44.25	49.04	59.56	115.92	128.23	179.43	144.74	86.86	67.71	86.62	94.41	1142.0

Eventual discharge (surplus discharge with 85% exceedance probability over 85% exceedance probable runoff) at Chiñihue is as follows;

Item	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Chiñihue	(Eventual discharge)													
Average	m^3/s	86.70	57.45	29.46	23.21	27.71	53.32	65.70	65.38	22.37	18.12	59.55	98.64	
	MCM	232.20	138.97	78.92	60.16	74.22	138.19	175.97	175.11	57.98	48.55	154.35	264.19	1598.8
85%	m^3/s	5.00	1.76	0.92	1.92	0.90	3.34	3.61	3.63	1.06	1.73	3.15	4.34	
	MCM	13.39	4.26	2.46	4.98	2.41	8.66	9.67	9.72	2.75	4.63	8.16	11.62	82.7

On the other hand, distribution of the existing intake facilities near the proposed site of integrated diversion weir (Chiñihue) for irrigation purpose can be summarized as follows. In the figures, C means maximum capacity of existing canals and D is the discharge on registered water rights.



When the integrated diversion weir is planned at Chiñihue, 6 existing intake facilities of irrigation system, Puangue, Picano, Calmen Alto, Cholqui, Chocalan and Culiprán, can be considered as the target intake facilities for unification taking the connection to the existing canals after water taking from the diversion weir into account. Puangue and Picano locate in the right bank and others are in the left bank of the proposed headwork.

Distribution of the available water at the integrated diversion weir will be made by the water right registered. When river runoff is lower than the discharge of 85% exceedance probability, river runoff will be distributed by the ratio of water right registered among the users. Following distribution ratio is employed to settle the available intake water volume for Popeta-Yali-Alhué irrigation system on 85% exceedance probable discharge condition. (Intake facilities of San José, Puangue, Picano and Calmen Alto irrigation systems are located in the upstream reach of proposed integrated diversion weir. Because discharge at Chiñihue expressed after deductions for intake water of those irrigation systems, distribution ratio at the proposed integrated diversion weir will be constructed by the balance of discharge between the water rights and existing canal capacity.)

Unit : m^3/s

Item	San José	Puangue	Picano	Calmen Alto	Cholqui	Chocalan	Culiprán	Codigua	(Total)	P-Y-A	Total
Existing Canal Capacity	3.7	2.9	8.7	1.0	3.2	2.7	3.0	2.7	27.9	-	-
Discharge on Water Right	5.7	3.6	9.2	8.0	2.0	5.0	5.0	4.8	43.3	25.0	68.3
Discharge for Distribution	2.0	0.7	0.5	7.0	2.0	5.0	5.0	4.8	27.0	25.0	52.0
Distribution Ratio	0.03846	0.01346	0.00962	0.13462	0.03846	0.09615	0.09615	0.09231	0.51923	0.48077	1.00000

With those 85% exceedance probable condition on permanent and eventual discharge, and distribution ratio for each irrigation system, available irrigation water for Popeta-Yali-Alhué irrigation system on 85% exceedance probable discharge condition

can be estimate as follows;

Item	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Popeta-Yali-Alhué Irrigation System (85% exceedance probability)														
Permanent	m^3/s	15.30	8.79	8.80	11.05	20.81	23.78	25.00	25.00	16.11	12.15	16.07	16.95	
Eventual	m^3/s	2.40	0.85	0.44	0.92	0.43	1.22	0.00	0.00	0.51	0.83	1.51	2.09	
Total	m^3/s	17.70	9.64	9.25	11.97	21.24	25.00	25.00	25.00	16.62	12.99	17.58	19.03	
	MCM	47.43	23.32	24.76	31.03	56.89	64.81	66.96	66.96	43.08	34.78	45.57	50.98	556.57

As described in the previous chapter regarding the available water for the Popeta-Yali-Alhué irrigation system, in the estimation of flood discharge within the Popeta area, data of Cabimbao observatory are used for estimation of flood discharge taking into account the discharge data available and basin characteristic of discharge observatories. Secure flood discharge for the structural design will be employed with the comparative study on discharge amount both basin ratio and regression equation

Data on maximum annual daily discharge at Cabimbao observatory are available for the duration of 57 years from 1941 to 1997. Regression equation at Chiñihue can be constructed as $y = 1.3969 \times^{0.8633}$ (y: Chiñihue, x: Cabimbao) on the basis of discharge data at Chiñihue and the discharge data on same period at Cabimbao observatory. Exceedance probable flood discharge at Cabimbao observatory and flood discharge estimated by the basin ratio and the regression equation at the proposed site of integrated diversion weir (Chiñihue) are as follows;

Exceedance probability		Flood discharge Q : m^3/sec		
		Cabimbao	Proposed site of integrated diversion weir	
Year	%	A = 15,040 km^2	A = 12,043 km^2	Caimbao-Chiñihue
			Basin Ratio	Regression Equation
200	0.5	7,843.2	6,280.3	3,215.7
100	1	6,027.5	4,826.4	2,561.9
50	2	4,524.8	3,623.1	2,000.1
20	5	2,954.6	2,365.8	1,384.3
10	10	2,032.4	1,627.4	1,002.2
6.7	15	1,581.6	1,266.4	807.1
5	20	1,302.9	1,043.3	682.8

c) Integration of intake facilities

Four sites in the left bank and two sites in the right bank are planned to be integrated. The quantity of water intake is $45m^3/sec$ in the right bank and $12.8m^3/sec$ in the right bank. The detail is shown in the table below;

Left Bank Intakes		Discharge (m^3/sec)	Right Bank Intakes		Discharge (m^3/sec)
New Irrigation Area Intake		25.0	New Irrigation Area Intake		-
Existing Intakes	Calmen	8.0	Existing Intakes	Picano	3.6
	Alto				
	Cholqui	2.0		Puange	9.2
	Chocalan	5.0			
	Culiprán	5.0			
Total		45.0			12.8

2) Conveyance system of irrigation water

The discharge of the main canal from the intake weirs is $45m^3/sec$ until the first diversion facility and $7.5m^3/sec$ at the diversion of Alhué. Because both of discharge scale are large, the conveyance system of the main canal is planned to be the gravity system considering convenience and economy of operation and maintenance. Basically the gravity conveyance applies also to the secondary canal, however the higher area where large irrigable land is located is supplied irrigation water by pumping. The area which needs water supply by pumping from the secondary canal is about

2,419ha in the proposed new irrigation area. The details are shown in the table below. In the planning of the proposed new irrigation canals, rehabilitation of existing canals are also planned to the areas where insufficient irrigation water supply is being made due to losses of existing irrigation canals.

Irrigation Area	Irrigation Area by Gravity Conveyance (ha)	Irrigation Area required Pumping-up (ha)	Total Irrigation Area (ha)
Popeta	4,975	-	4,975
Yali	8,309	1,506	9,815
Alhué	5,381	913	6,294
Total	18,665	2,419	21,084

(3) Diversion points and irrigation diagram

1) New irrigation areas

Sixteen diversion facilities to new irrigation areas and five to existing irrigation areas are to be constructed in the main canal starting from the diversion weir. The irrigation diagram consisted of these irrigation facilities in the new irrigation areas is shown in Fig. 1.2.3. Irrigation area and diversion amount at each diversion point from the main canal are shown in the table below. The diversion amount represents one at the maximum intake amount of 25m^3/sec at the intake weirs.

Irrigation Area		Diversion Point No.	Irrigation Area (ha)	Diversion Amount (m^3/sec)		
				Existing	New	Total
Popeta	Carmen	1	-	7.6	-	7.6
	Carmen	2	194	6.4	0.2	6.6
	Carmen	3	292	-	0.3	0.3
	Choluqui	4	316	0.2	0.4	0.6
	Choluqui	5	165	4.3	0.2	4.5
	Culiprán	6	257	1.5	0.3	1.8
	Popeta	7	1188	-	1.5	1.5
	Popeta	8	155	-	0.2	0.2
	Popeta	9	187	-	0.2	0.2
	Popeta	10	625	-	0.7	0.7
	Popeta	11	254	-	0.3	0.3
	Popeta	12	1,342	-	1.6	1.6
Yali		13	4,157	-	4.9	4.9
		14	629	-	0.7	0.7
		15	100	-	0.1	0.1
		16	4,929	-	5.8	5.8
Alhué		17	4.657	-	5.1	5.1
		18	1,637	-	2.4	2.4
Total			21,084	20.0	25.0	45.0

(Location of diversion No. is shown in Figure 1.2.4)

2) Existing irrigation areas

On water distribution to existing canals by integration of diversion weirs, water is divided after intake at Picano and Puangue respectively in the right bank, and then, directly discharges into the existing irrigation canals. On four canals located in the left bank, water is conveyed to each irrigation areas after taken at the weirs and detouring behind of the mountain at present. Yet, intaked water will pass through the mountain by tunnel and be raced to the upstream of *Estero* Carmen Alto after intake at the proposed integrated diversion weir, then conveyed to Yali and Alhué via Cholqui, Culiprán and Popeta. Water distribution to existing irrigation areas is basically divided at intake points and connect to existing canals, however, water will be distributed from new canals to the area where new canals pass through and water can be divided. On

diversion amount, the amount determined by water right to the area of the diversion facilities is to be distributed.

Existing Canal	Planned Diversion Point	Planned Discharge (m^3/sec)	Irrigation Area (ha) to new Diversion Point	Water right m^3/sec)
Puangue	Diversion Weir	3.6	-	3.6
Picano	Diversion Weir	9.2	-	11.6
Carmen Alto	Diversion Weir (No.1)	1.7	-	8.0
	Main Canal Diversion Point No.2	6.3	355.5	
Cholqui	Diversion Weir (No.1)	0.6	-	2.0
	Main Canal Diversion Point No.3	0.2	84.5	
	Main Canal Diversion Point No.4	1.2	392.9	
Chocalan	Diversion Weir (No.1)	5.0	-	5.0
Culiprán	Diversion Weir (No.1)	0.3	-	5.0
	Main Canal Diversion Point No.5	3.2	1,314.9	
	Main Canal Diversion Point No.5	1.5	635.0	

(4) Available water for irrigation and water requirement

As formulating the irrigation plan for Popeta area where is a new irrigation area, required amount of irrigation for the Popeta-Yali-Alhué irrigation system corresponds to 85% probability of exceedance on both intake amount and precipitation in hydraulic condition. According to the discharge of water at 85% probability of exceedance at the weir point, available water amount for the Popeta-Yali-Alhué irrigation system and precipitation at 85% probability of exceedance in the area are presented in the table below.

Type	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Popeta-Yali-Alhué Irrigation System (85% probability of exceedance)														
Permanent	m^3/s	15.30	8.79	8.80	11.05	20.81	23.78	25.00	25.00	16.11	12.15	16.07	16.95	-
Eventual	m^3/s	2.40	0.85	0.44	0.92	0.43	1.22	0.00	0.00	0.51	0.83	1.51	2.09	-
Total	m^3/s	17.70	9.64	9.25	11.97	21.24	25.00	25.00	25.00	16.62	12.99	17.58	19.03	-
	MCM	47.43	23.32	24.76	31.03	56.89	64.81	66.96	66.96	43.08	34.78	45.57	50.98	556.57
Precipitation		0.1	0.1	1.6	9.4	40.4	50.3	57.0	30.6	13.5	5.8	3.2	0.7	212.70

Based on the cultivation plan by farming scale proposed in the agricultural production plan, unit water requirement is calculated. Preconditions of calculation are as follows;

Effective Rainfall : according to USDA, SCS method
Irrigation Efficiency : Field - Furrow Irrigation 50%, California Type 60%, Drip Irrigation 90%, Canal - 80%

Summary of unit water requirement by farm scale at the integrated weir point which is calculated based on the conditions mentioned above, is as follows. Details of the water requirement calculation (field level) is shown in Table 1.2.1.

Type	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
5 ha	mm	91.51	66.56	47.72	29.80	2.37	0.00	0.00	23.69	83.77	150.32	170.81	146.77	813.32
10 ha	mm	126.18	90.71	65.03	40.47	3.19	0.00	0.00	20.46	74.83	139.29	169.02	157.16	886.34
15 ha	mm	161.67	116.90	75.12	40.95	2.03	0.00	0.00	7.92	44.31	96.48	146.05	170.55	861.96
50 ha	mm	145.23	107.14	71.46	39.77	1.91	0.00	0.00	10.49	65.76	138.70	192.03	195.93	968.43
100 ha	mm	160.66	123.30	82.99	46.57	2.26	0.00	0.00	11.94	66.68	133.95	185.65	193.48	1007.47
200 ha	mm	163.73	128.49	85.45	47.75	2.37	0.00	0.00	9.70	58.70	117.19	167.47	184.22	965.09

Irrigable area calculated from the available water amount at the integrated weir

and the unit water requirement are presented in the table below.

Type	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
5 ha	ha	51,836	35,039	51,923	104,101	100,000<	100,000<	100,000<	100,000<	51,425	23,145	26,678	34,727
10 ha	ha	37,592	25,710	38,098	76,663	100,000<	100,000<	100,000<	100,000<	57,566	24,978	26,961	32,432
15 ha	ha	29,341	19,949	32,983	75,760	100,000<	100,000<	100,000<	100,000<	97,229	36,062	31,201	29,886
50 ha	ha	32,661	21,768	34,668	78,006	100,000<	100,000<	100,000<	100,000<	65,512	25,084	23,730	26,014
100 ha	ha	29,525	18,915	29,854	66,621	100,000<	100,000<	100,000<	100,000<	64,609	25,974	24,544	26,344
200 ha	ha	28,971	18,150	28,993	64,976	100,000<	100,000<	100,000<	100,000<	73,391	29,688	27,209	27,667

According to the table above, irrigable area would be less than the proposed irrigation area, 21,084ha in February if farming scale is over 15ha in the cropping plan. In case that irrigable area is the smallest, deficit of water amount is calculated as follows.

$$\{(21,084 – 18,150) \times (142.27/1,000) \times 10,000\}/1,000,000 = 4.17 \text{ MCM}$$

This deficit amount planned to be adjusted by impounding water in the regulation reservoir constructed in the main canal.

(5) Supplemental water supply by regulation reservoirs

Regulation reservoirs are planned to impound the discharge of water right during non-irrigation period for the purpose of supplementing water resources and preventing ineffective discharge of the available water at 17 sites in the area. The scale and capacity of reservoirs are shown in the table below. Regulation ponds (storage water is supplied from canals) are planned at diversion points in the secondary and the tertiary canals for adjusting irrigation time in the field. Ten regulation ponds are to be constructed in the Popeta area.

No.	Site	Capacity (m^3)	Crest Length (m)	Crest Height (m)	Area
1	Loma El Litre	113,000	400	5	Carmen Alto
2	Pintilla de la Guaitata	265,000	280	10	Cholqui
3	Cholqui	165,000	280	10	Cholqui
4	El Cajon	1,029,000	750	10	Culiprán
5	*Estero* Tantehve	428,000	240	10	Popeta
6	Lomo La Curz	587,000	750	10	Popeta
7	Cajon del Rey	2,780,000	780	10	Popeta
8	Rincon lao Guindos	198,000	400	10	Popeta
9	Rincon La Monja	1,466,000	1,000	10	Popeta
10	S/N (Los Guidos)	493,000	600	10	Popeta
11	S/N (Co. Pordices)	416,000	400	10	Yali
12	S/N (Logovilo)	346,000	180	10	Yali
13	*Estero* El Parvon	2,517,000	670	10	Yali
14	Los Molles	1,988,000	900	10	Alhué
15	S/N (Santa los del Pecal)	848,000	600	10	Alhué
16	*Estero* Huillin	1,327,000	650	10	Alhué
17	S/N (La Sepulfura)	1,337,000	300	10	Alhué
	Total	16,303,000			

The storage capacity of the largest reservoir is 2,800,000m^3, and total storage capacity is about 16,303,000m^3. Through these, each irrigation area will hold freedom and safety of irrigation. Water amount relevant to the F/S area, Popeta is 7,524,000 m^3.

(6) Water management system

New diversion weirs are purposed to take water for Popeta-Yali-Alhué area at first, and integration of intake facilities close to new diversion weirs is also planned. The integration of intake facilities will realize accurate water distribution and intake management based on the water right of the third section. There are eight intake

facilities and thirteen canal associations (*Asociacion de Canalistas*) in the third section at present. Although there is movement of establishing *Junta de Vigirancia* in some canal associations for equitable intake management, it has not realized, yet. Exercise of the unused water right of 25m^3/sec is to give effect on the existing water right. Therefore, it is required to clarify the river discharge, accurately and fairly management of water diversion under the establishment of *Junta de Vigirancia*. Distribution of water from the main canal to respective irrigation area is planned to be managed by a *Cerrador* (gate manager) dispatched from a newly established canal association on the integrated diversion weir by canal associations concerned.

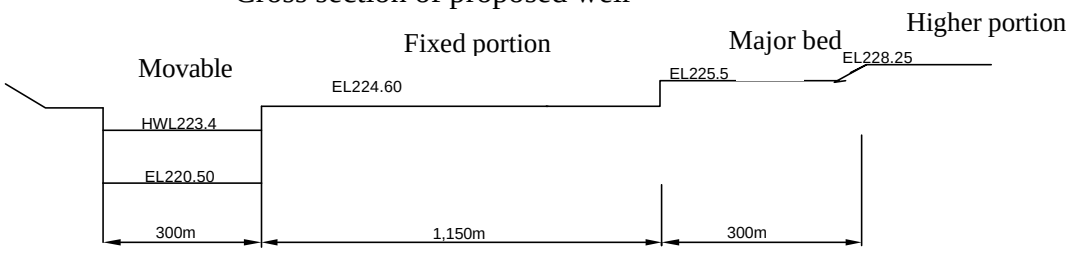
(7) Structural planning for Irrigation

1) Intake facilities

a) Design flood discharge and closing width of river

Design flood discharge at weir site is taken 4,826m^3/sec of 1 % probability of exceedance. The river width from the spur point of Loma la toma of the left bank to the river terrace of the right bank is 1,750m. Major water flows of river are generally running within the range of 300m along the left bank. Small water flows maintain to take water for Picano and Puangue irrigation systems in the right bank. The bear-trap weir, which does not disturb running flow at flood, is to be constructed at the part of water flows to maintain stable water intake at shortage of water and water routes. The concrete fixed weir is to be constructed to close cross direction entire sections in the other river sections. The water-level at closing sections are shown in the figures below. (See Annex K for hydraulic calculation)

Cross section of proposed weir



b) Structural arrangement of weir body

At the proposed weir site in the left bank, steep mountains reaches the river bank and it geologically consists of hard Andesite of the Cretaceous's lower part. The riverbed which water flows exist is covered with sandbars of riverbed, and Andesite which consists of the mountain is assumed to get in deep suddenly. The soil borehole log of the boring survey (two sites, at river center of left side of the weir) and N value of the standard penetration test are shown in Annex K. Riverbed deposit mostly consists of sandbars mixed with boulder. N value from 1 to 6m in depth is over 50, and at deeper place is over 30. Bearing capacity is judged enough for base of the weir.

The weir body is to be fixed at the mountain along the river in the left bank and at the river terrace which is from 3 to 5 meters above the river. The structure of weir is planned to consist of scouring sluice, movable part and fixed dam part. Dam-up height and the rate of movable and fixed parts will be planned within the range that the water level at flood does not overflow the river terrace of the right bank. Structure of the weir for planned flood discharge of 4,826m^3/sec is shown in the table below. (Detailed design is shown in Annex K)

Hydraulic Section	Structure	Dam-up Height(m)	Width (m)	Flood Depth (m)	Flow Speed (m/sec)	Discharge (m^3/sec)
Scoring Sluice (Left Bank)	Sluice Gate	2.7	30(15 x 2 gates)	3.4	3.0	500
Scoring Sluice (Right Bank)	Sluice Gate	2.7	10	3.4	2.5	168
Movable Part	Bear-trap weir	2.4	250	3.4	2.5	4,200
Fixed Part	Concrete Weir	1.5	1,150	-	-	-
Total			1,440			4,868

The structure of major parts of the weir is planned to be formed with steel sluice gate at the scouring sluice, bear-trap weir at the movable part and concrete structure at the fixed part.

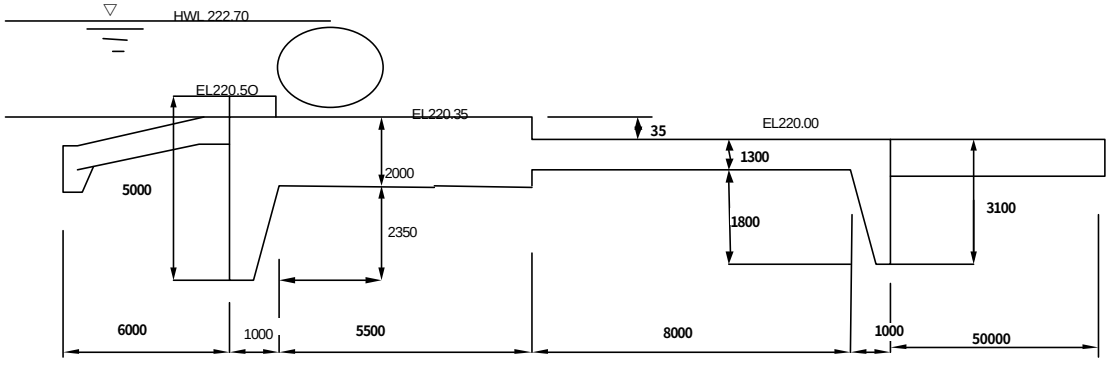
c) Selection of movable weir type

Considering the conditions of discharge duration for constructing the integrated diversion weir: the entire river width, flood discharge, moving range of the water flows, discharge depth and sediment run-off, closing length of the movable part is 250m. Dam-up depth is 2.4m according to intake level. Movable type weir under these conditions, steel sluice gate, steel hydraulic overturning gate, radial gate and rubber dam can be proposed. Based on the results of comparison among them, rubber dam is applied because it maintains easily and is economically reasonable.

Evaluation Term	Steel Sluice Gate	Steel Overturning Gate	Radial Gate	Rubber Dam
Gate Size & No.	25 m x 10 Gates	50 m x 5 gates	25 m x 10 gates	80 m x 3 gates
Gate Price (US$)	11,000,000	8,000,000	6,400,000	3,500,000
Engineering construction Cost (US$)	14,730,000	14,640,000	14,690,000	14,610,000
Total (US$)	25,730,000	20,640,000	21,090,000	18,410,000
Evaluation	Economically most expensive	Maintenance cost is higher than rubber dam due to hydraulic control	Damaged by obstacles such as drift wood leads to higher cost	Easy maintenance and economical compared to the others

d) Cross-section of the rubber dam

Height of the rubber dam is to be 2.40m because the placing elevation is 220.35m and intake level is EL 222.70m. The foundation which supports rubber dam, is planned to be constructed at 13.5m in total length and cutoff wall is constructed with 4m in the upstream side and 2.5m in the downstream side, so as to stabilize the dam and prevent piping. Cross-section of rubber dam is shown in the figure below.



Riprap block is planned to be constructed at the downstream apron of the dam for keeping the dam safety. Length of the consolidation works is 50m and the size of a block is 4 ton per piece.

e) Water-intake and settling basin

At the water-intake point in the left bank, intakes for the new irrigation area and four existing irrigation systems (Calmen Alto, Cholqui, Chocalan and Culiprán) are to be integrated. Two existing intakes for Puangue and Picano are also integrated. Water intake structure is planned to be constructed in front of scouring sluice, and be set up with the gate for controlling diversion volume and stopping mud-flow at flood. Planned stream velocity at the intake is to be 0.8～1.0m/sec. Settling basin is planned after taking water for stopping sediment flow.

Intake Site	Intake Structure				Settling Basin			
	Diversion Volume (m^3/sec)	Structure	Intake Depth (m)	Intake Width (m)	Basin Width (m)	Basin Length (m)	Average Depth (m)	Basin Area (m^2)
Left Bank	45.0	Gate	1.2	37.5	60	150	0.3	9,000
Right Bank	12.8	Gate	1.2	9.2	40	100	0.3	4,000

2) Canals and related structures

a) Main canal route alignment

The main canal in the new irrigation area is planned as common use system of Popeta area where is the F/S area in the project and Yali and Alhué where are located in the lower part of the main canal. The route of the main canal is set up by the elevation of the diversion weir and required water level for irrigation use in the area. Most of the route is planned to pass on the foot of mountain and the extension from the intake structure to Alhué area is 75km. Partially, the route reaches finally to the irrigation area along the Alhué river after penetrating the mountains by nine tunnels. The extension of the route is varied between 3 and 5km. Seven of nine tunnels can detour the mountain by open canals, however the extension of the open canals becomes five times as much as tunnel's extension. Thus, tunnel works are selected because the construction cost is economical.

The head loss of conducting water can be reduced by more than 15 m through taking tunnel works, and irrigation water supply by gravity method becomes possible for most of the area (93%) except some plateaus. Three canals taking water from the Maipo river which are detouring the hillside from the intake point to Culiprán are constructed. The selection of tunnel method considers the influence on these existing canals.

The bedrock of the route is shown in the table below. Many of main canals and aqueducts are to be constructed on the Colluvial soils covering on the bedrock.

	Area		Geological Feature	
			Bedrock of Foot of Mountain	Valley of *Estero*
1	Popeta	Carmen	Marine Sedimentary Rock, Effusive Rock	Colluvial soil of Alluviam & Diluviam (Q)
		Choluqui	Granites	Colluvial soil of Alluviam & Diluviam (Q)
		Popeta	Granites	Colluvial soil of Alluviam & Diluviam (Q)
2	Yali		Granites	Colluvial soil of Alluviam & Diluviam (Q)
3	Alhué		Marine Sedimentary Rock, Granites	Sand Bars of Alluviam & Diluviam (Q)

b) Structural planning of the main canal

The structure of the main canal consists of the open channel which passes foot of the mountain, the tunnel passing through the mountain and aqueducts crossing the streams. In the main canal, the siphon structure which will have the problems on maintenance (removing silt and leakage by water pressure) in the future is not planned as the structure passing through the small streams Canal gradient is to be set at not

less than 185m at diversion point of Alhué. Average gradient of all canals is approximately 1 / 3,000 considering diversion loss. The canal is to be constructed by concrete lining for prevention of leakage and simplifying maintenance. The tunnels are planned to shape the standard horseshoe type and free-flow without pressure tunnels. Major structure of the main canal in each irrigation area is as follows.

Area	Main Canal			Lateral Canal			
	Open Canal (km)	Tunnel (km)	Aqueduct (km)	Open Canal (km)	Tunnel (km)	Aqueduct (km)	Siphon Works (km)
Popeta	45.95	13.52	0.44	44.70	-	-	-
Yali	10.25	3.35	0.07	117.45	0.73	0.32	0.05
Alhué	-	3.90	-	91.86	0.28	0.31	1.60
Total	56.20	20.77	0.51	254.01	1.01	0.63	1.65

- Structure of the main canal

  The main canal is to be constructed in tails along with foot of the mountain by concrete lining because large leakage is occurred in case of earth canals, and the face of slope is easy to be collapsed. Inspection road is constructed beside the canal. Cross section of the canals is classified into 11. Hydraulic elements, scale of cross-section and structures of major canals are presented in the following table.

Hydraulic Elements	Type I	Type II	Type III
Canal Height (m)	3.00	2.5	1.5
Canal Bed Width (m)	6.0	4.0	2.0
Side Slope	1:0.3	1:0.3	1:0.3
Flow Velocity (m/sec)	1.5	1.3	1.3

- Structure of the secondary canals

  The secondary canals are canals conveying water from the main canal to a field canals (tertiary canals). They are set up outside of irrigation area and foot of a mountain. Canal type is a open canal and lining for prevention of leakage and smooth maintenance. Dimension of major canals is as following table.

Hydraulic Elements	Type I	Type II	Type III
Canal Height (m)	1.5	1.0	0.7
Canal Bed Width (m)	3.0	1.5	1.0
Flow Velocity (m/sec)	1.3	1.2	1.0

- Structure of the tertiary Canal

  A tertiary canal is to be set up at intervals of 200m in the field. The canal structure is open channel at area where ground slope is less than 1/50, and is pipeline type where ground slope is over 1/20 of for preventing erosion of farmland by irrigation and that fruit growing can be a major farming, there.

- Diversion facilities

  Diversion facilities from the main canal is set up in each irrigation area. However, the irrigation area where divided by large stream needs the crossing structure in the secondary canals. Therefore, diversion facilities are planned to be constructed in each valley. Total diversion facilities from the main canal are 18. Diversion facility structure of the main canal is a longitude separation work which divides a canal by the rate of flow. Each diversion facility is set up with a gate so as to maintain the canals by each diversion unit. Diversion facility structure of the secondary canals are longitude separation works divided by the rate of flow and set gate for maintenance.

c) Tunnel

Tunnels which get beyond mountains and distribute water to the other area are set up in two sites, between Popeta and Yali, and Yali and Alhué. In other areas, when a canal which detours the mountain is more than five times as much as the tunnel extension, tunnels are applied because the canal takes economical disadvantage. Geological feature and construction conditions of the areas where tunnels are applied are shown in the table below. The type of tunnel is a horseshoe type and slop of canal at tunnel part designed to be steep as much as possible in order to make the cross section small.

Area	Tunnel Length (m)	Stratum	Size of Cross Section Dia. & Length (m)	Alternative Method and Evaluation
Popeta	5,549	Sedimentary Rock, Igneous Rock	5.2	Detouring 36km: Tunnel is profitable
	300	Sedimentary Rock, Igneous Rock	4.6	Detouring 2.8km: Tunnel is profitable
	3,350	Sedimentary Rock, Igneous Rock	4.1	Detouring 46km: Tunnel is profitable
	3,210	Granites	4.1	Detouring 34km: Tunnel is profitable
	730	Granites	3.9	Detouring 3.4km: Tunnel is profitable
Yali	2,500	Granites	3.8	Crossing river basin, only tunnel
	250	Granites	3.6	Detouring 1.0km: Tunnel is profitable
	490	Granites	3.4	Detouring 3.2km: Tunnel is profitable
Alhué	3,930	Granites	2.6	Crossing river basin, only tunnel
Total	20,309			

d) Regulation reservoir plan

- Dam body structure

The reservoir is to be constructed at the lower site than the canal's elevation because redundant water is to be stored within available water of Popeta-Yali-Alhué irrigation system. The construction site is to be selected at a ravine of valleys within the storage depth of 10m. On storage capacity, that in two sites is around 2,000,000 m^3 , five sites is about1,000,000 m^3 and others areas is 300,000 to 600,000 m^3. Dam body will be the earth-fill type from the point of their capacities and construction materials. Homogeneous type or center core type is to be selected according to available materials of each dam body.

- Foundation treatment

Geologically foundation of each reservoir area is formed by gravel such as Colluvial soils of the Diluviam age and riverbed deposit of the alluvial age. Generally, the depth of cutoff wall is designed by 1.5 times of water depth in the site which has this kind of geological composition, but there is regional difference and confirmation of the geological composition is required. Accordingly, examination of the foundation treatment plan based on geological survey such as the seismicity, boring, permeability of Colluvial soil and groundwater level is necessary at the detailed design stage.

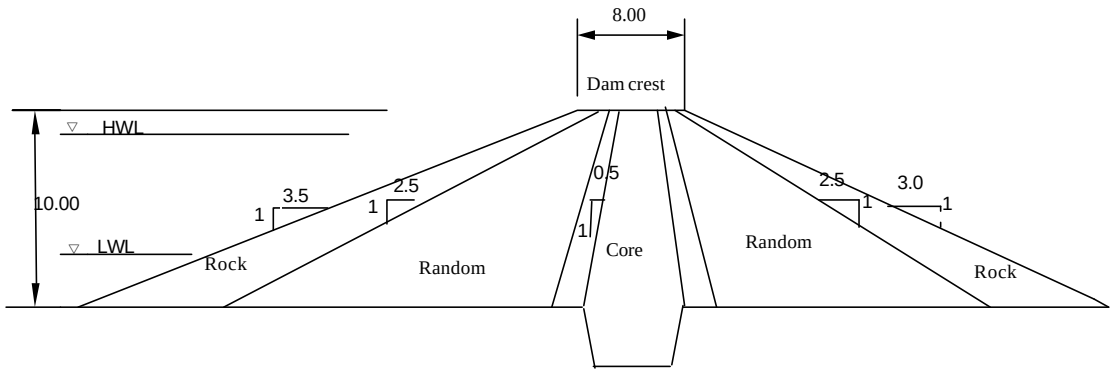
There is no concern on lack of bearing capacity or piping in bedrock of each reservoir, however, it should be careful with leakage water through sand layer. Because as the depth of the reservoir is deeper, leakage is larger, the depth of reservoir is designed by less than 10m. Planned cutoff wall is to be around water depth. Spillway is planned at flood discharge of 1% probability of exceedance (50 years probability) for safety of the dam body. Type of spillway is side spillway and foundation is designed to be rock mass.

- Cross-sectional structure of dam body

Standard cross section of the fill type dam is planned as follow based on the results of stability analysis. (See Annex k for stability analysis)

Type	Water Depth (m)	Crest Height (m)	Crest Width (m)	Crest Type	Dam Slope		Foundation Treatment (m)	Spill way	
					Upstream	Downstream		Probability Year	Flood Discharge ($km^2/m^3/sec$)
Type I	7	9	8.0	Center Core Earthfill	1 : 3.5	1 : 3.0	15	1/100	2.45～7.74
Type II	10	12	8.0	Center Core Earthfill	1 : 3.5	1 : 3.0	10	1/100	2.45～7.74

Typical cross section of the dam body is shown below.



Proposed Dam Dimension

No.	Site	Storage Capacity (m^3)	Side Slope of Dam (1: n)		Soil Volume (m^3)	Flow Volume of Spillway (m^3/sec)	Spillway Length (m)	Type
			Upper Slope	Lower Slope				
1	Loma El Litre	113,000	3.5	3.0	30.000	10.1	9	**I**
2	Pintilla de la Guaitata	265,000	3.5	3.0	27,000	21.8	20	**II**
3	Cholqui	165,000	3.5	3.0	54,000	26.8	24	**II**
4	El Cajon	1,029,000	3.5	3.0	180,000	73.2	66	**II**
5	*Estero* Tantehve	428,000	3.5	3.0	120,000	161.2	79	**II**
6	Lomo La Curz	587,000	3.5	3.0	230,000	7.7	7	**II**
7	Cajon del Rey	2,780,000	3.5	3.0	376,000	322.4	75	**II**
8	Rincon lao Guindos	198,000	3.5	3.0	65,000	67.9	63	**II**
9	Rincon La Monja	1,466,000	3.5	3.0	289,000	69.4	61	**II**
10	S/N (Los Guidos)	493,000	3.5	3.0	109,000	7.0	6	**II**

e) Field irrigation plan

The main and secondary canals are to be lining with concrete or masonry. The tertiary canals are earth canals at flat areas and employing the California type irrigation in the field.

At sloping land (gradient ; 1/20), the canals are to be pipelines for protecting canal and preventing erosion. Fruit growing is to be the major cultivation at the sloping land. Pipeline type tertiary canals make drip-irrigation by pressure from the secondary canals possible. Irrigation area and irrigation efficiency of the pipeline type tertiary canals which are earth canals are as follows.

Tertiary Canal Structure	Irrigation Method	Area (ha)	Irrigation Efficiency (%)
Earth Canal	Furrow irrigation	3,800	48
Pipeline	Drip Irrigation	1,200	72

f) Plan for electric generation

Electric generation is feasible at two sites in Carmen Alto, one site at Cholqui and one site at Culiprán by integration of existing intakes. Proposed dimension of proposed electric generation is as follows.

	Canal	Water Volume (m^3/sec)	Water Level (m)	Penstock Ø (mm)	Generation Capacity (kW)	Avg. Annual Production (MKW)
1	Carmen Alto	5.70	23.4	2000	970	262
2	Carmen Alto	6.30	20.6	2000	940	253
3	Cholqui	1.15	31.0	700	230	63
4	Culiprán	3.18	45.7	1200	1,040	281
					3,180	859

Agricultural infrastructure development plan is described in Fig. 1.2.4.

1.2.5 Rural Infrastructure Development Plan

Rural infrastructure development plan promotes from the point of permanent rural settlement through agricultural promotion, soundness and safety of inhabitants in the area. Accordingly, based on the present situation survey, the sectors where installation is behind (connecting roads, water supply facilities, rural sewerage treatment facilities and meeting facility) intend to be improved.

- On road improvement, it is planned to put stress on the establishment of road networks in the area. Trunk roads are to be paved up to the center of each community. On lateral roads, new connection roads between lateral roads are to be constructed and improved at the level for vehicle traffics.

- Regarding the improvement of rural water supply facilities, underdeveloped facilities in Carmen Alto and Cholqui are to be improved by a water source of new groundwater development. Estimated water supply amount is 100lit./day/head (drinking water: 50lit./day/head, domestic water: 50 lit/day/head).

- Rural sewage treatment facilities are to be improved mainly in the center of each *UV* for living and production environmental conservation. Because operation and management of treatment facilities are to be handled by community members, high operation technique and special chemical treatment should not be required. Treated water can be reused for agriculture. The target of treatment level is less than 30 mg/lit. on BOD and less than 1,000 MPN on coliform groups.

- CECUV is established for technical support on agriculture in the area, and providing the place for fostering agricultural successors, meeting of inhabitants, various subjects of training and rural women's activities. Obtaining the rooms of each producers' group for technical support in the center expects to result in easy access to effective support services and technology transfer. Popeta already has community center. Thus, existing facilities can be utilized as the place for agricultural support and community activities.

Based on the survey of the present situation and the irrigation facility improvement plan, required items and quantity for improvement of living environmental facilities are shown in the table below. Outline of the rural infrastructure development is described in Fig. 1.2.5.

Improvement Item	Popeta Area		
Road Improvement			
Trunk Road Pavement	5 routes	L= 30.0 km	W= 6.0
Lateral Road Improvement	4 routes	L= 21.6 km	W= 5.0
New Lateral Road	5 routes	L= 14.5 km	W= 5.0
Rural Water Supply Facility	2 sites		
	Carmen Alto	849 people	Ø100L= 16 km
	Los Guindos	615 people	Ø100L= 28 km
Rural sewage treatment Facility	8 sites		
	Chocalán	687 people	Ø150L= 19 km
	Carmen Bajo	1,125 people	Ø150L= 38 km
	Carmen Alto	849 people	Ø150L= 23 km
	Cholqui	1,211 people	Ø150L= 32 km
	El Pabellon	915 people	Ø150L= 27 km
	Culiprán	1,736 people	Ø150L= 33 km
	Popeta	1,309 people	Ø150L= 29 km
	Los Guindos	615 people	Ø150L= 16 km
Community Center (CECUV)	7 sites, 210 m2 / site Chocalán, Carmen Bajo, Carmen Alto, Cholqui, El Pabellon, Culiprán, Popeta, Los Guindos		

1.2.6 Environmental Conservation Plan

(1) Water quality in Popeta area

According to the construction plan of the sewage treatment plant in Santiago by EMOS, three plants will be completed along the Mapocho river in 2024 and then the treated water of approximately 25m^3/sec will be discharged into the Mapocho river. Consequently, water quality of the Maipo river joining the Mapocho River will be greatly ameliorated. Based on the predicted results of water quality at target year of 2010, water quality at the intake point of Popeta-Yali-Alhué irrigation system will be achieved less than 20mg/l in BOD according to the stage-wised completion of the treatment plant of EMOS.

(2) Environmental management plan

1) Promotion of environmental education in basins

After the construction of the plants proposed in this project, those plants will be managed by the canal associations. However, at the points where canals pass through villages, it is considered that the canals and irrigation water will be contaminated by wastes, domestic sewage, and livestock farming wastes.

UV, the smallest unit of the organizations for administrative support in *Comuna*, has a role of promoting to abide the hygiene regulation, of carrying out the activities for the environmental hygiene, pushing on the environmental conservation, and keeping the balance of ecosystem. In this project, it is planned that a campaign for enlightenment on the-village-basis with respect to the environmental conservation to maintain high quality of water. The promotion campaign of environmental education is also planned by recommending to have a qualification to be engaged in the environmental conservation among the youth group of UV or other groups, and farmers' groups.

2) Promotion of agriculture with environmental consideration

In order to prevent environmental pollution by expansion of utilization on pesticide and fertilizer and to promote sustainable agriculture, skill guidance and technology transfer to farmers concerning the reduction of using pesticide and fertilizer are executed by the public institutions such as INIA. These activities are carried out on the farmers' organizations established to receive the agricultural support services from INDAP.

(3) Environmental impact assessment (EIA)

EIA System in Chile, No. 35,731, established in April 1997 provides the object to be assessed from the environmental view. Related items between the EIA System and the development plan of Popeta area including Yali and Alhué are: "projects giving a great influence on waterworks, dams, drainage, and natural water system"; and "works or activities in the natural parks designated officially."

Environmental assessment with regard to the EIA System is conducted by the Chile side when the execution of this project is determined definitely as a project. In the process of the assessment, the environmental factors as to the conduction of the project are investigated and predicted on the basis of the contents of the project including the alternatives. The predicted results and designated goal for the environmental conservation are assessed, and then the goal is achieved by preparing the measures for the goal. If the goal is not achieved, the alternative is predicted and assessed instead, and the goal is achieved by making measures for the goal.

- Environmental impact in development of Popeta, Yali, and Alhue.

With respect to the environmental impact in the construction of canals and drainage from the new irrigated farmland, the following items are considered as the objects assessed by the results of scooping on environmental factors.

Livings of inhabitants	Planned or involuntary resettlement, and conflict among inhabitants.
Demographic issues	Drastic change in population composition by the changes in rural population engaged in agricultural production .
Economic activities of inhabitants	Relocation and change of bases for economic activities, and increase of unemployment and income disparities.
Institutions and customs	Readjustment of water right, social and structural changes such as establishing organizations and changes in existing institutions and customs.
Environment and sanitation	Generation of construction wastes, increased use of pesticide, and increase in domestic and human wastes.
Historic remains, cultural assets, landscape and others	Deterioration of aesthetic harmony
Precious biological and ecological system areas	Negative impacts on diversity of precious or indigenous fauna and flora, vegetation, and living things, invasion and proliferation of hazardous species, and extinction of wetland and wild land.
Soil	Erosion, salinization, deterioration of fertility and contamination.
Hydrology	Changes in surface water condition, and changes in groundwater condition and its level .
Water quality and temperature	Water contamination of surrounding rivers and canals during construction, deterioration of water quality and lowering its level after use for construction, eutrophication and changes in water temperature. .
Air pollution	Dust generated by vehicles during construction
Noise and vibration	Noise and vibration during construction.

As the evaluation standard, the influence of qualitative objects is set at the minimum, while water quality and noise are set at as follows:

Water quality	Turbidity 50-Silica, Color 100, Temperature 30℃, Transparency 1.2m, pH 6.5-8.3, Fecal coliforms 1000MPN/100ml
Noise	45-55dB

1.2.7 Summary of Agricultural Development Plan in Popeta Area

Proposed structural installation in Popeta area which relates to the priority project proposed in the Master Plan of the Study is formed as following contents.

Project	Project component				
Agricultural production infrastructure development project	1. Irrigation area (ha)	Popeta	Yali	Alhué	Total
		4,975	9,815	6,294	21,084
	2. Integrated diversion weir: Intake volume Left bank: 45.0 m^3/s Right bank: 12.8 m^3/s Total: 57.8 m^3/s				
	3. Irrigation canals	Popeta	Yali	Alhué	Total
	(1) Open canal				
	Main canal (km)	45.72	10.29	-	56.38
	Secondary canal (km)	66.73	133.80	110.90	311.43
	Tertiary canal (km)	235.00	(Excluding F/S)	(Excluding F/S)	235.00
	(2) Tunnel				
	Main canal (km)	13.14	3.24	3.93	20.31
	Secondary canal (km)	0.60	0.73	0.28	1.61
	(3) Aqueduct				
	Main canal (km)	0.44	0.07	-	0.51
	Secondary canal (km)	-	0.32	0.31	0.61
	(4) Diversion facility				
	Main canal (Nos.)	12	4	2	18
	(5) Improvement of existing canal				
	Main canal (km)	22.0	-	-	22.0
	4. Regulation reservoir				
	Number of place	10	3	4	17
	Capacity (1,000 m^3)	7,524	3,279	5,500	16,303
Rural infrastructure development project	1 Road improvement		(Excluding F/S)	(Excluding F/S)	
	Pavement of main road (km)	5 routes 30.0			30.0
	Improvement of lateral road (km)	4 routes 21.6			21.6
	Construction of lateral road (km)	5 routes 14.5			14.5
	2 Rural water supply facilities (Nos.)	2	(Excluding F/S)	(Excluding F/S)	2
	3 Rural sewage treatment facilities (Nos.)	8	(Excluding F/S)	(Excluding F/S)	8
	4 Community center (Nos.)	7	(Excluding F/S)	(Excluding F/S)	7

Development plan in Popeta area including Yali and Alhué is described in Fig. 1.2.6.

1.3 Project Cost

1.3.1 Basic Conditions of Cost Estimation

Project costs are estimated at the price level of December 1998 based on the results of field survey regarding the costs of labor, construction materials and equipment. Basic conditions of cost estimation are as follows.

(1) Construction cost

Construction works is executed by the contractor with contract basis. Since contractor prepares construction materials and equipment, which are necessary to execute the works, costs of construction materials and equipment are estimated by

depreciation cost. Referenced materials for construction costs are as follows.

- Cost of Corrales project which were executed by DOH（December/'98）
- Commodity price book published by ONDAC（December/'98）
- Prevailing costs in Chile is used on working ratio and depreciation cost of construction equipment, depreciation cost for temporary works.

(2) Project cost component and ratio applied for estimation

Component and ratio of indirect costs of the project against direct construction cost are assumed as follows.

- Project cost consists of preparation cost, direct construction cost, engineering and administration cost as well as physical contingency.
- Direct construction cost includes overhead and profits.
- Engineering and administration cost is assumed as 10% of direct construction cost.
- Each cost is divided into local and foreign currency portions. Labor costs and materials such as sand, aggregate, are assumed as local currency portion and others are foreign currency portion. Physical contingency is 10% of total costs from direct construction cost to engineering and administration costs.
- Price escalation is assumed as 5% of inflation index.
- Land acquisition and compensation costs are applied 600 to 1000 thousand pesos per ha based on kind of land.
- Operation and maintenance cost is estimated separately as the Operation and maintenance cost of canal association for water management.

1.3.2 Project Cost

Project component of the area is broadly divided into two (2). There are agricultural infrastructure development which main component is irrigation facilities improvement, and rural infrastructure development project consist of road improvement, rural sewage treatment facilities, rural water supply facilities and CECUV. Project costs of principal components are as follows. Detail of the cost is shown in Table 1.3.1. While, disbursement schedule of the project is shown in Table 1.3.2.

Unit: Thousand Pesos.

	Component	F.C	L.C	Total
1	Preparation cost	1,376,694	1,882,527	3,259,221
2	Construction cost			
	Agricultural production infrastructure development	26,572,601	35,803,362	62,375,963
	Rural infrastructure development	961,281	1,847,184	2,808,465
3	Land acquisition and compensation cost	-	40,894	40,894
4	Engineering and administration cost	2,716,686	4,479,185	7,195,871
5	Physical contingency (10%)	3,162,262	4,405,315	7,568,041
	Total	34,789,988	48,458,467	83,248,455

Total project cost on agricultural development project in Popeta area is estimated at 83,200 million pesos.

The integrated diversion weir which is constructed in the Maipo river, and the main irrigation canals from the integrated diversion weir to Popeta area, are proposed in the structural plan. The facilities' capacity is added the capacity of the integrated diversion weir which integrated six existing intake structures and intakes of Popeta, Yali and Alhué, and irrigation water of the main canals to the newly irrigated areas which attached three existing irrigation areas and Yali, Alhué areas. Therefore, construction cost has to be allocated in order to estimate the individual economic evaluation on

Popeta area. The construction cost of the integrated diversion weir and main irrigation canals are allocated to the beneficiaries based on the ratio of their water right discharge and distance ratio. Then, beneficiaries pay for their allotment. The cost allocation ratio is shown in the following table.

Cost allocation of integrated diversion weir			Cost allocation of main canals					
Related canals	Intake volume (m^3/sec)	Allotment	Related canals	Discharge (m^3/sec)	Related length (km)	Ratio of discharge	Ratio of length	Allotment
1 Puange	3.6	0.062	1 Carmen Alto	6.52	5.6	0.181	0.022	0.019
2 Picao	9.2	0.159	2 Cholqui	1.4	20.6	0.039	0.081	0.015
3 Carmen Alto	8	0.138	3 Culiprán	3.2	20.6	0.089	0.081	0.035
4 Cholqui	2	0.035	4 Popeta	5.9	59	0.163	0.231	0.183
5 Chocalán	5	0.080	5 Yali	11.64	73	0.322	0.285	0.446
6 Culiprán	5	0.087	6 Alhué	7.46	77	0.207	0.301	0.302
7 Popeta	5.9	0.102	Total	36.12	255.8	1.000	1.000	1.000
8 Yali	11.64	0.201						
9 Alhué	7.46	0.129						
Total	57.8	1.000						

1.4 Project Implementation Schedule

1.4.1 Executive Agencies

Agricultural development project in Popeta area (irrigation project) is evaluated by CNR, and its implementation is approved by *Consejo de Riego*. Approved projects are classified into direct controlled projects of DOH (MOP) as a national project and irrigation encourage projects of CNR by the project scale (construction cost). In case that project cost is more than 24,000UF, the projects will be national irrigation projects (Government ordinance No. 1123), and the projects whose cost is less than 24,000UF will be irrigation encourage projects (Law No. 18450). As for the scale of facilities, Government ordinance No. 1123 determines diversion weir, main canals, secondary canals as large scale irrigation facilities. Law No. 18450 determines tertiary canals to the fields as medium and small scale irrigation facilities. According to the project scale, the executive bodies of the project are classified as follows;

Classification of Project	Implementation agency	Project scale	Component of project
Government ordinance No. 1123	DOH	More than 24,000 UF	Diversion weir, main canals, secondary canals
Law No. 18450	PROMM	Less than 24,000 UF (*Comuna*: irrigation association)	Tertiary canal to farm ditches
	CNR	Less than 12,000 UF (private)	

1.4.2 Burden of Project Cost (Source of funds)

The project will be implemented by following governmental subsidy systems based on Government ordinance No. 1123 and Law No. 18450.

Laws	Ration of subsidy	Burden of beneficial farmer	Remarks
Government ordinance No. 1123	Maximum 70%	The rest	Ratio of subsidy is changed by the project components and the project scale.
Law No. 18450	Maximum 75%	The rest	Low interest rate credit UF+4.5%, long term loan Applicant applies advantageous rate for the proposal.

Farmers can use a long-term loan at low interest rate for the irrigation project in order to pay their burden. As for the project cost itself, the government of Chile will provide from a national budget or fund of international financial organizations.

1.4.3 Process of the Project Implementation

(1) Agreement on the project of beneficiaries

As for the projects under Government ordinance No. 1123 (main irrigation facilities), DOH examines the project implementation after *Consejo de Riego* approved the project. In the examination, at first, DOH carries out questionnaire survey on approval or disapproval of the project for expected beneficiaries, and then confirms if more than 50% of the benefiting farmland area agrees with the project (agreement on the repayment of the project cost). DOH usually explains and collects agreement sheets directly. In case of an irrigation project under Law No.18450 (terminal irrigation facilities), CNR decides approval or disapproval of the project based on the proposals from the beneficiaries.

(2) Establishment of canal associations

There is no existing canal association in the new irrigation area. Therefore, so as to distribute irrigation water, establish water right, and obtain land for irrigation facilities, it is required to establish canal associations by beneficiaries in each new irrigation area at early stage as a core organization for promoting projects. Establishment of canal associations and decision of the project implementation should be promoted at the same time.

For existing and new canal associations related to the construction of the integrated diversion weir in the project, establishment of the integrated canal association to distribute fairly and manage water right volumes and of *Junta de Vigilancia* to manage intake water from the rivers in the third section are needed.

1.4.4 Implementation Schedule

As for integrated weirs and the main canal facilities, DOH employs consultants to execute the detailed design (D/D) after confirmation of beneficiaries' agreement on participation of the project. Then, DOH promotes the project from the contract by competitive bidding among constructors to commencement of construction works. In case of the tertiary canals (terminal facilities), the canal associations concerned or individual farmers employ a consultant and submit the implementation plan to CNR. After approval of the project, they prepare fund and implement the project. Procedure of the project implementation is following.

(1) Consulting works

DOH will consign topographic survey, geological survey, survey for structural design and the survey relevant to the construction schedule for the detailed design to a consultant. The consultant restudies and examines the general issues on the project implementation such as the project plan and the detailed design of integrated diversion weir, canals, and regulation reservoirs, as well as the cost estimation, the bidding, the contract documents, quality control of the construction in accordance with indication of DOH.

(2) Preparation works

Preparation works consist of the topographical survey for the detailed design, additional geological survey for the integrated diversion weir and acquisition of land for facilities.

Topographical survey

- Longitudinal section, cross section and location of the main canal route in

Popeta-Yali-Alhué (Scale: 1/1000) : 57.00km
- Drawing the topographical map of Popeta area (Scale: 1/5,000) : 6,000ha
- The topographical map of location of the integrated diversion weir and regulation reservoirs (Scale: 1/1,000), longitudinal survey of dam axis (Scale: 1/5,000) : 40ha

Geological survey
- Additional geological survey of the integrated diversion weir, geological survey of tunnels and regulation reservoirs.

General quantities of the geological survey in Popeta area

Components	Drilling survey (m)	Soil test (No. of sample)	Permeability test (No. of test place)	Drawing up geological map (km^2)	Seismic survey (km)
Integrated diversion weir	210	105	42	-	-
Tunnels	900	-	-	26	16.0
Regulation reservoirs	1,500	780	300	-	6.0

Components	Rock test (No. of test place)	Horizontal loading test (No. of test place)	Dam body material test	
			Hand auger	Test pit
Integrated diversion weir	-	-	-	-
Tunnels	90	36	-	-
Regulation reservoirs	20	-	150	30

Required facilities for the supervision of the project implementation are prepared by the consultant or the constructor before starting the construction works.

(3) Land acquisition

The land for construction of the integrated diversion weir, canals, regulation reservoirs and so on is acquired by the consultant through the procedure of land acquisition under the consignment of DOH. Estimated land area is as follows.

Components	Area of land acquisition (ha)
Integrated diversion weir	2
A main canal	45
Regulation reservoirs	110
Total	157

(4) Construction method

The contractors who have qualification are selected through international competitive bidding for the contract of engineering works of irrigation projects under Government ordinance No. 1123. The construction work is executed by the contractor under the supervision of DOH and the consultant. On the other hand, as for the construction works after tertiary canals, the canal associations concerned and farmers' group take responsibility of the project. With this, the consultant designs and surveys and the contractor undertakes the construction works under the guidance of CNR, PROMM and other government concerned.

1.4.5 Construction Planning

The construction works such as the integrated diversion weir, irrigation canals and regulation reservoirs are ordered by DOH and the construction works are executed through the contract system under the supervision of the consultant.

(1) Construction materials and equipment

- Aggregates for concrete (sand, crushed stone) and crusher-run for

pavement of roads are produced at the site.
- Cement and reinforcement are carried from neighbor factories.
- Steel gates, hard rubber dams, pumps and vinyl chloride pipes for the integrated diversion weir and canals are foreign made.
- Although required equipment for construction is foreign made, the contractor should prepare contractor themselves.
- Embankment materials for construction of reservoirs is collected at the site principally. However, in case that there is no suitable material for embankment in Popeta area, clay soil in Yali area would be used.

(2) Construction method and notes

The notes concerned with the construction works are as follows.

- The weir is constructed by the temporary closure of half stream method all the year round. Since flood can be forecasted during the rainy season, a bypass canal is proposed at 10 year exceedance probability flood equivalent to 1,002m^3/sec.
- The main and secondary canals can be constructed all the year around because the route does not overlap with existing canals. However, construction of the crossing structure with stream needs measurements for safety against the freshet during the rainy season.
- Construction of tunnels plans to proceed from both sides of tunnels because the length of them is about 3 to 5 km. On construction, safety regulation of tunnel construction which DOH provides should be observed.
- Concrete is mixed at the site. The integrated diversion weir, a main canal and aqueducts are constructed through concrete placing by truck cranes. Concrete placing for the secondary canals is undertaken mainly by man power. Countermeasures should be taken against water flow contamination during the concrete works.
- In case that the construction gives negative influence on the existing canals such as obstacles or interruption of water flow, compensation would be considered.

(3) Implementation method of construction

Implementation schedule of the project is formed under the plan in which implementing projects of each field interact effectively each other. Construction in the project starts from the integrated diversion weir, then the main canals connecting with the weir (including tunnels and aqueducts), secondary canals, tertiary canals, connecting canals to the existing canals and regulation reservoirs.

1) Construction works of the integrated diversion weir

Construction of the integrated diversion weir which closes the river is undertaken by temporary closure of half stream method because the length of weir is 300m. One of three rubber dams for spillway, intake facilities of the left bank and scouring sluice are to be constructed at the first stage, and two of them, the scouring sluice and the intake facilities of the right bank and a headrace are to be constructed at the second stage. Principal construction machines are bulldozers for foundation excavation, back hoe, dump truck for conveyance of sedimentation. For concrete placing, batching plants and truck cranes are main machines. Fitting construction of rubber dams, intake gates, and scouring sluice gates is undertaken under the technical guidance of professional companies. Main works of the sedimentation basin constructed next to the weir are foundation excavation and then concrete placing.

2) Construction works of canals

The construction of canals consists of open canals along with the skirts of mountains, tunnels passing through mountains, aqueducts crossing rivers and diversion facilities and so on.

Canals

Canals are evacuated mainly by bulldozers and backhoes because the scale of main canals (width: from 15 to 5m, height: 3m) is large. Especially, as the canals which run the skirts of mountains pass through the slope, it is necessary to note that the canals are located on the natural ground. Concrete placing is undertaken by agitator trucks and truck cranes because the temporary road for construction is constructed at only one side of canals. As for the embankment works, soils should be compacted carefully taking the moisture rate into account.

Tunnels

Nine tunnels are planned to be constructed in the project. The longest tunnel is 5.6km. Both of width and height are 5.2m, and the section is the horseshoe culvert. Therefore, it is possible to excavate the tunnel by machines. The tunnel is excavated by full face excavation method from both sides of the tunnel. The steel sliding form is favorable to line the tunnel lining concrete. The air conditioner should be equipped as health control.

Aqueducts

Aqueducts are constructed for main canals to cross mountain streams. The structure of aqueducts is precast concrete type, and the foundation is spread foundation. Construction equipment is same as that of canal construction. It had better avoiding construction of the aqueducts at the time of freshet during the rainy season.

3) Construction works of regulation reservoirs

Since construction sites of the regulation reservoirs are located in the mountain streams, the embankment works should avoid during the rainy season but concentrate during the dry season because the regulation reservoirs is constructed through using the streams. On the embankment materials, soils around the site are utilized basically, however, in case that there is no clay soil, suitable materials should be procured from other places.

1.4.6 Implementation Schedule of the Project

The implementation period of the project as a whole is planned to be for 7 years, from 2000 to 2006. In the project, the irrigation water supply project for the irrigation areas in Popeta area is a main project. Beside this, the components of the project includes the project evaluation and the reservation of budget by government of Chile, the establishment of canal associations, the agreement of farmers for the burden of the project cost, the detailed design, construction works, and so on. The implementation schedule should be planned to make benefit at the early stage. The implementation schedule of the project as a whole is shown in Table 1.4.1.

1.4.7 Operation and Maintenance Plan

(1) O & M organizations

The irrigation facilities that are transferred from DOH after completion of the construction works are operated and maintained by beneficiaries in Culiprán-Popeta-

Yali-Alhué irrigation area and canal associations concerned which use the integrated diversion weir commonly. Each facility is managed by a canal association which use the facility. Especially, in the new irrigation areas in Popeta-Yali-Alhué, canal associations should be established. The canal associations operate and maintain common irrigation facilities and own facilities, and manage water. The canal associations consist of two associations; the integrated water management association which manages the integrated diversion weir and main canals, and the regional canal association which operates and maintains canals after the secondary canals by regional unit.

1) Integrated water management association

The integrated water management association consists of all canal associations which use the irrigation water from the integrated diversion weir. The roles of this association are O & M of the integrated diversion weir, management of intake water, O & M of the main canals from the weir to Popeta-Yali-Alhué and diversion management. In the integrated water management association, president is selected above the board of directors that formed by chiefs of each canal association as directors. Under the board of directors, executive organizations for O & M and water management are set up.

2) Regional canal association

After diversion discharge (secondary canals) from the main canal, canal associations are established by each secondary canal and they manage water of the water systems concerned. Although existing canal associations which get benefit of water intake by the integration are maintained, new canal associations are established by each new irrigation area in Popeta-Yali-Alhué area. The new canal associations are Calmen-Cholqui canal association which is the integrated association of Calmen and Cholqui basins, Culiprán canal association in Culiprán basin, Popeta canal association in Popeta basin.

3) Establishment of canal association

Existing and new canal associations concerned with the areas which benefited by irrigation facilities including the integrated diversion weir are shown in the table below.

Area	Canal association	Remarks
Popeta	Carmen Alto	Existing
	Cholqui	Existing
	Calmen-Cholqui	New
	Chocalán	Existing
	Culipurán	Existing
	Popeta	New
Yali	Yali	New
Alhué	Alhué	New

Since existing canal associations have operated and maintained existing canals and managed water, they hold enough capacity to participate the integrated canal association. Newly organized canal associations need to be approved by DGA in order to get a qualification of juridical person as canal associations. Documents on components of the association and water right prepared for application for a qualification of juridical person submit to DGA under the guidance of the consultants.

(2) Operation and maintenance plan

1) O & M of facilities

The integrated canal association and the regional canal associations operate and maintain weirs and main canals, and secondary and tertiary canals, respectively. In regular maintenance of facilities, water intake from the weirs should be stopped during winter season when irrigation area is reduced. At that time, main and lateral canals are maintained together.

2) Water management

Intake water management of the integrated diversion weir is carried out by *Junta de Vigilancia* which organized in the third section. Water flow of the river which changes seasonally is distributed by proportional allotment in accordance with number of *Acción* which belongs to the third section as a whole. Irrigation water taken from the integrated diversion weir in the right and left banks is distributed by a water manager (*Cerrador*). As for the main canal, water flow of the main canal which changes seasonally as well as the weirs', is distributed at diversion point by proportional allotment in accordance with number of *Acción*. This water management is operated by a water manager who is dispatched from the canal association as well as the case of the weir.

3) Management items and allocation of manpower, material and equipment plan

Management items and allocation of manpower related to O & M plan, and material and equipment plan are summarized as follows.

Component	Management items	Allocation of man power	Material and equipment
Integrated diversion weir	Management of gut, scouring sluice Management of settlement basin	Driver: 1 person	Bulldozer 1 unit
	Management of gate operation	Mechanic: 1 person	
	Management of intake water volume	Manager of discharge measurement : 1 person	Water level gage, Stuff gauge
Main canals	Management of diversion gate	*Cerrador*: 2 persons	Small truck 1 unit
	Management of canal (canal, diversion facility)	Manager of canal, and diversion facility: 3 persons	Small truck 3 unit Small back hoe: 1 unit
Administration	Budget, provision of material and equipment, vehicle General affair	Accountant, mechanic, general affair, typist: 4 persons	Administrative material and equipment: 1 unit

4) O & M cost

Integrated canal association

O & M cost consists of repairing costs of the integrated diversion weir, main canals, diversion facilities, maintenance cost of the office, personnel expenses, maintenance cost of management equipment and so on. These costs are paid by farmers who use the facilities concerned in accordance with the number of *Acción*.

- O & M cost of the weir is paid by farmers who belong to 10 canal associations in the right bank and 2 canal associations in the left bank. Allotment is collected through regional canal associations.
- O & M cost of the main canal is paid by canal associations in the left bank.

Regional canal associations

Components of O & M cost of regional canal associations which are self-independent by regional water system organization are O & M cost of the secondary and tertiary canals, a maintenance cost of the office, personnel expenses, maintenance cost of management equipment, and so on. These costs are paid by beneficiaries of the facilities in accordance with the number of *Acción*.

Components of O & M cost

The integrated diversion weir and the main canal

Items of expense	Components of O&M	Expense (pesos)
O&M cost of facilities	Clerical staff and engineer	43,200,000
O&M cost of materials and equipment	Maintenance materials and equipment, operation of bulldozer	4,000,000
Personnel expenses of maintenance works	Labor for repairing and O&M	7,200,000
Total		54,400,000

Canals after the secondary canals (by regional canal associations)

Items of expense	Components of O&M	Expense (pesos)
O&M cost of facilities	Clerical staff and engineer	21,600,000
O&M cost of materials and equipment	Maintenance materials and equipment, operation of bulldozer	2,500,000
Personnel expenses of maintenance works	Labor for repairing and O&M	1,800,000
Total		25,900,000

1.5 Development Impact and Evaluation

1.5.1 Project Evaluation

(1) Basic assumption

1) The economic life of the project facilities is 30 years. Replacement costs for gates and machinery are included after 20 years when project works are completed.
2) All prices are shown in 1998 prices of Chilean pesos.
3) Evaluation is made on financial and economic aspects. Market prices are used for financial evaluation and economic prices for economic evaluation.
4) Economic evaluation of the project requires conversion of market prices into economic prices. For this purpose, adjustment factors provided by the Chilean Planning Ministry consist of the following:

Foreign currency	1.06	Skilled labor	1.00
Semi-skilled labor	0.65	Unskilled labor	0.85
Social Discount Rate	12%		

On economic prices, tariff of 11% and value added tax of 18% are subtracted as transfer expenditure.

(2) Benefits

1) Quantified benefits in the Popeta project area include increase of agricultural production and hydroelectric generation.
2) Financial agricultural benefits in the Popeta area takes $916,642/ha “with project” condition, because present value of agricultural production “without project” is so small that it is negligible.
3) Transformation of agricultural benefit into economic prices is undertaken

by applying the standard coefficient of transformation. The production costs are classified into foreign and local currency portions. In case of foreign currency portion, transformation coefficient is applied to it after excluding tariff and value added tax. On the other hand, in case of local currency portion, transformation coefficient is applied to personnel expenses after excluding value added tax. Share of personnel expenses is adopted at 25% of local currency portion. The rest of that, 75% is cost of input materials and equipment. The transformation coefficient is applied to it after excluding value added tax.

4) Benefits from hydroelectric generation are estimated at $25/kwh, 10% generation loss, and 95% of bill collection rate. Marginal cost estimated at $7.657/kwh by the National Energy Commission (CNE) in April 1998 applies to economic benefits from hydroelectric generation.
5) Transformation of items which cannot be divided clearly is undertaken by applying the standard transformation coefficient of 0.96, which is used in the Chilean foreign trade data.

Accordingly, market prices and economic prices of the project are presented in the table below.

Benefits	Market Prices	Economic Prices
Agriculture	916,642 ($ /ha)	1,122,311 ($ /ha)
Hydroelectric generation	487 ($ Million)	149 ($ Million)

(3) Costs

Costs used in the project evaluation are allocated costs to the project of the Popeta area among total project cost. The project cost in market prices is the cost which was estimated in the previous chapter. On transformation of the project cost into economic prices, the project cost is divided into foreign and local currency portion. In case of foreign currency portion, transformation coefficient is applied to it after excluding import tariff and value added tax. In case of local currency portion, transformation coefficient is applied to personnel expenses after excluding value added tax. Share of personnel expenses is adopted at 20% of local currency portion. The rest of that, 80% is cost of input materials and equipment. Land acquisition cost is excluded from economic prices.

Accordingly, market prices and economic prices of the project are presented in the table below.

	Market Prices ($ Million)	Economic Prices ($ Million)
Project costs	29,258	22,565

(4) Evaluation

Evaluation results indicated in internal rate of return (IRR), benefit cost ratio (B/C), net present value (NPV) at social discount rate of 12% are shown in the table below. The details are presented in Table 1.5.1.

Evaluation	IRR (%)	NPV at 12% ($ Million)	B/C
Financial	15.4	3,949.1	1.26
Social	21.1	9,231.3	1.80

(5) Sensitivity analysis

Sensitivity analysis is conducted in case that 10% increase in cost and 10% reduction in benefit are occurred, simultaneously. As shown in the table below, even

in case that increase of cost and decrease of benefit are occurred simultaneously, internal rate of return (IRR) exceeds the social discount rate of 12%.

Sensitivity Analysis	Internal Rate of Return (IRR)	
	Economic	Financial
1. Basic Case	21.1%	15.4%
2. Cost Increase: + 10%	19.4%	13.9%
3. Benefit Reduction: -10%	19.2%	13.8%
4. 2+3	17.6%	12.5%

1.5.2 Financial Analysis

The effects of the project on typical farms are examined in the table below on the basis of the improving farmers' income and expenditure, repayment of the project cost and operation & maintenance cost relevant to each farmer stemming from the agricultural development plan. The repayment of the project cost by farmers is examined in the cases that the subsidy for the project is not provided, and 75% of the project cost is subsidized. In those cases, the term of repayment is set up at 20 years at 12% of interest rate. Annual operation and maintenance cost does not include subsidy.

Item	5 ha	15 ha	40 ha	200 ha
Popeta Project				
Average area (ha)	5	15	40	200
Number of farms	132	40	54	8
Investment cost	$3,846,827,092	$3,497,115,538	$12,589,615,936	$9,325,641,434
O&M cost	$3,405,179	$3,095,618	$11,144,223	$8,254,980
Investment/farm	$29,142,629	$87,427,888	$233,141,036	$1,165,705,179
O&M/farm	$25,797	$77,390	$206,375	$1,031,873
Income and Expenditure of Farmers				
Gross income	$6,526,045	$15,182,713	$58,173,310	$270,436,670
Production cost	$3,453,545	$4,352,713	$16,113,310	$86,286,670
Net income	$3,072,500	$10,830,000	$42,060,000	$184,150,000
Living expenses	$1,800,000	$2,400,000	$3,000,000	$6,000,000
Net profit	$1,272,500	$8,430,000	$39,060,000	$178,150,000
Without subsidy				
Investment/year/farm	$3,901,580	$11,704,739	$31,212,637	$156,063,187
O&M/year/farm	$25,797	$77,390	$206,375	$1,031,873
Total cost/year/farm	$3,927,377	$11,782,129	$31,419,012	$157,095,060
Net profit/year/farm	$1,272,500	$8,430,000	$39,060,000	$178,150,000
Surplus/year/farm	($2,654,877)	($3,352,129)	$7,640,988	$21,054,940
With 75% subsidy				
Investment/year/farm	$975,395	$2,926,185	$7,803,159	$39,015,797
O&M/year/farm	$25,797	$77,390	$206,375	$1,031,873
Total cost/year/farm	$1,001,192	$3,003,575	$8,009,534	$40,047,670
Net profit/year/farm	$1,272,500	$8,430,000	$39,060,000	$178,150,000
Surplus/year/farm	$271,308	$5,426,425	$31,050,466	$138,102,330

In Popeta, farmers who hold 5ha or 15ha land need 75% subsidy to repay the project cost. Although the annual surplus of 5ha farmers is low, $271,308, their living expenses would be improved significantly. In case of farmers who hold more than 5ha land, annual surplus is $5,426,425 with 15ha farmers, $31,050,466 with 40ha farmers, and $138,102,330 with 200ha farmers. Accordingly, in Popeta area, any landholding scale farmers have ability to repay the project cost and to pay operation and maintenance cost, in case that there is 75% subsidy against the project cost.

1.5.3 Other Development Impact

By the project implementation, following socio-economic impacts is expected in addition to the benefit estimated by financial and economic evaluation. The effect of the project implementation will be borne by following conditions ;

- Inhabitants' will to improve the present situation

- Promotion of the project by participation of inhabitants
- Support organization system for realizing the will of improvement
- Construction and improvement of irrigation facilities and highly-advanced land use
- Expansion of irrigable area
- Activation of agriculture by improvement of irrigation facilities, highly-advanced land use and improvement of farming technique.
- Advancement of product marketability and promotion of diversification
- Promotion of socio-economic interchange by improvement of roads
- Activation of the area based on CECUV
- Conservation of regional environment through permanent settlement of farmers

Main expected socio-economic impact by the project implementation is as follows;

(1) Creation of the solidarity among inhabitants

In the process of the project, the beneficiaries themselves are to participate the plan for improvement of the present situation, and agreement on the goal of better improvement is formed. As a result, solidarity of inhabitants is created. Based on the solidarity of inhabitants, it is expected that mutual confidence of farmers, who are easy to be isolated, is created and then motivation of creating various organizations such as producers' cooperation is established.

(2) Stable supply and diversification of agricultural products

The project implementation is expected to promote stable self-sufficiency of main crops and contribute to economic independence of the area by regular and stable supply of agricultural products such as vegetable and the others. Corresponding to regular and stable supply of agricultural products to markets, a planned commercial crop production system will be established in the future. This leads to organizing collection and shipment, and promoting agricultural processing industries. Moreover, it is expected that quality of the production for shipment is improved in order to enhance the marketable value of productions.

(3) Establishment of systematic water use

Existing individual canal associations are integrated by construction of the integrated diversion weir in the project and then, the systematic water use for the area as a whole is established. As a result, in the existing irrigation systems, accuracy of agricultural water conveyance increases due to diversion discharge from the newly constructed main canals. This contributes to the improvement of agricultural environment in the area as a whole. Moreover, establishment of systematic water use brings about forming feeling of the solidarity among the beneficiaries and contributes to smooth operation of various activities in the area as a whole.

(4) Promotion of organizing farmers

In the process of promoting the project by participation of inhabitants, individual farmers' viewpoints and direction of eagerness for improvement are clarified. This is an opportunity to promote establishing organizations such as producers' organizations. It is expected that uniting farmers, who are responsible for the management of the area, becomes the motive power to promote socio-economic self-reliance.

(5) Increase of job opportunity

During the construction period of the project, job opportunity is created because most of construction workers might be recruited from farmers in and around the project area. It is expected that the technique which the employed farmers achieve through the construction works is useful for operation, management and maintenance of the constructed irrigation system and roads by farmers.

After implementation of the project, activation of agricultural production activities in the area crate job opportunity. Creation of job opportunity for non-farm households can be also expected because increased farm works by irrigation and intensive land use boosts the demand of labor force in and around the project area.

These created job opportunity alleviates out flow of rural population to big cities such as Santiago and contributes to balanced development of the country.

(6) Increase of intention for working

Compared to low productivity of the present agriculture, increase of agricultural production and its result, improvement of living standard after the project implementation give the farmers satisfaction and sufficiency in the area. This raises farmers' intention to increase the productivity, and promotes development of the area.

(7) Activation of socio-economic activities

Traffic condition in the area are to be significantly improved by construction of road networks. Established road network promotes activation of socio-economic activities through activating and easing interchange of people and materials not only within the area but also outside of the area. The activities of CECUV promote comprehensive interchange in the area as a whole. The comprehensive interchange leads to the motive power of activating and developing the area.

(8) Development of regional economy

It is expected that increase of agricultural products brings about increase of farmers' income after the project implementation. Increases of farmers' purchasing power can contribute largely to development of regional economy and also stable national economy of Chile.

(9) Development of human resource

CECUV is expected to be a base of manpower development for not only the area but also Chile by fostering human resources who will be in charge of rural areas through conducting social education and technical training on such as living improvement, irrigation technique, agricultural technique, operation and maintenance of various facilities and environment. The activities of the center are expected to promote women's participation in the project and to improve their social status.

(10) Impact on the environment

The project implementation contributes to conservation of national and regional natural environment through farmers' stable engagement in agricultural production activities. Conduction of environmental education in the activities of CECUV makes the relationships between agriculture and environment, and between human activities and environment clear. This becomes the motive power to promote practical activities of environmental conservation.

1.5.4 Justification of the Project

The objectives of the project implementation are providing the support for farmers' will to improve the present situation in order to improve agricultural productivity, and realizing comfortable rural areas as the place for permanent settlement. On the other hand, the precondition of the project is that the development for achieving the objectives is harmonized with the nature.

In the development plan, agricultural production increases through improvement of the present farming by improvement of basic infrastructure based on the objectives and the preconditions mentioned above. Farmers' income growth resulted from the development plan is reflected in not only household expenditure but also improvement of farmers' quality of life as a whole with development of living infrastructure and improvement of knowledge and technique. Then, it is promoted that the farmers can be free from the present situation.

Improvement of the basic rural living condition as living environment satisfies the condition of permanent settlement. At the same time, through the activities of farmers' production activities in the area, activation of socio-economic interchange such as human communication among inhabitants in the area activates the area as a whole.

The method of development intends to minimize the impacts on the natural environment and ecosystem as much as possible. Introduction of agricultural technique also cares them very carefully. As a result, the impacts of the development plan implementation on natural environment are minimized.

Evaluating implementation of the proposed development plan from the point of economic aspect, economic internal rate of return (EIRR) of the entire project is 21.1 %.

Accordingly, the implementation of the project is justified.

1.6 Conclusion and Recommendation

1.6.1 Conclusion

As the results of studying and examining the present situation, problems, development potentials in order to formulate the agricultural development project in Popeta area, following conclusions are obtained.

(1) In the project area, small scale cereal and traditional crop cultivation and extensive animal raising are mainly carried out in most farmland because surface water use is limited by rainfall in winter. Recently, large scale year-round cultivation of fruits and forage crops by utilizing groundwater has increased. In the plan, it is proposed that existing unirrigated area of 21,000ha is irrigated by unused water right ($25m^3$/sec) in the Maipo river. In this project, a part of 21,000ha, 5,000ha is to be irrigated in the Popeta area. The components of the plan are formed by improvement of production and living infrastructure, of farm management for small scale farmers, and support services for making them possible in accordance with agricultural policy, "Strategic Agenda" which aims at improving production infrastructure by irrigation improvement, and strengthening farming of medium and small scale farmers.

(2) Accordingly, the plan on facility improvement in the project area are proposed as follows.

Component	Unit	Quantities
Agricultural production infrastructure development		
Irrigation area	ha	4,975
Integrated diversion weir	unit	1
Main canals	km	59.3
Secondary canals	km	67.3
Tertiary canals	km	235.0
Improvement of existing canals	km	22.0
Regulation reservoir	sites	10
Rural infrastructure development		
Road		
Pavement of main road	km	30.0
Improvement of lateral road	km	21.6
Construction of lateral road	km	14.5
Rural water supply facilities	sites	2
Rural sewage treatment facilities	sites	8
CECUV	sites	7

(3) Total investment for implementation of the project mentioned above is estimated at 83,248 million pesos (local currency portion: 48,458 million pesos, foreign currency portion: 34,790 million pesos) as a whole. Required period of constructions is proposed 7 years including the period of the detailed design.

(4) The economic internal rate of return of the project is 21.1% according to the required cost and the expected benefit. Socio-economic impacts resulted in the project implementation are expected to be improvement of productivity through intensive utilization of land and water, strengthening small scale farmers, expansion of irrigated farmland, activation of agricultural activities and creation of job opportunity.

1.6.2 Recommendation

(1) The project implementation benefits directly to the farmers in the project area. Especially, economic balance of the small scale farmers is improved drastically. In addition, as the proposed integrated diversion weirs of the Maipo river includes water intake of existing irrigation systems, the project implementation contributes to establishing the system to adjust of water utilization among the users in the third section of the Maipo river. Therefore, it is recommended that the government of Chile would prepare to implement the project early based on the results of the F/S.

(2) Because Government ordinance No.1123 applies to the project, close cooperation between CNR and DOH is necessary at every stage such as adoption of the project, approval of the project, and implementation of the project. Therefore, establishment of the project promotion committee consisting of CNR and DOH is recommended.

(3) The beneficiaries of the project in new irrigation areas need to establish the project promotion organization as the local receiver organization under the guidance of OMPC. It is necessary to establish new canal associations relevant to new irrigation and the integrated diversion weir canal association which consists of existing and new canal associations relevant to the integrated diversion weir. Establishment of these new canal associations is carried out by the project promotion organization. Accordingly, it is recommended to start discussion early among the project promotion committee, relevant Comuna and UV which will be a core of the project promotion organizations.

(4) Agricultural development project in Popeta area is established on the premise that the unused water right of 25 m^3/sec (*Reserva Fiscal*) which DOH is reserved in the second section of Río Maipo is utilized as the water source of the project. Available irrigation water for the project is settled with the runoff condition on 85% exceedance probability of Río Maipo taking the exisiting water utilization into account. Along with the execution of the fesibility study on the agricultural development project in Popeta area, Chilian side applies to the DOH for legislation of the reserved water right as the substantial water right. No conclusion on the legislation procedures is met at the time of

compilation on this Final Report. When a change of contents on the water right is arisen through the legislation procedures of reserved water right, it is necessary to consider the supplemental and/or alternative water source for the project. Following should be studied for the supplemental and/or alternative water source; (1) Utilization of runoff on rivers flowing in the projected area is impossible because no thaw water is available in the river basin of the projected area. (2) Utilization of groundwater in the projected area is not suitable as the new water source taking the annual rainfall (450 mm), irrigation requirement (800 to 1,000 mm) and present utilization of groundwater. Groundwater utilization should be restricted to the small scale development without influences on the present utilization. (3) Flood of the Río Maipo caused by the rainfall in the winter season is discharged to the sea without contribution for the present water utilization. As an alternative water source, it should be planned to storage flood runoff in the projected areas. (4) As the facilities to storage flood runoff, heightening of dam body on regulation reservoir that designed in this report is proposed as realistic measures to increase storage volume for the project.

Table 1.2.1 Irrigation Water Requirement (Popeta)

	Item	Area (ha)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
5 ha														
	Wheat	0.130	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.98	148.78	217.31	159.68	44.25
	Potato	0.100	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.98	142.24	250.74	291.18	247.80
	Pumpkin (1)	0.020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.90	111.40	191.04	169.45	86.45
	Pumpkin (2)	0.020	90.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.12	176.71	244.22	191.58
	Cucumber (1)	0.020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.74	104.93	138.74	64.58	0.00
	Cucumber (2)	0.020	76.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.44	139.30	219.17	205.67
	Tomato	0.040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.66	106.27	197.01	216.56	88.50
	Forage Crop (Maiz)	0.040	204.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.40	198.20	303.71	371.70
	Alfalfa	0.140	278.54	240.41	172.35	102.92	6.95	0.00	0.01	18.81	75.37	159.20	234.83	265.50
	Avocado	0.200	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Unused Land	0.270												
	Total	1.000	73.21	53.25	38.17	23.84	1.90	0.00	0.00	18.95	67.02	120.26	136.65	117.42
10 ha														
	Wheat	0.120	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.98	148.78	217.31	159.68	44.25
	Potato	0.030	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.98	142.24	250.74	291.18	247.80
	Cucumber (1)	0.015	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.74	104.93	138.74	64.58	0.00
	Cucumber (2)	0.015	76.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.44	139.30	219.17	205.67
	Forage Crop (Maiz)	0.030	204.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.40	198.20	303.71	371.70
	Water Melon	0.020	141.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36.89	160.00	266.14	300.90
	Green Bean	0.020	154.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.67	206.12	144.55
	Alfalfa	0.200	278.54	240.41	172.35	102.92	6.95	0.00	0.01	18.81	75.37	159.20	234.83	265.50
	Avocado	0.250	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Seed Production (Hybrid)	0.050	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Unused Land	0.250												
	Total	1.000	100.95	72.57	52.02	32.38	2.55	0.00	0.00	16.37	59.87	111.43	135.21	125.73
15 ha														
	Maize	0.100	269.25	146.33	37.92	0.00	0.00	0.00	0.00	0.00	14.92	89.31	144.81	274.35
	Pumpkin (1)	0.007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.90	111.40	191.04	169.45	86.45
	Pumpkin (2)	0.007	90.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.12	176.71	244.22	191.58
	Cucumber (1)	0.010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.74	104.93	138.74	64.58	0.00
	Cucumber (2)	0.010	76.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.44	139.30	219.17	205.67
	Forage Crop (Maiz)	0.020	204.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.40	198.20	303.71	371.70
	Tomato	0.013	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26.66	106.27	197.01	216.56	88.50
	Green Bean	0.020	154.74	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	65.67	206.12	144.55
	Alfalfa	0.100	278.54	240.41	172.35	102.92	6.95	0.00	0.01	18.81	75.37	159.20	234.83	265.50
	Avocado	0.200	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Vineyard	0.200	204.26	176.30	125.11	65.18	0.00	0.00	0.00	0.00	38.56	78.27	160.03	194.70
	Seed Production (Hybrid)	0.033	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Unused Land	0.280												
	Total	1.000	129.33	93.52	60.09	32.76	1.62	0.00	0.00	6.33	35.45	77.18	116.84	136.44
50 ha														
	Wheat	0.040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.98	148.78	217.31	159.68	44.25
	Maize	0.060	269.25	146.33	37.92	0.00	0.00	0.00	0.00	0.00	14.92	89.31	144.81	274.35
	Pumpkin (1)	0.020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.90	111.40	191.04	169.45	86.45
	Pumpkin (2)	0.020	90.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.12	176.71	244.22	191.58
	Flower	0.030	106.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.46	151.24	253.09	256.65
	Alfalfa	0.100	278.54	240.41	172.35	102.92	6.95	0.00	0.01	18.81	75.37	159.20	234.83	265.50
	Avocado	0.100	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Lemon	0.040	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Orange	0.040	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Peach	0.080	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Cherry	0.040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Ciruelos	0.060	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Vineyard	0.200	204.26	176.30	125.11	65.18	0.00	0.00	0.00	0.00	38.56	78.27	160.03	194.70
	Seed Production (Hybrid)	0.020	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Seed Production (Maize)	0.060	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Unused Land	0.090												
	Total	1.000	116.19	85.71	57.17	31.82	1.53	0.00	0.00	8.39	52.61	110.96	153.62	156.74
100 ha														
	Wheat	0.040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	48.98	148.78	217.31	159.68	44.25
	Maize	0.060	269.25	146.33	37.92	0.00	0.00	0.00	0.00	0.00	14.92	89.31	144.81	274.35
	Pumpkin (1)	0.010	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13.90	111.40	191.04	169.45	86.45
	Pumpkin (2)	0.010	90.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	62.12	176.71	244.22	191.58
	Alfalfa	0.100	278.54	240.41	172.35	102.92	6.95	0.00	0.01	18.81	75.37	159.20	234.83	265.50
	Avocado	0.100	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Orange	0.070	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Lemon	0.070	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Peach	0.040	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Cherry	0.020	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Plum	0.050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Vineyard	0.240	204.26	176.30	125.11	65.18	0.00	0.00	0.00	0.00	38.56	78.27	160.03	194.70
	Seed Production (Hybrid)	0.010	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Seed Production (Maize)	0.090	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Unused Land	0.090												
	Total	1.000	128.53	98.64	66.39	37.26	1.81	0.00	0.00	9.55	53.34	107.16	148.52	154.78
200 ha														
	Maíz	0.075	269.25	146.33	37.92	0.00	0.00	0.00	0.00	0.00	14.92	89.31	144.81	274.35
	Arveja	0.055	0.00	0.00	0.00	0.00	0.00	0.00	0.01	14.17	98.21	115.58	79.21	0.00
	Alfalfa	0.100	278.54	240.41	172.35	102.92	6.95	0.00	0.01	18.81	75.37	159.20	234.83	265.50
	Paltos	0.100	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Mandarinas	0.080	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Limoneros	0.080	113.48	97.94	70.22	47.17	4.63	0.00	0.00	15.16	45.78	79.60	95.67	108.17
	Duraznos	0.050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Ciruelos	0.050	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	45.78	115.42	156.55	137.67
	Viñas	0.240	204.26	176.30	125.11	65.18	0.00	0.00	0.00	0.00	38.56	78.27	160.03	194.70
	Semillero maíz	0.060	73.53	0.00	0.00	0.00	0.00	0.00	0.00	19.34	119.47	229.25	272.40	193.92
	Sin uso	0.110												
	Total	1.000	130.99	102.79	68.36	38.20	1.90	0.00	0.00	7.76	46.96	93.75	133.98	147.38

Table 1.3.1 Agricultural Development Project Total Construction Cost in Popeta Area

（Unit : Thousand Pesos）

Description	F.C	L.C	Total
1 Preparation Cost			
1) Agricultural Production Infra	1,328,630	1,790,168	3,118,798
2) Rural Infrastructures	48,064	92,359	140,423
Sub-total	1,376,694	1,882,527	3,259,221
2 Civil Facilities Construction Cost			
(1) Agricultural Production Infrastructure Construction Cost			
1) Integrated Diversion Weir	3,082,109	2,634,195	5,716,304
2) Main Irrigation Canal	11,229,864	18,858,582	30,088,446
3) Secondary Irrigation Canal	743,667	3,923,895	4,667,562
4) Regulation Reservoir	5,337,186	8,895,756	14,232,942
5) Tertiary Irrigation Canal	1,295,407	896,329	2,191,736
6) Small Scale Hydropower Ge	4,884,368	594,605	5,478,973
Sub-total	26,572,601	35,803,362	62,375,963
(2) Rural Infrastructure and Agricultural Support Facilities Construction Cost			
1) Agricultural Support Facilitie	53,534	32,854	86,388
2) Rural Infrastructures	517,697	277,219	794,916
3) Rural Road	295,610	1,229,305	1,524,915
4) Community Centers (CECU\	94,440	307,806	402,246
Sub-total	961,281	1,847,184	2,808,465
3 Land Acquisition and Compensation Cost			
1) Agricultural Production Infra	0	38,606	38,606
2) Rural Infrastructures	0	2,288	2,288
Sub-total	0	40,894	40,894
4 Engineering and Administration Cost			
1) Agricultural Production Infra	2,620,558	4,294,467	6,915,025
2) Rural Infrastructures	96,128	184,718	280,846
Sub-total	2,716,686	4,479,185	7,195,871
5 Total (1-4)	31,627,262	44,053,152	75,680,414
6 Physical Contingencies (10%)	3,162,726	4,405,315	7,568,041
7 Total (5+6)	34,789,988	48,458,467	83,248,455
8 Price Contingencies	6,024,516	8,022,597	14,047,113
9 Grand Total	40,814,504	56,481,064	97,295,568

Table 1.3.2 Disbursement Schedule (Total Construction Cost in Popeta Area)

（Unit : Million Pesos）

Year	F.C	L.C	Total
2000	0.0	0.0	0.0
2001	1,048.2	1,733.1	2,781.3
2002	1,702.1	2,830.3	4,532.4
2003	4,600.9	6,852.7	11,453.6
2004	9,316.9	14,861.4	24,178.3
2005	15,135.5	18,765.0	33,900.5
2006	8,885.2	11,564.2	20,449.4
Total	40,688.8	56,606.7	97,295.5

Table 1.4.1 Project Implementation Schedule in Popeta Area

Development Items	Quantities	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008
1. Project Evaluation by the Government of Chile											
2. Provision of Fund by the Government of Chile											
3. Agricultural Development Project in Popeta Area											
(1) Preparation Works for the Implementation of the Project											
Contract with Consultant Company	1.0	unit									
Detail Design Study	1.0	unit									
Land Acquisition and Compensation	1.0	unit									
Selection and Contract of Construction Company	1.0	unit									
(2) Agricultural Production Development Project											
Construction of Integrated Diversion Weir	320.0	m									
Construction of Irrigation Canals											
Construction of Main Irrigation Canals	50.0	km									
Construction of Secondary Irrigation Canals	130.0	km									
Construction of Farm Ditches	5000.0	ha									
Construction of Regulation Reservoir	10.0	Places									
(3) Rural Infrastructure Development Project											
Construction of Road	66.1	km									
Construction of Rural Water Supply Facilities	2.0	Places									
Construction of Rural Sewage Treatment Facilities	8.0	Places									
Construction of Community Centers (CECUV)	7.0	Places									

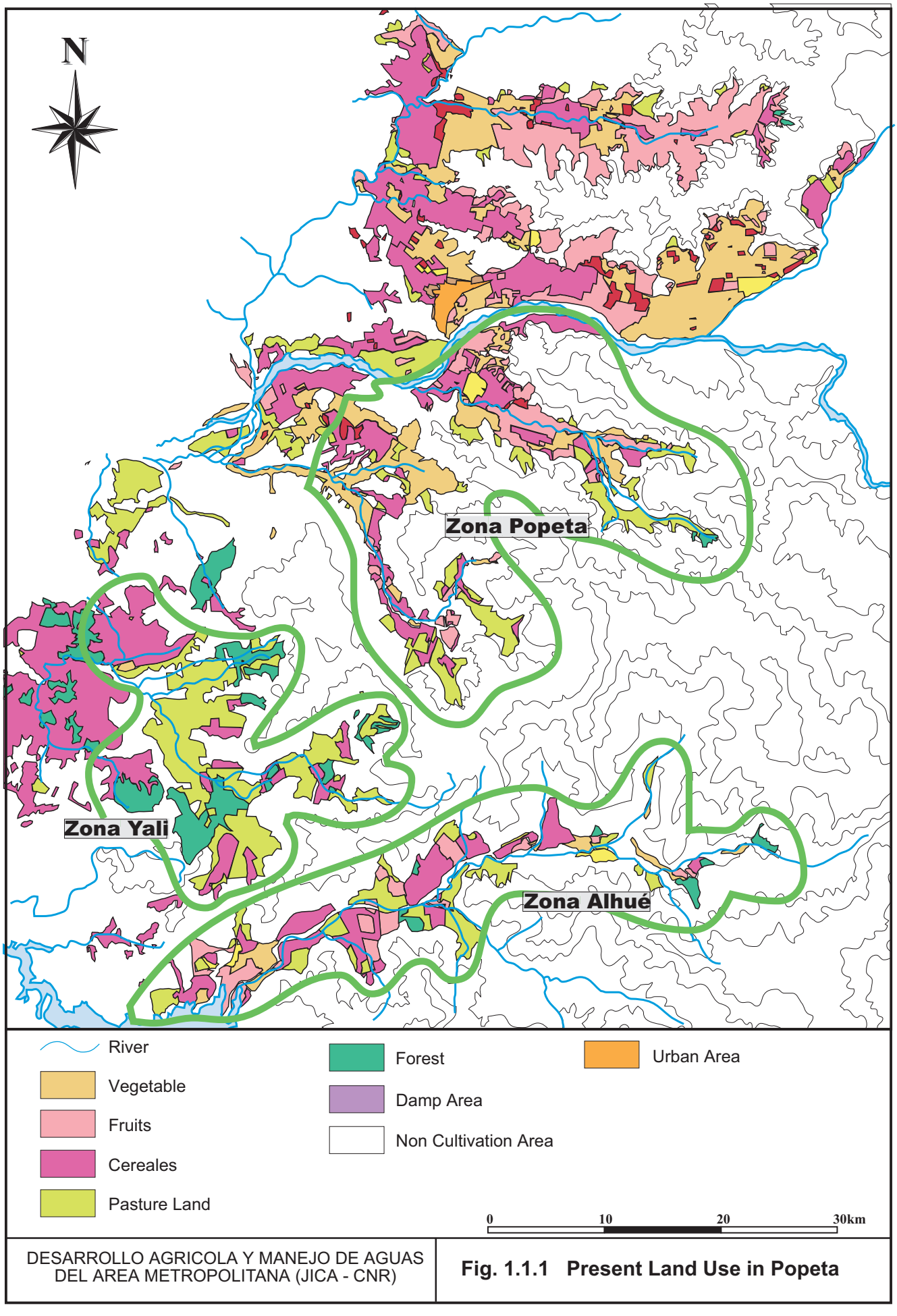
Table 1.5.1 Project Evaluation (Popeta Area)

＜Financial Evaluation of the Project：Popeta＞

Year	Costs			Benefits			Cash	Cost	Benefit	Cost + 10%
	Investment	O & M	Total	Agriculture	Electricity	Total	Flow	[+10%]	[-10%]	Benefit-10%
2000			0.0			0.0	0.0	0.0	0.0	0.0
2001	528.5		528.5			0.0	-528.5	-581.4	-528.5	-581.4
2002	820.1		820.1			0.0	-820.1	-902.1	-820.1	-902.1
2003	2565.5		2565.5			0.0	-2565.5	-2822.1	-2565.5	-2822.1
2004	6469.9		6469.9			0.0	-6469.9	-7116.9	-6469.9	-7116.9
2005	10896.3	2.6	10898.9	916.6	108.6	1025.2	-9873.7	-10963.6	-9976.2	-11066.1
2006	6682.4	7.8	6690.2	2291.6	222.9	2514.5	-4175.7	-4844.7	-4427.1	-5096.1
2007		20.7	20.7	3666.6	397.1	4063.6	4042.9	4040.9	3636.6	3634.5
2008		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2009		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2010		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2011		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2012		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2013		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2014		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2015		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2016		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2017		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2018		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2019		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2020		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2021		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2022		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2023		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2024		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2025		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2026	1296.6	25.9	1322.5	4583.2	487.1	5070.3	3747.8	3615.6	3240.8	3108.5
2027		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2028		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
2029		25.9	25.9	4583.2	487.1	5070.3	5044.4	5041.8	4537.4	4534.8
			$15,003.8			$18,952.9				
						IRR=	15.37%	13.94%	13.79%	12.45%
						NPV(12%)=	$3,949.1	$2,448.7	$2,053.8	$553.4
						B/C=	1.26			

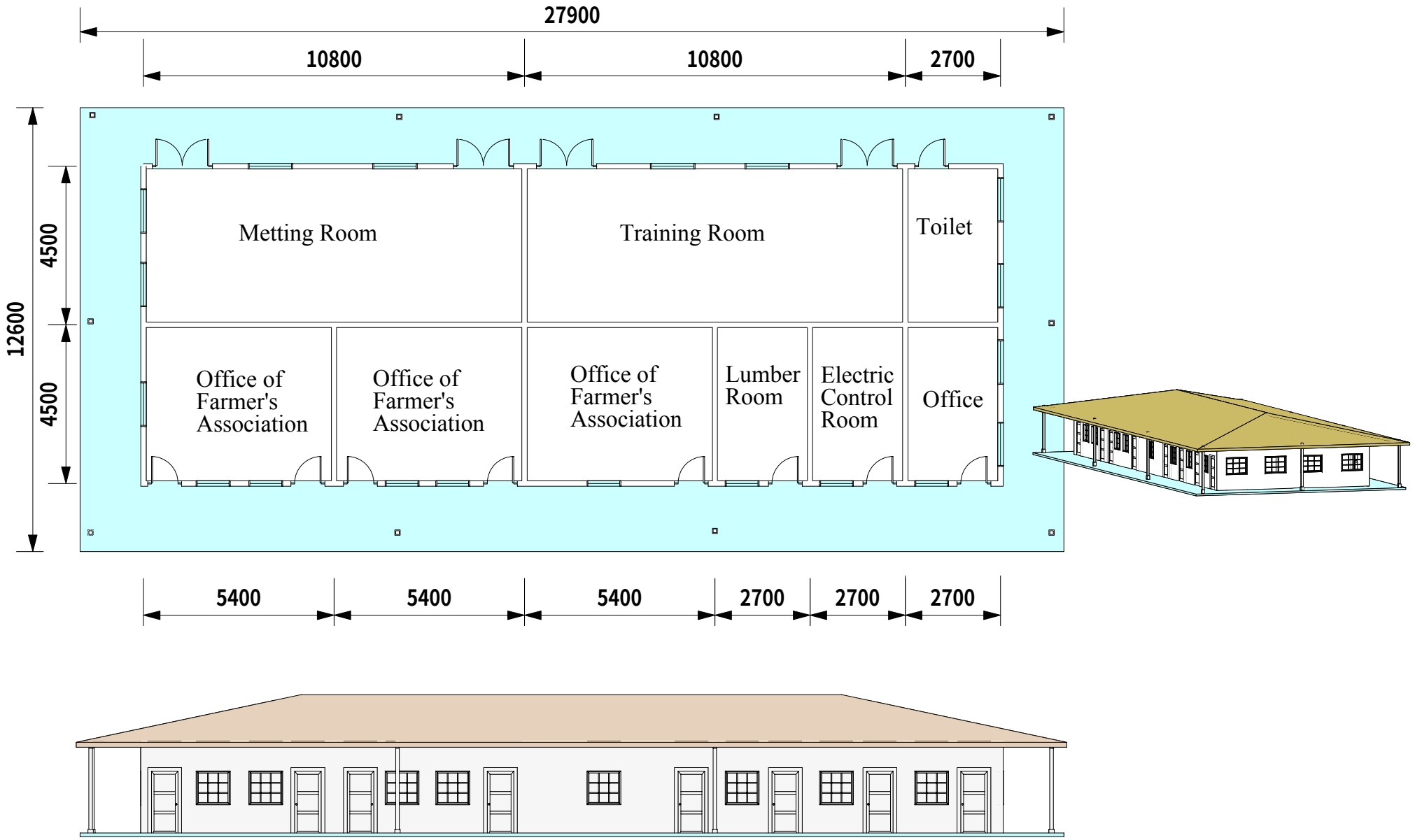
＜Social Evaluation of the Project：Popeta＞

Year	Social Cost			Social Benefits			Cash	Cost	Benefit	Cost+10%
	Foreign	Local	Total	Agriculture	Electricity	Total	Flow	[+10%]	[-10%]	Benefit-10%
2000	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0
2001	154.1	251.9	406.0	0.0	0.0	0.0	-406.0	-446.6	-406.0	-446.6
2002	238.3	392.5	630.8	0.0	0.0	0.0	-630.8	-693.8	-630.8	-693.8
2003	926.4	1052.1	1978.6	0.0	0.0	0.0	-1978.6	-2176.4	-1978.6	-2176.4
2004	2124.8	2863.7	4988.6	0.0	0.0	0.0	-4988.6	-5487.4	-4988.6	-5487.4
2005	4249.0	4158.3	8407.3	1122.3	33.3	1155.6	-7251.7	-8092.5	-7367.3	-8208.0
2006	2301.5	2857.5	5159.0	1683.5	68.3	1751.8	-3407.3	-3923.2	-3582.4	-4098.3
2007	3.3	12.6	15.9	3928.1	121.6	4049.7	4033.8	4032.2	3628.8	3627.2
2008	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2009	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2010	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2011	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2012	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2013	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2014	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2015	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2016	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2017	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2018	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2019	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2020	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2021	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2022	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2023	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2024	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2025	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2026	1007.2	15.8	1023.0	5611.6	149.2	5760.8	4737.8	4635.5	4161.7	4059.4
2027	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2028	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
2029	4.2	15.8	19.9	5611.6	149.2	5760.8	5740.8	5738.8	5164.8	5162.8
			$11,568.8			$20,800.2	$9,231.3	$8,074.4	$7,151.3	$5,994.4
						IRR =	21.11%	19.41%	19.23%	17.64%
						NPV =	$9,231.3	$8,074.4	$7,151.3	$5,994.4
						B/C =	1.8			



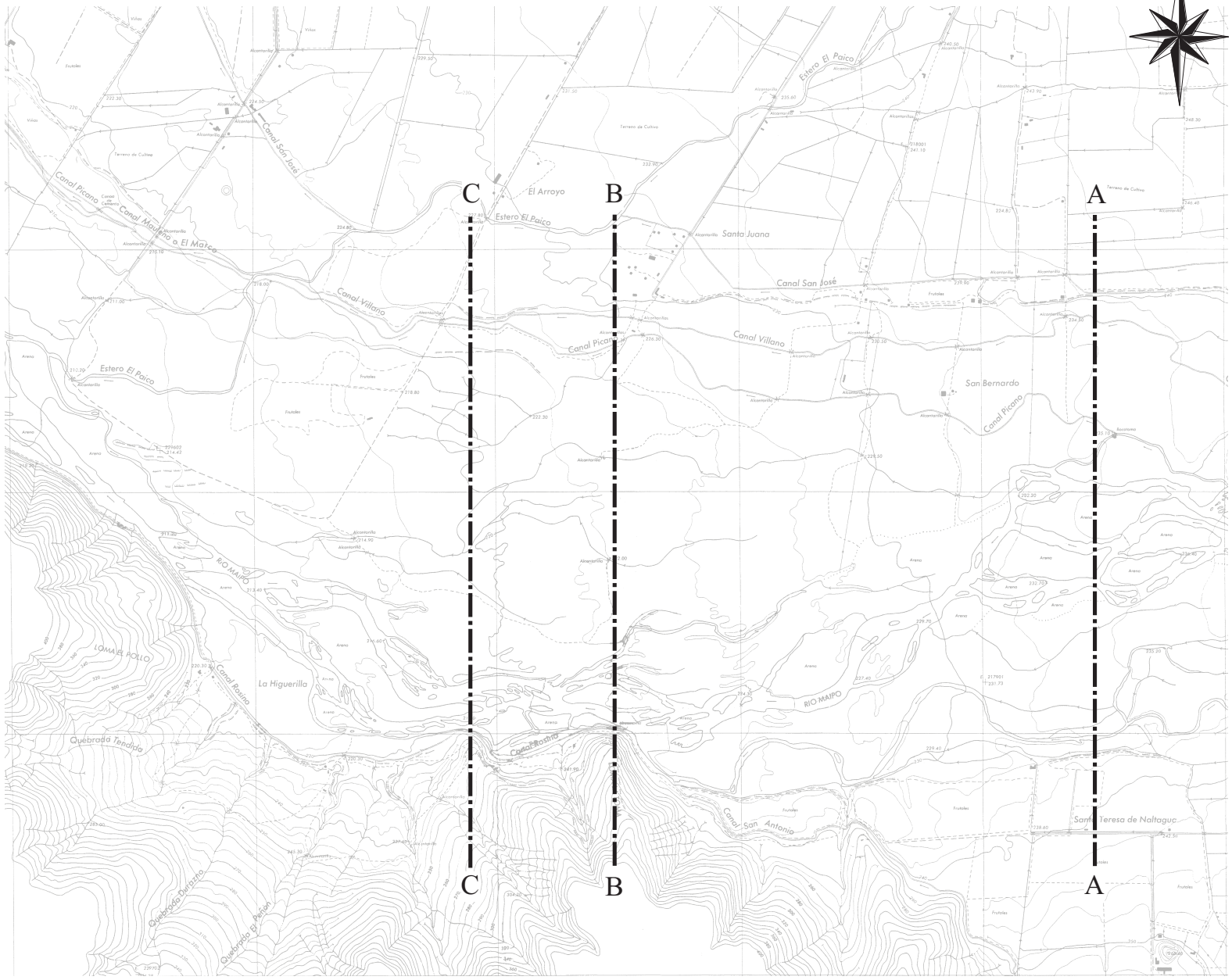
DESARROLLO AGRICOLA Y MANEJO DE AGUAS DEL AREA METROPOLITANA (JICA - CNR)

Fig. 1.1.1 Present Land Use in Popeta



DESARROLLO AGRICOLA Y MANEJO DE AGUAS DEL AREA METROPOLITANA
JICA - CNR

Fig. 1.2.1 PLAN OF CECUV



LEGEND

Axis

Fig. 1.2.2

LOCATION MAP ON COMPARISION OF WEIR AXIS

0 200 400 600 800 m

DESARROLLO AGRICOLA Y MANEJO DE AGUAS DEL AREA METROPOLITANA JICA - CNR

Fig. 1.2.3 Irrigation Diagram