REPUBLIC OF CHILE
NATIONAL IRRIGATION COMMISION
(CNR)

JAPAN INTERNATIONAL
COOPERATION AGENCY
(JICA)

THE STUDY
ON
AGRICULTURAL DEVELOPMENT AND WATER MANAGEMENT
IN METOROPOLITAN AREA

MAIN REPORT

August, 1999

NAIGAI ENGINEERING CO., LTD
ASIA AIR SURVEY CO., LTD

REPUBLIC OF CHILE

THE STUDY ON AGRICULTURAL DEVELOPMENT AND
WATER MANAGEMENT IN METROPOLITAN AREA, CHILE

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Exchange Rate

The exchange rate is as follows:

1.00 $ = 0.002083US$ = 0.2352Yen

August 1998

PREFACE

In response to a request from the Government of Republic of Chile, the Government of Japan decided to conduct the study on Agricultural Development and Water Management in Metropolitan Area and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Chile a study team headed by Mr. Hisashi Terakado, Naigai Engineering Co., Ltd., three times between June 1998 and June 1999.

The team held discussions with the officials concerned of the Government of Chile, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of Chile for their close cooperation extended to the team.

August 1999

Kimio Fujita
President
Japan International Cooperation Agency

▲Large scale vineyard (Pirque)

▲Cultivation of avocado (Maria Pinto)

▲Cultivation of chirimoya (Mallarauco)

▲Collecting and shipping center of strawberry (San Pedro)

▲Direct sale shop by farmers (Talagante)

▲Raising seedling facility manged by a production enterprise of small and medium scale farmers (El Monte)

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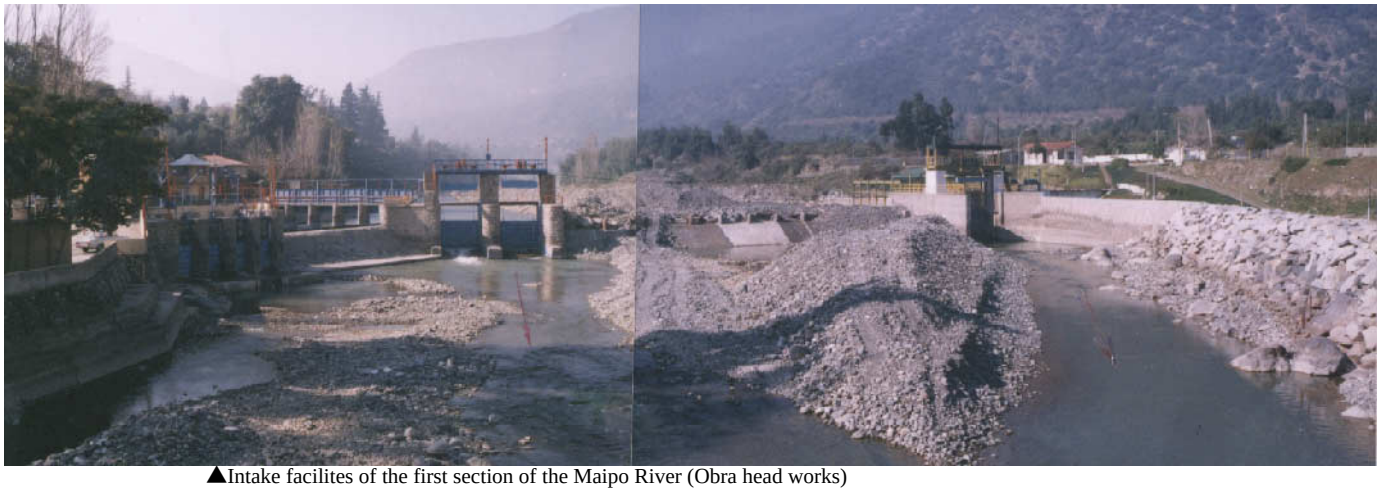
▲Setting nursery stocks of grape and prevention nets against small amnimals with tube irrigation

▲Midstream of the Mapocho River where urban sewage is flew into



▲Intake facilites of the first section of the Maipo River (Obra head works)
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▲Traditional intake facilities (Downstream of the Mapocho River)

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▲Proposed site for new irrigation area in Culipran area

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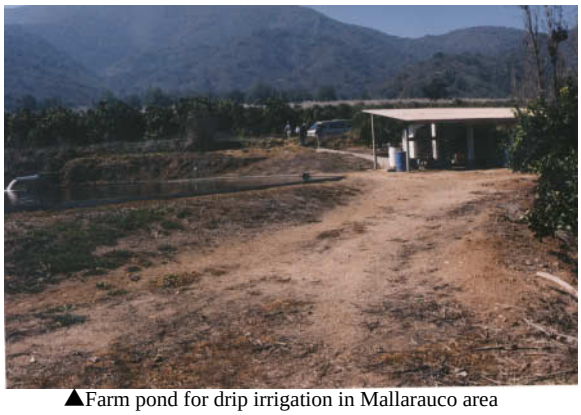
▲Water contamination in the terminal part of Mallarauco canal

▲Water contamination in the terminal part of Mallarauco canal

▲Water contamination in the terminal part of Mallarauco canal



▲Farm pond for drip irrigation in Mallarauco area

▲Complete view of Mallarauco - Manzano area

▲Proposed site for a sewage treatment plant in Mallarauco - Reforma area

▲South main canal in Mallarauco - Las Carrera area

▲Proposed site for a sewage treatment plant in Mallarauco - Las Carrera area

▲Explanation and discussion on Inception Report

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▲Explanation and discussion on Progress Report 2

▲Signing for M/M on Progress 2

ABBREVIATION

Institutions and Organizations

- AGCI Agency for International Cooperation of Chile
- BCC Central Bank of Chile
- CASEN Survey of Socioeconomic Characterization (Ministry of Planning)
- CEPAL Economic Commission for Latin America and the Caribbean
- CIREN Center of Natural Resources Information
- CNR National Irrigation Commission
- CONAF National Forest Corporation
- CONAMA National Environmental Commission
- COREMA Regional Environmental Commission
- CORFO Production Development Corporation
- DGA General Department of Waters
- DOH Department of Hydraulic Works (Former Department of Irrigation)
- DR Department of Irrigation
- EMOS Metropolitan Company of Sanitary Works
- ESSEL El Libertador Company of Sanitary Services
- ESVAL Valparaiso Company of Sanitary Works
- FAO Food and Agriculture Organization of the United Nations
- FOSIS Solidarity and Social Investment Fund
- FUCOA Foundation of Communications, Training and Farming Culture
- IDIEM Institute of Materials Testing Research
- IGM Military Geographic Institute
- INDAP Agricultural Development Institute
- INE National Statistics Institute
- INIA National Institute of Agricultural Research
- INN National Standards Institute
- IRM Intendency of the Metropolitan Region
- MINAGRI Ministry of Agriculture
- MI Ministry of the Interior
- MIDEPLAN Ministry of Planning and Coordination
- MINVU Ministry of Housing and Urbanism
- MOP Ministry of Public Works
- ODEPA Office of Studies and Agricultural Policy
- SAG Agriculture and Livestock Service
- SMAPA Municipal Service of Drinking Water and Sewer System
- PROMM Program of Medium and Small Irrigation Works
- SECPLAC Communal Secretariat of Planning and Coordination
- SEREMI Ministerial Regional Secretariat
- SERNAGEOMIN National Service of Geology and Mining
- UFOCO Union for the Development of Competitiveness
- MEFR Ministry of Economy, Development and Reconstruction

Others

- $ Chilean Peso
- US$ United States Dollar

- B/C Benefit Cost Ratio
- IRR Internal Rate of Return
- SDR Social Discount Rate
- NPV Net Present Value
- EC Electric Conductivity
- BOD Biochemical Oxygen Demand
- DO Dissolved Oxygen
- pH Hydrogen Ion Concentration
- S.S. Suspended Sediment
- mm Millimeter
- cm Centimeter
- m Meter
- km Kilometer
- g Gram
- kg Kilogram
- t Ton
- m^2 Square Meter
- km^2 Square Kilometer
- ha Hectare
- HRB Hectáreas de Riego Básico (= Basic Irrigation Area)
- m^3 Cubic Meter
- MCM Million Cubic Meter
- l Litter
- l/s Litter per Second
- m/s Meter per Second
- m^3/s Cubic Meter per Second
- t/ha Ton per Hectare
- % Percentage
- °C Degree Centigrade
- MSL Mean Sea Level

Republic of Chile

The Study on Agricultural Development
and
Water Management in Metropolitan Area, Chile
Main Report

S U M M A R Y

I MASTER PLAN STUDY

1 Introduction

(1) Authority

The Government of Chile requested the Government of Japan to undertake a study on "Agricultural Development and Water Management in Metropolitan Area, Chile" in July 1996. The study aims mainly to formulate a master plan for agricultural development and water management reflecting upon environmental conditions in metropolitan area, Chile and to conduct a feasibility study for the agricultural development plan(s) in the priority project area(s). The study covers 3,200 km^2 of farm land located in outskirts of Santiago metropolitan area. In response to the request, the Government of Japan dispatched the Preparatory Study Team from November 3,1997 to November 21, 1997 through JICA, and agreed on the Scope of Work for the Study. The study was conducted in two steps; Phase I and Phase II from June, 1998 to March 1999. During the Phase I study, master plan on the agricultural development in the whole study area was formulated. In the Phase II study, feasibility study on priority areas selected among the master plan was carried out. This report describes results of field study and detailed development plans derived from the analysis of present situation of the study area.

(2) Background

The Republic of Chile faces the Pacific Ocean of the South American continent and stretches about 4,300 km from south to north. Andian mountains are the east frontier by Argentine, the north is bordered by Peru and Bolivia, and the south reaches to the Antarctic Ocean. Total population is 15 million and GDP per capita is US$ 5,000 in 1998. The secondary industry is mainstay of economical activities in Chile.

In the beginning of 1970s, economic policy of Chile advanced to the market oriented and open economy. Continuous economic growth is lasting at 6.4 % of average economic growth rate after overcoming the debt crisis in the beginning of 1980s. Recent national economy is also stabilized as shown in the economic parameters such as 8.2 % of inflation rate and 5.5% of unemployment rate. Agriculture and fisheries sector occupies around 7 % of GDP, 14% of employment and 10% of exports, and takes position which next to mining industry in the national economy. Agricultural development policy of the government toward 2000 puts stress on increase of agricultural production and export. And policy also aims at the balanced development of agriculture through supporting and strengthening of small scale farmers.

Agriculture in Chile has large varieties depending on the land condition derived from a long and narrow shape stretching from south to north. Metropolitan region having capital city of Santiago is the important areas of agriculture in the nation because of irrigation facilities provided for a long time, fertile soils and abundant variable climatic condition that is cultivable from sub-tropical till temperate crops. Since the late 1970s, metropolitan area has been expanded drastically with population growth and industrial development in the capital city of Santiago. This phenomena

causes urban sprawl and tightness of water utilization due to increase of demand such industrial water use as water works, hydraulic generation and mining industries.. Moreover, agriculture in the metropolitan area suffers on negative effects by contaminated irrigation water because kinds of crop cultivation are limited. Various water demand in the metropolitan area depends on surface water and groundwater in the Maipo river basin originated in the Andes mountains. According to the situation mentioned above, the evaluation of available water resources, optimum allocation of water, and the conservation of the basin environment have been recognized their necessities.

Reflecting these situations, the government of Chile has been started the study on "Maipo Project" in 1979 by the National Irrigation Commission as the competent authorities. Major objectives of the project were the water source development for the new irrigation scheme, the overall basin irrigation study contributing to the coordination and the management of the present water utilization on the Maipo river basin. The study consisted of four stages; to grasp the natural condition of the basin, to grasp the water demand of the basin, to establish the water utilization plan of the basin and evaluate the project. The first stage had been completed, however, the study had been suspended by the domestic affairs. Review of the first stage study results and the execution of the further stages are the urgent issues

(3) Objectives of the Study

The objectives of the study are; to formulate a master plan for agricultural development and water management reflecting upon environmental conditions in metropolitan area, Chile, to conduct a feasibility study for the agricultural development plan(s) in the priority project area(s) and to carry out technology transfer to the Chilean counterpart personnel through on-the-job training in the course of the study.

(4) Study Area

The study covers the Metropolitan Region and the part of V and VI Regions. Total area for the master plan is about 3,200 square kilometers, which consists of actual and potential irrigated areas.

2 The Present Situation of the Study Area

(1) Rural society

Rural society in Chile was drastically changed from the simple structure, which there are the owners of large plantations and their labor farmers, by Agrarian Reform in 1962. The present rural society is a newly created society which consists of new and old landholders. Therefore, establishing communal society as an unity of inhabitants has been not matured, yet.

The names of administrative division; *Ciudad* (city), *Pueblo* (town), and *Aldea* (village) do not represent the community as a social unit but are just classifications by geographical location.

The unit of the most fundamental organization in rural society is Community Council (*Juntas de Vecinos* - JJVV) which is the divided organization of *Comuna* or the terminal organization of national administration. JJVV consists of those who have settled down there and are older than 18 years old. The unity of JJVV is called *Unidad Veecinal* (UV). The self-government right of both JJVV and UV is established, legally. JJVV is formed by territorially related connection and can be regarded as the community unit. Thus, hereafter, when the report says "community," it refers to JJVV. The communities in the study area are extended into main roads and shape row

communities.

Under JJVV which plays a main role as an organization, various activity groups such as improvement of education groups, volunteer activity groups and clubs are working. Moreover, there are canal associations and producers' organizations as farmers' organizations. These are not limited by UV but established as regional wide organizations by their purposes and functions.

(2) Administrative division and sub-basin division in the study area

According to the Census in 1992, the population in the study area was about 546,000 persons. While 96% of the total population concentrates in urban areas, 4% of those lives in rural areas. Administrative divisions are Region, Province, and *Comuna*. To grasp the basins' characteristics in the study, the study area is divided into 12 sub-basins by *Comuna* based on natural and agricultural conditions.

(3) Geology

Chile locates the part of volcanic and seismic zones in the Pacific Rim. The downgoing plate from the Pacific Ocean forms the upheaval of the Andes mountains and volcanic and seismic zones exist in the country. Geology in the study area consists of sedimentary and volcanic rocks which deposited from the Mesozoic Jurassic period to the Mesozoic Cretaceous period.

(4) Climate

The climate in the study area is the Mediterranean climate. Annual average temperature is 16℃ and annual rainfall is 438mm. The rainy season is from April to September (fall / winter) and the dry season is from October to March (spring / summer). About 90% of total rainfall is concentrated in the rainy season.

(4) Land use

The study area is highly irrigated area and total area of its agricultural and livestock farming development is about 1,465,000ha. 68% of this is utilized for cultivation. The metropolitan area of Santiago in 1992 is about four times as much as that in 1940. The progress of this has been accelerated and the metropolitan area of Santiago has sprawled out, rapidly. So as to regulate this disordered expansion and sprawling, "The Metropolitan Area of Santiago Regulation Plan (*Plan Regulador Metropolitano de Santiago*-SEREMI-MINVU 1994)" was established. On the other hand, there is the system which enables to sell farmland as 0.5ha sub-divided housing lot. This strengthens the sprawling.

(5) Water resource

1) Surface runoff

The major rivers in the study area are the main and branch streams of the Maipo river. Relevant to water use in the area, the surface runoff from each sub-basin under the condition of average year and 85% probability of exceedance is calculated as the table below.

Item	Annual Average year (MMC)	85% Probability of Exceedence (MMC)
Total annual runoff	5,822.1	3,396.6
Oct. to Mar.	2,989.6	1,756.0
Apr. to Sep.	2,832.5	1,640.6

Item	Annual Average year (MMC)	85% Probability of Exceedence (MMC)
Runoff from the Andean Mountains	4,060.2	2,448.5
Oct. to Mar.	2,867.7	1,689.1
Apr. to Sep.	1,192.5	759.4
Runoff from areas except the Andean Mountains	1,761.9	948.1
Oct, a Mar,	121.9	66.9
Apr. to Sep.	1,640.0	881.2

Surface runoff in the study area can be estimated around 58 MCM in the average year. 70% of total surface runoff is supplied by thaw in the Andes Mountains, furthermore, 70% of runoff from the Andes Mountains concentrates upon summer, from October to March. Runoff from areas except the Andes Mountains is estimated around 17.6 MCM and 90% of total runoff generates by precipitation falling in winter from April to September.

2) Groundwater

As the results of calculation by obtaining from the executed survey on aquifer distribution, depth of aquifer and effective porosity, the potential yield of groundwater in the study area is estimated at about 26,000 MCM. Among this, Maipo-Mapocho groundwater unit occupies more than half of it, 22,000 MCM.

(6) The present situation of water use

Water utilization in the study area is broadly divided into three categories, irrigation water use for about 180,000ha of farmland, drinking water supply for 5.5 million residents including Santiago city and the other industrial water utilization. This depends mostly on discharge from the upstream basin of the Maipo river.

Based on the required water for crops, the required irrigation water amount in the study area counts 4,370 MCM (surface runoff; 4,130 MCM, groundwater; 240 MCM). Including the return flow, about 2,460 MCM and about 2,240 MCM of surface runoff are used for irrigation in average year and 85% probability of exceedance. The water use for domestic water supply, and mining and the other industries is about 910 MCM. Among it, about 450 MCM of domestic use depends on the surface runoff of the Maipo river. On the other hand, during irrigation period, from October to March, the discharge from the upstream reach of the Maipo river is about 2,870 MCM and about 1,690 MCM in average year and 85 % probability of exceedance, respectively. The present utilization of surface runoff of the Maipo river has reached to its limit. Moreover, the tightness of water use leads to speculative acquisition of water right which focuses on the free trade of water right under the Law.

(7) Water balance

So as to clarify the present water use, water balance study of each sub-basin is carried out under the condition of average year and 85% probability of exceedance on rainfall and surface runoff. Present water utilization in each basin is presented in the table below.

Sub-basin	Demand (a) (MCM)		Average		85% probability of exceedance	
	Irrigation	Others	Deficit (b) (MCM)	Ratio (b/a) %	Deficit (b) (MCM)	Ratio (b/a) %
1. Río Maipo Alt	65.798	3.190	0.000	0.00	0.000	0.00
2. Río Clarillo	140.478	0.620	0.000	0.00	3.048	0.02
3. Río Mapocho Alt	242.758	804.310	0.000	0.00	0.000	0.00
4. Estero Lampa	392.614	38.470	158.857	0.37	194.815	0.45
5. Río Mapocho Bajo	725.123	28.085	0.000	0.00	62.610	0.08
6. Río Angostura	1204.022	9.726	508.621	0.42	594.097	0.49

Sub-basin	Demand (a) (MCM)		Average		85% probability of exceedance	
			Deficit (b)	Ratio (b/a)	Deficit (b)	Ratio (b/a)
	Irrigation	Others	(MCM)	%	(MCM)	%
7. Estero Alhué	259.128	0.580	199.570	0.77	214.339	0.83
8. Melipilla	796.971	5.168	549.590	0.69	564.292	0.70
9. Estero Puangue	360.834	1.350	126.089	0.35	131.278	0.36
10. Estero Yali	39.495	0.690	5.746	0.14	7.315	0.18
11. San Antonio	13.625	7.010	7.855	0.38	8.774	0.43
12. Estero Casablanca	125.595	8.939	48.650	0.36	54.470	0.40
Total	4366.440	908.138	1604.978		1835.038	

(8) General situation of agriculture

In the study area, various types of agriculture by irrigation is carried out. Especially, large amount of grapes for wine production, table grapes and deciduous fruit trees are cultivated. Moreover, cultivation of semi-tropical fruit trees (avocado, citrus) has been increased in the hillside of hilly area, recently. Main cultivation crops and livestock raising situation are shown in the table below.

Crops	'75-'76 Census (ha)	'97 Census (ha)
Cereals, Processing crops	67,391	31,748
Vegetable, Flower	23,686	25,885
Fruits	28,411	43,506
Vineyard	2,985	6,703
Seeds and seedlings	N.A.	5,898
Forage	28,979	30,619
Total	151,452	144,359

Source: Domestic agriculture and livestock, Recent trend and forecast, , CORFO, 1998

Animals	Head		%
	Metropolitan Region	National	
Cow	229,531	4,141,545	5.5
Sheep	60,544	3,710,549	1.6
Swine	643,066	1,722,403	37.3
Horse	40,016	415,184	9.6
Goat	21,005	738,183	2.8

Source: 1997 Census

(9) Farmers and their agriculture

In the study, farmers are classified according to the landholding area as follows.

Landholding area (ha)	Name	Share in the study area (%)
0.5～15	Small scale farmers	74.7
15～100	Medium scale farmers	19.2
100 以上	Large scale farmers	6.1

Through the 12 sub-basins, farming in the study area can be summarized as following. In case of medium and large scale farmers, fruits growing or forage crop dominates their cultivation. While in case of small scale farmers, forage crop dominates their cultivation, then, vegetable and flower cultivation occupies the share in their cultivation.

(10) Agricultural infrastructure

1) Facilities

Irrigation system starts from the intake facilities in rivers or reservoirs. Then, the irrigation water flows through the settling basin, main canals, branch canals, and then to fields. Structures of existing intake facilities vary from concrete to gabion

and/or rock-fill. Its structural level differs from each other. Both main and branch canals in the study area are generally unlined. Even though lining entire canals might be effective against the leakage from canals, it is hard to be facilitated because beneficiaries have to bear the cost for the rehabilitation works and it affects the downstream areas where return flow is used as the irrigation water. The incentive to rehabilitate the facilities is low because water balance is considered in the area as a whole. The irrigation method in the fields is furrow irrigation generally, but the areas where suffers from shortage of water adopt water saving irrigation methods (Californian method, drip irrigation). Most of the areas, where groundwater is used for irrigation, adopt pumping irrigation.

2) Operation and maintenance of irrigation facilities

O & M of irrigation facilities is handed by canal associations (*Asociación de Canalistas*) which are established by farmers and approved legally. The associations manage canal facilities including intake structures. O & M cost is paid by the burden charge according to the number of water right, or *Accións* which hold the water users.

(11) Market / Marketing

The Metropolitan Region is the central market of agricultural products domestically and also the consumption area. There can be seen economic activities of various industries concerned such as wholesalers, large scale retailers, exporters, processers and so on. The market which holds long history and traditional system has come not to adopt to the demand of the age, gradually. The market which has a new system such as wholesale market in Santiago city and a model market is planned. Generally, main buyers of agricultural products of small scale farmers in rural areas are middlemen, traditional wholesale markets and livestock markets. Selling to middlemen on the fields is one method, but its price is low. Direct sale along with roads is also often seen. Moreover, there is another selling method that farmers pay from 2 to 7% commission to intermediaries or traders with special contracts.

(12) Agricultural support

Government agencies concerned with agricultural support are MOP (Ministry of Public Works), MINAGRI (Ministry of Agriculture), and MEFR (Ministry of Economic Promotion and Reconstruction). Main support programs are providing information, establishment of organizations, technology transfer, providing credit and so on. The objects of the programs are farmers of all classes, but especially small scale farmers are put stress on. Nevertheless, the support system by public institutions is not enough from the aspect of personnel and budget. The fundamental condition to be provided the support from these institutions is holding water right. The applicants of the INDAP projects which is the support institution of small scale farmers have following limitations; they must be farmers who hold water right of 0.5 ~ 12ha irrigate area, the beneficiaries should be organized, and the project plan has already formulated and so on. The financial support for small scale farmers whose access to general financial institutions such as city banks is weak is executed by government agencies concerned such as INDAP and PROMM. INDAP provides long term credit for investment in facilities and short term credit for cropping budjet. PROMM provides financial and technical support for irrigation at the same time.

(13) NGOs

From the point of agricultural support, there are about 800 active NGOs (Non Governmental Organizations). In the study area, there are 450 organizations, and two of them are working on the field of agriculture concerned.

(14) Farmers' organizations

As farmers' organizations, there are canal associations, their upper organizations, farmers' association, producers' organizations and so on. However, there is not a cooperative including functions such as selling and purchasing, and providing credit. The farmers' association is the organization for protecting farmers' right but its activities are stopped at present. Producers' organizations are established by small scale farmers who hold less than 15ha land according to the purpose of production. They are working as *Asociación Gremial de Pequeños Agricultores* (small scale farmers production organization) and organizations provided the support from government agencies concerned.

(15) Rural infrastructure

On the whole, installation ratio of basic infrastructure is high. Nevertheless, installation of water supply facilities and sewerage system are behind in regional rural areas, especially mountainous areas.

(16) Environment

1) Environmental administration

The national steps to solve environmental problems are carried out by the Fundamental Law of Environment, systematically and CONAMA (National Environment Committee), institutionally.

2) Designated area for protection

In the study area, there are four conservation areas, one natural monument, four protection areas, and three sanctuaries. Among them, Estero el Yali, which belongs to conservation areas, was registered as the marsh of the Ramsar Convention.

3) Environmental pollution

The metropolitan area has took pride in its traditional characteristics of the particular scenery which urban areas and farmland are closely located. Transformation of farmland into housing lots or industrial areas with urban population growth impacts on not only change of the scenery but also on regional environment, ecologically. Furthermore, lack of proper sewage treatment system in Santiago city leads to contamination of irrigation water by urban sewage. This results in prohibition of some kind of vegetable cultivation by using surface flow of water entire part of the study area. According to this situation, sewage treatment plan in Santiago city which targets at 2024 has been established by EMOS. In the plan, Santiago city is divided into three treatment plant sections and three improvement stages (starting from 2001, 2004, and 2009). Treatment of sewage starts to implement, gradually. The third stage will be terminated in 2024.

3 Constraints and Development Potentials on Agricultural Development

According to the results of the study on the present condition, the problems on the agriculture in the study area can be summarized in following four points.

(1) Disparity caused by landholding scale

- The landholding structure in the study area is distorted. 6% of landowners who hold more than 100ha farmland occupy 86% of total farm land in the study area and more than 80% of landowners who hold less than 15ha

occupy only 5% of that.

- Large and medium scale farmers have established their bases for farming and management. On the other hand, small scale farmers have not established stable farming and management. Thus, extended reproduction of agriculture is difficult for them.
- Migration of the small scale farmers from rural to urban areas has been increased.

According to the present problems, following points will be cared in the future.

- Quitting agriculture by small scale farmers and concentration of farmland to large and medium scale farmers
- Collapse of rural society and deterioration of rural ecosystem by quitting agriculture of small scale farmers
- Causing social problems in urban areas

(2) Tightness and competition of water use

- Increase of water use other than agriculture with urban expanding
- Available capacity of both surface runoff and groundwater reaches to their limits under the present water right.

According to the present situation, following points are given as direction of the future water use.

- It is hard to settle new water right through the easy method such as use of surface runoff.
- New water utilization will be promoted through the use of small scale groundwater development, obtaining the established water right in the water market, utilization of unused water right, storage of runoff of flood, rationalization of water use so far, and so on.

(3) Contamination of agricultural water

- Utilization of contaminated water by sewage from the metropolitan area irrigation water
- Prohibiting cultivation of designated vegetables by contaminated irrigation water
- It will take about 25 years to improve the present situation of contamination

In case that improvement of the present situation is not considered, following points are given.

- Lowering the credibility against the safety of Chilean perishable food in the world market
- Deteriorating health and sanitary environment of farmers

(4) Decrease of farmland

- Transformation of superior farmland into urban land use
- Existence of the system which approves the transformation of farmland

According to the trend of the present situation, following points are given on the future land use in the study area.

- Change of land use will be limited by establishment of urban planning
- Decreased farmland by urbanization will be developed for fruits growing

through utilizing micro climate condition in regional rural areas.

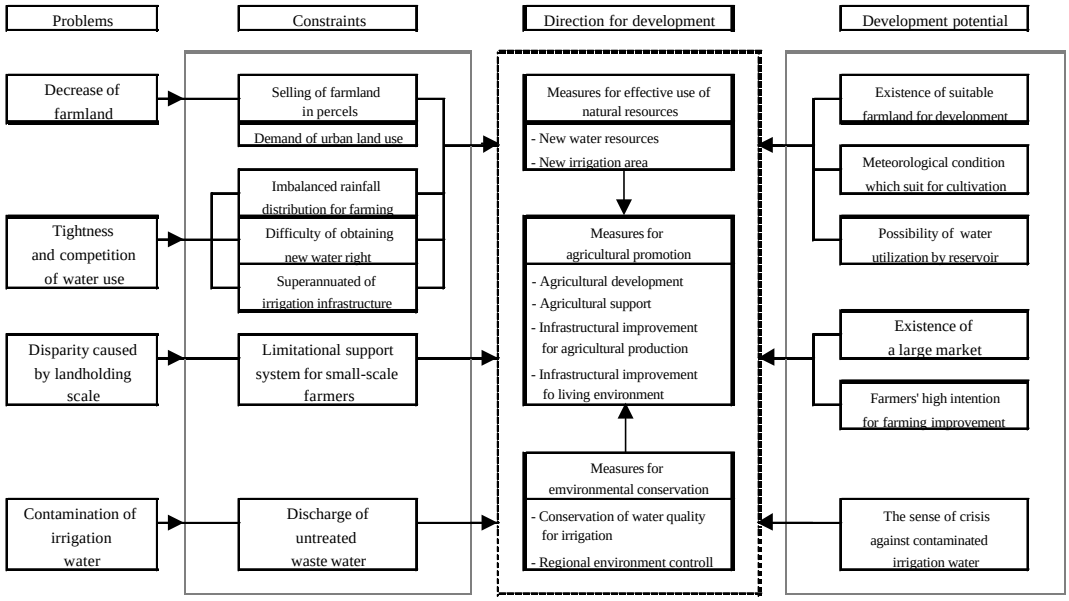
From the problems of the present situation and their future prospects as mentioned above, constraints and development potentials to examine the methods for solving the problems in the area are regarded as follows.

Constraints	Development Potentials
• Limited support system for small scale farmers • Decrepit infrastructure and facilities' environment • Little amount of rainfall and imbalanced rainfall distribution • Difficulty of obtaining new water right • Discharge of untreated waste water • Demand of urban land use	• Existence of a large market • Farmers' high intention for improvement of farming • Meteorological and topographical conditions which suit for cultivation • Possibility of utilizing impounded water • The sense of crisis of farmers against contaminated agricultural water • Existence of suitable farmland for development

As mentioned above, the problems of agriculture in the metropolitan area are

- Existence of disparity among farmers by landholding scale,
- Competition of land and water resources between agricultural and urban uses,
- Deterioration of regional producing and living environment that represents discharge of untreated sewage water into rivers.

The countermeasures to solve these problems are summarized in the following figure based on the future prospects of each problem, constraints on agricultural development, and development potentials mentioned before.



4 Basic Concept and Approach of Development Plan

From the recognition of present situation in the study area, agriculture in the metropolitan area is affected by sprawled expansion and contaminated irrigation water due to sewage by population growth. The development plan is envisaged to promote

socio-economically well-balanced agriculture for the harmonized progress by effective use of limited sources of water and land considering environmental conservation

The plan should be accorded with "Strategic Agenda 1998/2000 Agricultural Development Targets" which is the national agricultural policy. The direction of the plan aims at alleviating disparity between urban and rural areas, coexistence of these areas, and harmonizing with environment. The target year in the plan is set up in 2010.

Based on the concept of development, the framework of the development plan is as follows.

- Agricultural promotion in the metropolitan area
- Effective utilization of potential land and water resources in the study area
- Environmental conservation in the entire basin

5 Agricultural Development and Water Management in Metropolitan Area

(1) Water resource development plan

1) Water source development plan

According to development constraints and potentials, the development constraints in the plan are the limited natural resources. Among them, the key resource is water. Considering that water is necessary for agricultural production and tightened at present, development of new water sources should be examined in the study area. Five methods can be given; a) reservoir facilities (large scale, medium and small scale reservoirs, b) new water creation by saving irrigation water, c) groundwater, d) water use by utilizing unused water right effectively, and e) treated sewage water. Among these, b) can be returned only to the farmers who save water under the present water use system. Groundwater is regarded as small scale supplementary water source, considering that new development of it is regulated by government agencies concerned. Accordingly, both of them are not included in the plan.

According to the topography, geography, scale of the reservoirs, and scale of the basins in the area, possibility of constructing reservoirs is examined in 14 sites, 6 rivers. Considering social, economic, and environmental conditions of each reservoir site, total four sites; one site for large scale and three sites for medium and small scale are selected. New water source amount by construction of reservoirs is estimated at 398.6MCM as presented in the table below.

River	Site	Area of basin (km^2)	River bed elevation (m)	Dam height (**m**)	Dam crest-length (**m**)	Storage capacity (MCM)
Maipo	El Ingenio	2,785	1,159	161	800	360
Colina	El Cepo	208	970	45	630	4.6
RosaRío	Patagua Chica	184	120	37	350	29.3
Curacavi	El Flamenco	244	331	27	250	4.7

It is also possible to construct small reservoirs in streams in the area beside the dams mentioned above. The small reservoirs can be used as storage of surplus water from irrigation canals and discharge of its basin by rainfall, and can be used as supplementary water source during irrigation period.

DOH has an undistributed but available water right of 25.0m^3/s (*Decreto* No.1039) for the irrigation project in the second section. In the development plan, the irrigation utilization plan is formulated through utilization of this water right held by DOH from the view of effective utilization of unused water right.

EMOS has the plan of using treated water of 3.5m^3/s as irrigation water because an urban sewage treatment plant, the first stage, in South Santiago will start the operation from 2001. Utilization of the treated water has some problems to be solved in near future, such as decreasing return flow in the downstream basin and water right on the treated water. Nevertheless, the development plan assumes the problems would be solved. Thus, this is included into the development plan.

2) Water resources distribution

Among new water source development plans, the water source which is available for domestic water is only the large scale dam plan. Therefore, concerning both irrigation and domestic water uses, expansion of domestic water use in 2010 will be 40 MCM among 360 MCM of newly developed water amount. Thus, the rest of it, 320 MCM is new irrigation water source. The irrigation area is expected to be about 18,500ha. On the other hand, available supply of middle and small-scaled dams, 39 MCM is regarded as new irrigation or supplementary water sources around reservoir sites. The water with unused water right in the downstream basin of the Maipo river is distributed only for irrigation use, and new irrigation area will be 21,000ha. Treated sewage by EMOS can irrigate about 3,000ha.

The water distribution mentioned above, the alternatives to newly developed water amount are summarized as follows;

Item	The alternatives of water source development plan			
	Without dams	With dams		
	A－1	A－2 (middle and small scale dams)	A－3 (Large scale dam)	A－4 (A-2+A-3)
Large dam	—	—	360 MCM	360 MCM
Middle and small dam	—	39MCM	—	39MCM
Water right of the 2nd section	25.0 m^3/s	25.0 m^3/s	25.0 m^3/s	25.0 m^3/s
Treated sewerage use	(3.5 m^3/s)	(3.5 m^3/s)	(3.5 m^3/s)	(3.5 m^3/s)
Water supply	—	—	40 MCM	40 MCM
Irrigation development (With existing water right)	21,000 ha	21,000 ha	21,000 ha	21,000 ha
Treated sewerage use	(3,000 ha)	(3,000 ha)	(3,000 ha)	(3,000 ha)
Total (1)	21,000 ha	23,300 ha	39,500 ha	41,800 ha
Total (2)	(24,000 ha)	(26,300 ha)	(42,500 ha)	(44,800 ha)

(2) Land resource development plan

In this plan, urbanization areas are to be established in accordance with "The Metropolitan Area of Santiago Regulation Plan (*Plan Regulador Metropolitano de Santiago* – SEREMI-MINVU 1994)" which is the regulation for controlling disordered expansion of Santiago city and sprawling. Except urbanization areas, the present land use will remain. As new irrigated farmland, about 112,000ha land is regarded in the northern, western, and southwestern parts of the area based on land productivity classification shown in the table below. The reclamation of these farmlands is limited by the location of water source and available water amount.

Division of basin	Land productivity potential I – IV	
Est. Yali	26,002	*
Est. Casablanca	25,779	**
Est. Alhué	19,184	*
Est. Lampa	20,688	**
Est. Puangue (Curacaví, Maria Pinto)	9,634	*
Cue. Melipilla	10,383	*
	111,670	

*Source : * CIREN , **REA*

(3) Agricultural promotion plan

Basic concept of agricultural promotion in the plan is social balance by economic development and coexistence of urban and rural areas as described in "Development concept and approach." From this meaning, plans of production infrastructure improvement for increasing agricultural productivity, both technological and financial supports required for production activities with this infrastructure, and alleviating disparity between urban and rural areas on living environment are to be established.

1) Agricultural production plan

a) New irrigation area

The agricultural production plan established in the study is backed up basically by the condition of new irrigation areas selected throuh the study. The production plan which is implemented at present is conditioned by economically successful export. Nevertheless, the basic approaches of the plan are supplementing insufficiency of small scale farmers' production opportunities and increasing their productivity because their productivity is low in agricultural production structure and modernization of agriculture burdens them. So as to promote agriculture in the metropolitan area, which is the target of the study plan, selection of new irrigation areas is required to deal with decreasing farmland. In the master plan, 6 areas (Popeta, Yali, Alhué, Puangue, Casablanca, and Lampa) will be new irrigation areas. These areas are selected based on examination of land and water resources from the view point of agricultural development.

The preconditions of the established crop cultivation plan are as follows;

- The farmland which plans to be newly irrigated is unirrigated land at present.
- The crop cultivation plan includes estimation of unused land area for production such as follow land, staircase land and meadow on both small scale farmers and large and medium scale farmers. Under the present condition, the area is estimated at from 27 to 69% with small scale farmers' and from 15 to 20% with large and middle scale farmers. In the plan, it is estimated at from 22 to 33% with small scale farmers and from 9 to 20% with large and medium scale farmers. The average percentage in the new irrigation areas is 12.7%.
- On the other hand, from the point of land use in the crop cultivation plan, one of the standards is not beyond largely the portion of intensive cultivation (fruits, vegetables, grapes for wine and table grapes, seed production, and seed) in Lampa, Mapocho Bajo, and Angostura where intensive cultivation has been already operated. In case of subjecting average regions, the degree of intensity in these three basins is realistic, feasible and best level for reaching under the present market condition and the framework of economic policy.
- In crop selection, available crops in basins of the Maipo river and crops whose planting and cultivation area is large in the project area and its suburb are selected.

The present cultivated crops and proposed crop cultivation plan are presented below based on geographical location in the study area.

- Popeta area

  The cultivation plan is mainly relevant to the present crop cultivation in present irrigated areas, Melipilla and Popeta. In irrigated areas in Popeta

(including Cholqui, Carmen Alto, Culiprán, Tantehue, and Los Guindos), a lot of grapes, vegetables and fruits are cultivated due to its climatic condition. Many private investors promote cultivation by groundwater and rainfall in unirrigated area here.

- Alhué area

It is planed that the present level of Alhué area, where large unirrigated land exists even it is blessed with fertile soil and fine climatic condition, alters to the level of Melipilla basin and irrigated areas in Cabras where a lot of fruit trees and grapes for wine are cultivated. This area is provided very appropriate climatic condition for grape cultivation as well as Casablanca area. High potentials of this area are supported by keen interest of many vineyards and investors on the expanding cultivation plan in this area. On the other hand, there is possibility of cultivation crop diversification on vegetables, flowers, crop cultivation for seed production because of advantage on the aspect from producing environment, which is isolated condition due to natural condition, the neighboring of markets, and blessed climatic condition.

- Yali area

San Pedro area where much fruit trees, grapes, and crop cultivation for seed production have been cultivated in these years is provided with blessed climatic condition. Nevertheless, there is large area of unirrigated land. Because of this, the crop cultivation plan for fruit trees, grapes, seed production is planned.

- Puangue area (Curacaví, Maria Pinto, and Ibacache)

The idea of the crop cultivation plan in this area mainly connects with the crop cultivation system of present irrigated area in Puangue and Melipilla basin. In the plan, mainly fruit tree growing and secondly grape cultivation for wine will be major cultivation crops. Besides them, vegetable and flower cultivation will occupy some potion because this area is the suburb of Santiago.

- Casablanca area

The idea of crop cultivation plan mainly connects with present irrigated area in Casablanca basin and rapid growth of grapes for wine cultivation in these years. Therefore, grapes and fruit tree growing is planned as main crops in this area. The portion of forage crop cultivation will decrease compared to the present level, but it will remain an important crop especially in the area where irrigation water is not distributed. Furthermore, vegetable cultivation also has a certain level of possibility because main road to the central coast is passed through in this area.

- Lampa area (Colina and Polpaico)

Crop cultivation relates to crop cultivation system of the present irrigated area in Lampara basin where a lot of vegetables, fruit trees, and crop cultivation for seed production are cultivated. At present, cultivation of vegetables, fruit trees, and crops for seed production occupy 69% of farmland. Yet, cultivation of vegetables and crops for seed production which need small investment will be stressed.

b) Area for rehabilitation of existing irrigation facilities

The farming in the areas for rehabilitation of existing irrigation facilities will remain the present farming type but fruit tree growing will increase at hilly and sloping areas. Accordingly, based on the present cultivation crops, proposed main cultivation

crops in each area are presented in the table below.

Farmers' scale	Small scale farmers				Medium and large scale farmers			
Farming area	24,562.9 ha				105,165.7 ha			
Sub-basin	Decreased crops		Increased crops		Decreased crops		Increased crops	
Clarillo	Cereals	17.1ha	Fruit tree	24.2ha	Cereals	120.7ha	Fruit tree	63.3ha
	Fallow land	21.4ha	Forage crop	14.3ha	Forestation	65.5ha	Forage crop	60.5ha
							Seed	62.4ha
Lampa	Cereals	65.2ha	Fruit tree	65.2ha	Forestation	155.2ha	Fruit tree	155.2ha
	Fallow land	97.9ha	Forage crop	97.9ha				
Angostura	Cereals	69.2ha	Fruit tree	34.6ha	Cereals	442.1ha	Fruit tree	443.7ha
			Vegetable / Flower	34.6ha	Forestation	492.2ha	Forage crop	490.6ha
Melipilla	Cereals	82.2ha	Fruit tree	106.8ha	Cereals	259.4ha	Fruit tree	257.8ha
	Fallow land	106.8ha	Forage crop	82.2ha	Forestation	265.2ha	Vegetable	266.8ha
Puange	Cereals	49.4ha	Fruit tree	64.2ha	Cereals	105.9ha	Fruit tree	88.8ha
	Fallow land	64.2ha	Forage crop	49.4ha	Traditional crops	102.4ha	Forage crop	119.5ha
Total		573.4ha		573.4ha		2,008.6ha		2,008.6ha
Crop transformation ratio	2.3 %				1.9 %			

c) Area for the water quality improvement

Crop cultivation plan in the improvement area of irrigation water quality, cropping ratio of vegetables will be increased in case of small scale farmers by introducing the chard, cabbage, cauliflower, and so on which prohibited the cultivation at present. Even the quality of irrigation water is improved, utilization of irrigation water will be made mainly on prevailing fruit cultivation in case of large and medium scale farmers. Quality of fruits cultivated by the improved irrigation water has high marketability. Accordingly, the present cultivation of fruits will be followed on the crop production plan for the large and medium scale farmers.

2) Agricultural support plan

More than 80% of small scale farmers among those who engage in agriculture live in rural areas, and they are in charge of main role in rural and regional society in fact. Therefore, it is important for vital and stable development of rural areas to make the small scale farmers vital and settled down. The support institutions for changing the present situation of small scale farmers and supportive methods for implementing the plan are ordered by support institutions such as SECPLAC, INDAP and FOSIS or as support programs of each institutions.

In order to be provided financial and technical supports from the support institutions, the basic condition is establishment of small scale farmers' organizations. Based on the present situation of the existing support system, in the support plan, establishing organization of unorganized small scale farmers is mainly promoted. Advancing the functions of the existing producers' organizations and construction of the base facilities for various activities to develop regional agriculture which each organization can use are also proposed.

3) Rural infrastructure improvement plan

The infrastructure relevant to living is relatively highly installed in rural areas, the study area. The disparity between rural and urban areas has been shrunk in the points of living environment. Therefore, in the plan, improvement of roads in mountainous areas, drinking water supply facilities, and sewage treatment plants in regional urban areas are proposed. Proposed amount of installation is as follows;

Basin	Installation of rural water supply	Sewage treatment plants	Local road installation
	Unit	Unit	Km
1.Río Maipo Alto	-	2	-
2.Río Clarillo	4	1	-
3.Río Mapocho	-	6	-
4.Est. Lampa	3	3	-
5.Río Mapocho	-	6	-
6.Río Angostura	4	6	15
7.Est. Alhué	8	2	35
8.Melipilla	5	1	20
9.Est. Puangue	9	2	12
10.Est. Yali	8	3	55
11.San Antonio	3	3	28
12.Est. Casablanca	8	4	26
Total	52	39	191

4) Agricultural infrastructure improvement plan

The agricultural infrastructure improvement plan in the objective area is irrigation facility improvement. The irrigation facility improvement consists of rehabilitation in the existing irrigated areas and construction of facilities in new irrigation areas.

Irrigation facilities rehabilitation plan in the existing irrigation area, Clarillo, Angostura, Puangue, Lampa and Melipilla in which indicate significant shortage of irrigation water are selected as the objective areas. Reduction of O & M cost of irrigation facilities and alleviation of water shortage at the field level are intended. Moreover, regarding the rehabilitation of the existing intake structures in the second and third sections in the Maipo river, those structures are to be integrated into the proposed intake weirs of new irrigation areas. In accordance with establishment of *Junta de Vigilancia* which manages water utilization among water users, water management is handed by and supported from the structural aspects. Summary of the improvement plan by area is presented in the table below.

Sub-basin	Area	Main improvement structures		
	(ha)	Intake structures (unit)	Diversion works (unit)	Canals (km)
Río Clarillo	2,500	-	12	16
Río Angostura	45,105	22	47	235
Est. Puangue	13,412	6	17	98
Est. Lampa	13,381	-	14	63
Melipilla	28,690	5	34	211
Total	103,088	33	127	623

New irrigation plan is proposed based on the water amount created by unused water right, large scale dam, and medium and small scale dams in accordance with a plan for water source development described in the water resource development plan. Irrigation by unused water right uses DOH's water right of 25m^3/s in the second section of the Maipo river. The objective areas are sub-areas of Yali, Alhué, and Popeta (21,000ha). Expected available supply of 320 MCM by construction of a large scale dam distributes to sub-areas of Lampa and Curacavi (18,500ha) relevant to location of a constructed dam. Expected available water of 39 MCM by construction of middle and small dams is distributed as new irrigation water around the dam sites and supplementary water source for areas of Colina and Curacavi (550ha). The objective area of irrigation plan by using treated sewage is Curacavi area (3,000ha).

(4) Environmental conservation plan

1) Irrigation water conservation plan

As the countermeasure against the problem of contaminated irrigation water in Santiago city, there is a sewage treatment plant construction plan by EMOS. In this plan, the treatment plants are to be constructed in three sites step by step in Santiago city. The plants will start to operate from 2001 to 2009. Nevertheless, it takes about 25 years to obtain adequate irrigation water from the rivers sanitarily after completing the plants.

The present situation which Chilean agricultural products gains good reputation in the international market should not be lost and be sustained for long time from now on. Taking a long time to solve a problem of the contaminated irrigation water should be considered as anxiety relevant to sustainability of good reputation in the international market. Thus, the countermeasures should be prepared as soon as possible. In the plan, the countermeasures for water quality improvement from agricultural side are proposed in order to accelerate recovering the function of the suburban agricultural area as a perishable food supply center for consumers in the metropolitan area and to protect the inflow of unexpected negative information into the international agricultural product market where competition is very severe before it happens.

The objective areas do not include the proposed areas by EMOS in the plan. On changing water source, there is the only possibility to avoid contamination by groundwater after the confluence of the Maipo and Mapocho rivers as adopted methods for countermeasures. Two methods; avoiding the source of contamination by bypass and water quality improvement are practicable. The sewage treatment is planned by the method of Standard Activated Sludge as well as the treatment method planned by EMOS. The targets for improving water quality are less than 23/100ml groups of colitis germ, BOD of 20mg/l, and SS of 30mg/l.

The measures for improvement of water quality with canals are summarized as follows;

Measures for improving water quality	The objective canals	Intake amount (m^3/sec)
Avoiding contamination sources (through bypass)	Canal La Polvora	0.5
	Canal La Punta	5.8
	Canal Casas de Pudahuel	0.8
	Total	7.1 m^3/sec (3 canals)
Improving water quality	Canal Las Mercedes	10.5
	Canal Esperanza Alto	0.7
	Canal Esperanza Bajo	1.7
	Canal Romero	1.0
	Canal Castillo	2.0
	Canal Domingano	0.8
	Canal Mallarauco	8.5
	Canal El Paico	2.5
	Canal San Miguel	4.2
	Canal Lo Aguirre	3.6
	Canal Lo Chacon	3.6
	Canal La Manresa	1.2
	Total	40.3 m^3/sec (12 canals)

2) Promotion of environmental education

Urban areas in the study area have the problems of illegal disposal of wastes and untreated discharge of contaminated water, while rural areas have the problems of the canal contamination by domestic wastes, miscellaneous sewage and waste of

animals. An areal approach is to play an important role based on the national environmental conservation policy in order to solve these problems. This is also expected to have a positive impact. In the plan, "countermeasures against contamination campaign" implemented by CONAMA expands to rural areas, and environmental education and enlightenment activities are to be carried out under the cooperation with SECPLAC by *Comuna*.

3) Promotion of agriculture concerned environment

Agricultural promotion plan formulated in the plan aims at sustainment of farmers' farm management by improving their farming and maintains the present ecosystem and environment by promoting sustainable agriculture. Therefore, the plan is based on environmental consideration, and considers avoiding environmental pollution and destruction from agriculture itself as much as possible. On the purpose of penetrating and extending farming methods relevant to environmental consideration, technological instruction to farmers is implemented by INIA, universities, and so on.

4) Establishment of an environmental monitoring system

Conservation areas related with the Ramsar Convention, sanctuaries and protection areas exist in the objective area. Although these areas are excluded from the objects of the development plan, the study on the present situation around these areas is needed to be implemented early because impact of the plan on these areas might be considered. The impact caused by further development should be observed and supervised, certainly. Moreover, regular environmental monitoring on change of land use pattern in the future and change and impact of ecosystem with promotion of agriculture is required in the area. Thus, establishment of the system by institutions concerned for this is planned.

5) Selection of the development scenario

Based on the alternatives of water resource development in the study area described in the water source development plan, four development scenarios are proposed. According to the alternatives of new water sources, irrigable areas and available water amount, development scenarios are presented in the table below.

New water source	Water volume			Generation of electricity (ヶ所)	Irrigation area (ha)	Scenario			
	Creation	For water supply	For irrigation use			S - 1	S - 2	S – 3	S – 4
I. Unused water right	25m^3/s	-	25m^3/s	4	21,000	○	○	○	○
II. Large dam	360MCM	40MCM	320MCM	4	18,500	-	-	○	○
III. Middle and small dam	39MCM	-	39MCM	-	550	-	○	-	○

The areas	Objective area (ha)			
New irrigation	21,000	21,550	39,550	40,050
Rehabilitation of irrigation facilities	9,400	9,400	9,400	9,400
Water quality improvement	53,000	53,000	53,000	53,000
Rehabilitation of irrigation facilities and water quality improvement	93,700	93,700	93,700	93,700
Total	177,100	177,650	195,650	196,150

The structural components and the project cost of each scenario are presented in the table below.

Item	Component	S - 1	S - 2	S - 3	S - 4
1 Agricultural infrastructure Development					
Irrigation development					
Colina-Casablanca	Irrigation area (Colina, Porpaico, Curacavi, Casablanca)	-	-	18,500 ha	18,500 ha
	Water source facilities (Maipo Dam) V=360 MCM, H=161 m, L=800 m	-	-	1 site	1 site
	Main canal	-	-	296.5 km	296.5 km
	Related structures (tunnels、siphons)	-	-	21.7 km	21.7 km
	Power station	-	-	4 sites	4 sites
Colina	Irrigation area (Colina)	-	270 ha	-	270 ha
	Water source facilities (Colina Dam) V= 4.6 MCM, H= 45 m, L=230 m	-	1 site	-	1 site
	Main canal	-	4 km	-	4 km
Curacavi	Irrigation area (Curacavi)	-	280 ha	-	280 ha
	Water source facilities(Cracavi Dam) V= 4.7 MCM, H= 27 m, L=150 m	-	1 site	-	1 site
	Main canal	-	30 km	-	30 km
Yali -Popeta	Irrigation area (Yali, Alhué, Popeta)	21,000 ha	21,000 ha	21,000 ha	21,000 ha
	Headworks (Integration)	1 site	1 site	1 site	1 site
	Main canal	140.5 km	140.5 km	140.5 km	140.5 km
	Related structures (tunnels、siphons)	13.6 km	13.6 km	13.6 km	13.6 km
	Power station	4 sites	4 sites	4 sites	4 sites
Improvement of existing irrigation system	Objective sites (Clarillo, Angostura, Lampa, Puangue, Melipilla)	5 sites	5 sites	5 sites	5 sites
	Objective area	103,088 ha	103,088 ha	103,088 ha	103,088 ha
	Objectives for improvement				
	rehabilitation of intake structures	33 sites	33 sites	33 sites	33 sites
	:rehabilitation of main canal	623 km	623 km	623 km	623 km
2 Rural Living infrastructure Development	Rural water supply	52 sites	52 sites	52 sites	52 sites
	Rural sewerage system	39 sites	39 sites	39 sites	39 sites
	Local roads improvement	191 km	191 km	191 km	191 km
3 Environmental conservation	Improvement of water quality				
	Bypass canal	3 sites Q= 7.1 m^3/s	3 sites Q= 7.1 m^3/s	3 sites Q= 7.1 m^3/s	3 sites Q= 7.1 m^3/s
	Treatment of water quality	12sites Q=4.74m^3/s	12sites Q=4.74m^3/s	12sites Q=4.74m^3/s	12sites Q=4.74m^3/s

Regarding internal rate of return on each scenario, S-1 and S-2 are 16.99% and 14.77%, respectively. Those on S-3 and S-4 are not beyond 12% of social discount rate set up by MIDEPLAN. On evaluation of social and environmental impact, that on S-1 and that on S-2 are equal. In the plan, considering effective use of water resource in the study area, S-2 which plans to construct facilities for new water source is selected as the agricultural development scenario (the master plan on agricultural development) whose target year is 2010.

6 Priority Projects

On selection of the priority projects, model or pilot projects / areas for agricultural promotion in the objective area will be selected among the projects proposed as the master plan projects.

In the existing irrigation area, agricultural infrastructure improvement concerned environmental conservation consisting water quality improvement for irrigation and rehabilitation of the existing irrigation system will be proposed as the priority project in the area where improvement of water quality for irrigation is required. This priority project is settled as the pilot scheme related to the water quality improvement. Moreover, in the existing unirrigated farmland, agricultural development with effective use of present water resources is proposed as the priority project. As for living environment improvement, the plan relevant to living environment improvement is established in the areas where priority projects will be implemented.

(1) Selection of the area for agricultural infrastructure improvement concerned environmental conservation

Required areas of the rehabilitation on the existing irrigation system are 5 areas,

Clarillo, Puangue, Lampa, Melipilla and Angostura. Entire part of Puangue and Melipilla areas and some parts of Clarillo, Lampa and Angostura areas use contaminated river flow for irrigation. Out of three areas, bypasses method to avoid contamination sources is applied for the Lampa area. Both Cralillo and Angostura areas are excluded from the objective area of improvement because water quality will be improved by the plan of EMOS up to the target year of 2010.

Contaminated water of the Mapocho river is used for irrigation water through Canal Las Mercedes, and Canal Mallarauco in the area of Puangue and Melipilla, respectively. EMOS has the plan to use the treated sewage for irrigation in the Puangue area. So, the agricultural infrastructure improvement concerned with environmental conservation is planned as a pilot plan in the existing irrigation area with Canal Mallarauco where water quality will not be improved up to the target year of 2010 because EMOS does not have the treated sewage use plan. 1,500ha is selected as the objective areas to be ameliorated in its farming and farm management due to improvement of water quality.

(2) Selection of the area for agricultural development with water resource utilization

The areas for agricultural development with water resource utilization are three. They are Yali-Alhué-Popeta irrigation areas by utilizing unused water right and Colina and Curacavi to be irrigated by construction of small scale dams. Based on the comprehensive evaluation applied the standard of project evaluation method by PROMM-World Bank, Popeta area is selected as the area for agricultural development with water resource utilization.

7 Conclusion and Recommendation

(1) Conclusion

According to recognition of the present situation in the study area, the master plan on "Agricultural development and water management in metropolitan area" targeted year of 2010 is examined. Main points of the master plan are effective use of land and water resources, environmental conservation and agricultural promotion. In the examination, development scenarios of the study area are set up based on the alternatives of newly available water resource development. After evaluation on the social and economic impacts of each scenario, the adequate scenario is proposed as the master plan. The components of the master plan are creating new irrigation areas of 21,550ha by utilizing the existing water right and small reservoirs, rehabilitating five existing irrigation systems of 103,088ha, water quality improvement projects relevant to 15 existing irrigation canal systems and rural infrastructure improvement consisting of rural water supply, sewage of regional urban areas, and local roads.

(2) Recommendation

1) Proposed integration of the existing intakes in the master plan supports management of water use among water users. Early implementation of the project is proposed.

2) In Chile, water belongs to personal property based on the water right. At the same time, water is also a social common capital. Unused water right and reusable water right are required to be dealt with some legal measures from the point of effective use of limited resource.

3) Quality improvement of contaminated water by domestic waste water is indispensable not only to maintain the good reputation of Chilean agricultural

products in the international markets and diversify cultivation crop but also to improve living environment. However, the investment of this project is huge compared to direct benefit. Therefore, it is difficult to implement the project by only private sector, and thus required introducing governmental budget as a public work.

4) Water sources for reclamation of farmland caused by present animated agricultural export mostly depends on groundwater. This situation brings about decline of water level and interference of groundwater. Thus, groundwater for agricultural use should be limited only to small scale development or supplemental use.

5) Water saving effect by lining of main canals should be appreciated. It is proposed that rehabilitation of major infrastructure among the existing irrigation systems should be promoted, actively.

6) Countermeasures to regulate sprawling are needed from the aspect of taxation system.

II Feasibility Study

1 Agricultural Development Plan in Popeta area

1.1 The Present Situation of the Objective Area

(1) Society

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. Popeta area administratively consists of eight (8) *Unidad Vecinal* (United community), and each *Unidad Vecinal* consists of several *Junta de Vecinos* (Council of community). According to Census '92, population of the area is 8,447 persons.

The smallest unit as a group is *Junta de Vecino* in the area. It is possible to consider that the *Junta de Vecino* is an unit of community because it is organized based on territorially related connection.

The ratio of the extremely poor in *Comuna* Melipilla is high, compared to that in whole the Metropolitan Region. Yet, the ratio 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%.

(2) 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

(3) Climate

The objective area of the study categorizes in the Mediterranean climate and the division of winter and summer seasons is clear. While most of annual rainfall is concentrated in winter season, dry and fair climate continues in summer season. General climate is as follows.

Annual rainfall	400 mm	Annual average temperature	14.8℃
Annual average maximum temperature	28.0℃	Annual minimum temperature	3.3℃
Annual average relative humidity	69.7%	Annual average wind velocity	1003.6km/month
Annual average sunshine hours per day	6.9 hr	Annual average evaporation	1,212 mm

(4) Soil and land use

According to agricultural landholding survey (REA) in 1995, the objective area coves 60,826ha, and among this, farmland occupies 23,243ha. Crop cultivation suitability of soils in new irrigation area is clarified based on land productivity classification by REA.

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

(5) Water resource

Discharge at Chiñihue of the Maipo river which is to be a water source of new irrigation area is estimated by regression formula with correlation of discharge at Cabimabao. Annual average discharge and discharge at 85% probability of exceedance at Chiñihue are as follows;

Item	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
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

In the objective area, average coefficient of permeability is 5×10^{-4} m/sec. 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. In Popeta area, total number of wells is 234. Wells that use for irrigation is 125 and for domestic use is 16 of 234. According to the results of long term observation of groundwater fluctuation, groundwater level of each basin tends to be declined, or has the possibility to be reduced in the future. It is judged that the large scaled development of groundwater for irrigation is limited in the areas near future.

(6) Agriculture

As farmers in the project area are classified by scale of landholding, farming pattern in the objective area is shown in the table below.

Farming 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.

Fruit growing area in Melipilla Province has increased by 12.4 % in the last four years. On the other hand, its cultivation has decreased by 9.7 % in the same period in the Metropolitan Region. The objective area is included in a part of the increased areas. Recently in the objective 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 area of the project reach 1,000ha. However, a problem of reducing groundwater that is the water source is raised in those projects.

Regarding wine production, a 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*" and has achieved prestige as one of export wines and recorded good sale. This suggests a possibility of further expansion of vine cultivation in the objective area. Moreover, the objective area has the similar climate characteristics to Alhué area where is one of the most promising areas for expanding wine production in the country.

As an important crop in Popeta area, there is vegetable cultivation such as pumpkins, melons, watermelons, tomatoes, green beans and others by small and large scale farmers. Forage crop cultivation shares an important portion in the objective area. The products are sold mainly as dried feed to other regions. Seed production is also important even though the produced area is small.

On the other hand, the present land use of the proposed 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. There are agricultural activities whose gross income ranges between $50,000/ha of cattle raising and $30,000/ha of charcoal in the proposed 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 proposed irrigation area exists as abandoned land because land price increase can be expected due to land use opportunities for other purposes.

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 installed. In Santiago, many fields of agro-processing are operated. Different fields from Santiago's 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 objective area is located, there are food processing facilities.

(7) 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. In order to utilize the service system of INDAP, farmers are required to be organized by themselves. This was a big bottleneck 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 forming organizations.

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. They give consulting services on INDAP services; formation of organizations, application for projects, and financial procedures. Then, they also continue to give guidance on operation and maintenance after the project.

(8) 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.

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. 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. 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.

(9) Marketing of agricultural products

Marketing of farm products in the objective area is divided into two; (a) individual, in which the producer sells his/her products to an intermediary without a contract, generally obtaining low prices, 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. The marketing channels of small producers are intermediaries, direct sale from producers to consumers, a market of agricultural products, and contract production, generally involving agro-industry or packing plants. Small collective milk marketing centers in the Objective area include Codigua, Culiprán, Popeta, Puerta and Colorada.

(10) Farm Income

The income and expenditure of farm household who hold less than 15ha in the objective area is 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

The results presented above indicate that the small farm is in a difficult situation, requiring off-farm income to make the farm viable.

(11) Agricultural infrastructure

The agricultural development project in the objective area is a part of "Popeta-Yali-Alhué" agricultural development plan proposed in the Master Plan. Irrigation facilities consist of commonly used facilities for three areas of Popeta, Yali and Alhué. New irrigation areas are uncultivated land and do not have any organized irrigation systems. There are some small irrigation areas where take water for irrigation from small streams, but water shortage is always occurred.

In each area, existing irrigation area in the objective area is basically excluded

from the object of newly irrigated areas. The existing irrigation areas where locate close to proposed canals and shortage of water has been occurred such as Culiprán is required to be supplied irrigation water. In Yali area, the basin of the Yali river includes new irrigation area where does not have irrigation system by using river flow. Construction of large scale irrigation system using groundwater has increased recently. In Alhué area, the new irrigation area is located in the Alhué river basin. At present, there is an irrigation system taking water from branch of the downstream Rapel river. Beside this, irrigated areas by pumping groundwater up are also distributed.

Around Chiñihue of the Maipo river which is the water source of new irrigation, eight intake facilities of existing canal associations are located. Three intake facilities, San José, Puangue, and Picano are located in the left bank of the weir and the rest is located in the right bank. Volume of these intakes and of water right is shown in the table below.

Unit: m^3/s

Item	San José	Puangue	Picano	Calmen Alto	Cholqui	Chocalan	Culiprán	Codigua	(Total)	P-Y-A	Total
Capacity of existing canals	3.7	2.9	8.7	1.0	3.2	2.7	3.0	2.7	27.9	-	-
Water right	5.7	3.6	9.2	8.0	2.0	5.0	5.0	4.8	43.3	25.0	68.3

(12) Rural infrastructure

Present condition of basic infrastructure in the objective area is shown in the table below.

Unit: %

Area		*Unidad Vecinal*	Electricity	Water supply	Sewerage facility
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

Among basic infrastructure in the objective 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 based on the community unit. 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.

(13) Environment

Designated areas in Popeta, Yali, and Alhue 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

to be continued

Type of designation	Name of areas	Size	Place (Basin)
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.

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 Chilean Standard for Irrigation, 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.Based on the construction of sewage treatment plant plan by EMOS, 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 at the intake points of the Maipo river. The BOD value in 1998 is an average value of the water analysis made in this study.

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 points for Popeta-Yali-Alhue will be 20 mg/l or less in 2010, that results in the water quality improvement. Moreover, because number of fecal coriform group of treated water is determined to be satisfied with the national standard, less than 1000MPN, it is expected to be improved through dilution effect as well as BOD.

(14) Problems and approach of development in the objective area

Examining the present situation of agriculture in Popeta area, existence of large number of small scale farmers who are not blessed with the favor of the farming infrastructure, and proceeding of agricultural development by a form of enterprise using groundwater are risen as typical problems of the area. The measures to solve them and to promote a well-balanced rural development are recognized improvement of farming condition of the 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 should be a core through using improved productionmeasures. On the other hand, for large and medium scale farmers who hold land in the projected area, implementation of the new irrigation system is to alleviate dependency on groundwater for development. Thus, it contributes to conservation of groundwater, which is reaching its limit.

1.2 Agricultural Development Plan

(1) Basic concept

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. The projected areas cover about 21,000ha totally and utilize the unused water right of the Maipo river. The project also consists of agricultural production plan including the support system and rural infrastructure improvement plan.

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 should be made along with the agricultural policy of "Strategic Agenda" by Ministry of Agriculture. The policy aims at installation of infrastructure on agricultural production by improvement of irrigation facilities, and development contents to contribute for the supporting and strengthening of small and medium scale farmers. Regarding the facilities relevant to new irrigation, structural composition is planned to possible the smooth management of water use in the upstream reach of the third section of the Maipo river and stable supply of irrigation water to the downstream reach of the existing irrigation system. Through them, it is planned to contribute to future water management of the Maipo river basin as a whole from the structural aspect.

(2) Agricultural production plan

The present crop cultivation reflects the conditions of agricultural production in the objective area such as landholding scale, ability for investment, farming technology, opportunities of non-agricultural activities and labor forces. On the other hand, changes of farming environment by introduction of irrigation develop the present cultivation system more intensive in the objective area.

The prospect mentioned above is realistic for two kinds, medium and large scale, of farmers, while expanding landholding scale is unrealistic for small scale farmers. Therefore, cultivation crops which is highly realistic and includes farming support are selected for the cultivation system of small scale farmers proposed by introduction of irrigation. On the selection of cultivation crops, prospects on respective crops are as follows.

Fruit tree growing	Recently, cultivation of stone fruits (peaches, nectarines, plums and apricots) and avocados has been started in the enterprise scale.
Grape vines	Private investment for grape vines has started. A distinguish vineyard made a contract with small scale farmers. This contract tends to expand in the future.
Vegetables	A medium scale agricultural development plan by private sector which includes vegetable cultivation is planned. The cultivation area tends to expand in the area.
Seed production	F1 hybrid seeds of maize, sunflower, and vegetables are produced.
Forage crops	Alfalfa shares 22% of crop cultivation in Melipilla Province. Most of them is sold to out of the Region after drying. Forage crops are highly profitable and important components of crop rotation.
Traditional crops	The Objective area is close to the Santiago among the potato production areas and very popular in rural markets.
Flowers and green house products	They become more important crops in future because the location of the objective area is close to Santiago and the seaside resorts.

Based on the considerations above, crop cultivation plans are formulated for

four farming types classified according to landholding scale in the objective area. In the plans, the basic crops are intensive cultivation crops. Cereals and forage crops are added to them from the point of profitability, self-consumption, and crop rotation. Number of farmers in each landholding scale is as follow.

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

Cropping pattern by land holding scale is as follows;

Small scale farmers(Average land holding area; 5ha)

Crop	Cultivation area (ha)	Share of cultivation (%)
Cereals	0.65	13.0
Wheat	0.65	13.0
Chacras	0.50	10.0
Potato	0.50	10.0
Vegetables	0.80	16.0
Pumpkin	0.20	4.0
Onion	0.20	4.0
Water melon	0.20	4.0
Kidney beans	0.20	4.0
Forage crops	0.70	14.0
Alfalfa	0.70	14.0
Fruit trees	1.00	20.0
Avocado	1.00	20.0
Sub-total	3.65	73.0
Others	1.35	27.0
Total	5.00	100.0

Small scale farmers(Average land holding area; 15ha)

Crop	Cultivation area (ha)	Share of cultivation (%)
Cereals	1.3	9.00
Maize	1.3	9.00
Vegetables	1.0	6.66
Pumpkin	0.2	1.33
Onion	0.3	2.00
Water melon	0.2	1.33
Kidney beans	0.3	2.00
Forage crops	1.5	10.00
Alfalfa	1.5	10.00
Fruit trees	4.0	26.60
Avocado	4.0	26.60
Grape vines	3.0	20.00
Seed production	0.5	3.32
Vegetable seeds	0.5	3.32
Sub-total	11.3	75.3
Others	3.7	24.7
Total	15.0	100.00

Medium scale farmers (Average landholding area; 40ha)

Crop	Cultivation area (ha)	Share of cultivation (%)
Cereals	5.0	12.50
Wheat	1.6	4.00
Maize	3.4	8.50
Vegetable	1.6	4.00
Pumpkin	1.6	4.00
Flowers	1.2	3.00
Forage	6.0	15.0
Alfalfa	6.0	15.0
Fruit trees	14.4	36.00
Avocado	4.0	10.00
Grape	3.2	4.00
Peach	5.6	14.00
Yellow peach	1.6	4.00
Grape vines	5.0	12.50
Seed production	3.2	8.00
Seed of vegetables	0.8	2.00
Seed of maize	2.4	6.00
Sub-total	36.4	91.00
Others	3.6	9.00
Total	40	100.00

Large scale farmers (Average landholding area; 200ha)

Crop	Cultivation area (ha)	Share of cultivation (%)
Cereals	27	13.50
Wheat	27	13.50
Vegetable	23	11.50
Melon	12	6.00
Kidney beans	11	5.50
Forage	20	10.00
Alfalfa	20	10.00
Fruit trees	72	36.00
Avocado	20	10.00
Grape	32	16.00
Peach	20	10.00
Grape vines	24	12.00
Seed production	12	6.00
Seed of maize	12	6.00
Sub-total	178	89.00
Others	22	11.00
Total	200	100.00

Gross income by farming scale is presented below.

Small scale producers	(Average farming area 5ha)	$	3,072,500
Small scale producers	(Average farming area 15ha)	$	10,830,000
Medium scale producers	(Average farming area 40ha)	$	42,060,000
Large scale producers	(Average farming area 200ha)	$	184,150,000

(3) Farmers' organization / Agricultural support plan

Organizations of beneficiaries which are recipients of the project required to be improved in the objective area for proceeding to implement projects, and utilization and promotion of effective use of improved facilities. Basically, following two systems are to be established in the plan.

- 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 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 diversion 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 recipients 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

- Organization for effective use of irrigation facilities

Regarding financial support required for construction of branch canals, the subsidy 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, an organization is established by the support of OMPC organized in Cumuna.

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 by INDAP, SAL, SAP, or SAE is to be utilized according to the level of organization.

The base facility for rural activation, Communication Center for *Unidad Vecinal* (CECUV: *Centro de Communicación para Unidad Vecinal*) is constructed to activate *Unidad Vecinal*, and promote communication among inhabitants in the area and the support activities for farmers in each *Unidad Vecinal*. Among agricultural support activities of CECUV, promotion of uniting, extension and technological guidance are undertaken by advisors organized by OMPC through cooperation with external support organizations (INIA, universities, private consultants and NGOs). Seven CECUVs are to be constructed in the area.

(4) Agricultural infrastructure improvement

A new irrigation development area is a part of "Popeta-Yali-Alhué development plan" by unused water right (25m^3/sec) of the Maipo river. The diversion weir and the main canal are planned to use commonly considering a water source and the location of the irrigation area. Accordingly, feasibility study will cover two development aspects, one is a development plan in the objective area (Popeta), and the other is the development plan in Yali and Alhué areas such as determination of irrigation area and its water requirement, design of the main and secondary canals.

In the newly irrigated farmland of Popeta-Yali-Alhué, existing farmland irrigated by groundwater is excluded from the project. The farmland of 21,000ha which includes a part of irrigated farmland by pumping (2,232ha) in Yali and Alhué areas shown in the table below is the objective areas of the project.

	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

On construction of the intake weir in new irrigation areas, existing intake structures are integrated to simplify management of water use in the third section of the Maipo river. Four sites in the left bank and two sites in the right bank of existing intake structures are integrated. Intake amount is 45m^3/sec and 12.8m^3/sec in the left and right banks, respectively.

Total length of the proposed main canal is 56.2 km and design with open channel under gravity flow. Diversion of water from the new canals is planned for the existing irrigated areas where diversion of water is possible at the points which new canals pass through. Regarding canal routes, nine sites where the canals need to detour peninsular ridges, about 20km are planned to penetrate the mountains by tunnels. The generation of electricity at 3,200kw is also planned in four sites where surplus cascade can be obtained. Moreover, regulation reservoirs are planned at 10 sites where can be dammed up by banking, geographically. Dam height of these reservoirs is considered about 10m. Through this, effective use of water resource is aimed by impounding redundant water during non-irrigation period.

(5) Rural infrastructure improvement plan

Rural infrastructure development plan promotes from the point of settlement in the rural area through agricultural promotion, soundness and safety of inhabitants in the area. Accordingly, infrastructure whose installation is behind; connecting roads (14 routes, 66.1km), water supply facilities (2 sites), rural sewage treatment facilities (8 sites), and meeting facilities (7 sites), is planned to be improved based on the analysis of the present situation.

(6) Environmental conservation plan

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.

Unidad Vecinal, 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 *Unidad Vecinal* or other groups, and farmers' groups.

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 formed to receive the agricultural support services from INDAP.

EIA System in Chile 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." The Chile side conducts environmental assessment with regard to the EIA System when the execution of the project is determined definitely.

1.3 Project Cost

The construction period of the project is to be 7 years including detailed design, preparation of contract and tender documents, tendering procedure, and construction works. The project cost is estimated at the price level as of December, 1998 based on the results of field survey on costs of labor, construction materials and equipment. Construction works are executed by constructors under contract. Summary of the project cost is presented in the table below.

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	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 the objective area, are proposed in the structural plan. Capacity of these facilities is added the capacity of the integrated diversion weir which integrated six existing diversion weirs and irrigation

water of the main canals which cover three existing irrigated areas and Yali, Alhué areas. Therefore, construction cost has to be allocated in order to estimate the individual economic evaluation on the objective area. Construction cost of the integrated diversion weir and the main canals is allocated by ratio of water right. The allotments are shown in the table below.

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

Agricultural development project in the objective 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). 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)	

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. Low interest rate credit UF+4.5%, long term loan
Law No. 18450	Maximum 75%	The rest	Applicant applies advantageous rate for the proposal.

The irrigation facilities that are transferred from DOH after completion of the construction works are operated and maintained by beneficiaries in Culiprán-Popeta 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, canal association should be established. The canal association operate and maintain common irrigation facilities and own facilities, and manage water. The newly established canal 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. Annual O&M cost is estimated at $54.4 million and $25.9 million at the integrated water management association and the regional canal association, respectively.

1.5 Development Impact and Evaluation

Evaluation of the project is made by internal rate of return of the project. The benefits are estimated by increase of agricultural production and power generation. The costs are used by allocated cost to Popeta area according to the results of the project cost estimation.

Economic net present value of the entire project and economic internal rate of return (EIRR) are estimated at $9,231.3 million and 21.1%, respectively at 12% of discount rate. Implementation of the project is expected to bring about following socio-economic impacts beside direct benefits estimated by economic evaluation.

Creation of the solidarity among inhabitants
Stable supply and diversification of agricultural products
Establishment of systematic water use
Promotion of organizing farmers
Increase of job opportunity
Increase of intention for working
Activation of socio-economic activities
Development of regional economy
Impact on the environment

Accordingly, implementation of this project is justified.

1.6 Conclusion and 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 intake structures 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 recipient 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, *Comuna* and relevant *Unidad Vecinal* which will be a core body of the project promotion organizations.

2 Agricultural Development Plan in Mallarauco Area

2.1 The Present Situation of the Objective Area

(1) Society

Mallarauco area which belongs to *Comuna* Melipilla consists of 4 *Unidad Vecinal*. According to the Census '92, population of the objective area is 8,145 persons.

Unidad Vecinal forms administrative districts and regional society as an unity of *Junta de Vecino* which is the minimum unit of regional society. Communities in the area are extended into both sides of main roads, and shape so-called "row community." In case of row community, it is difficult to form the center of a community. The place where public facilities such as churches and schools are located is the center of a community at present.

(2) Geology

Mallarauco area consists of a plain where old riverbed deposit and terrace deposit of Quaternary age cover the valley formed by impervious base rock. However, the surface layer is a tableland composed by Alluvial pumice volcanic ash. The rivers flow and erode the tableland at present. Diluvium aquifers is overlain by the volcanic ash deposit, and development of alluvial deposit along the existing river is poor.

(3) Climate

The objective area categorizes in the Mediterranean climate, The division of winter and summer seasons is clear. While most of annual rainfall is concentrated in winter season, dry and fair weather continues in summer season. General climatic condition is as follows.

Annual rainfall	400 mm	Annual average temperature	14.8℃
Annual average maximum temperature	28.0℃	Annual minimum temperature	3.3℃
Annual average relative humidity	69.7%	Annual average wind velocity	1003.6km/month
Annual average sunshine hours per day	6.9 hr	Annual average evaporation	1,212 mm

(4) Soil and land use

According to agricultural landholding survey (REA : *Rol Extracto Agrícola*) in 1995, land use of the objective area is presented in the table below.

Unit: ha

Area	*UV*		Total area	Farmland	Others
Mallarauco	UV1	Bollenar	2,369.9	1,777.4	592.5
	UV2	Mallarauquito	2,952.6	1,535.4	1,417.2
	UV3	Pahuilma	5,379.4	1,882.8	3,496.7
	UV4	Mallarauco	9,622.4	4,041.4	5,581.0
		Total	20,324.4	9,237.0	11,087.4

For soil and land classification of the objective area, the data of REA and the orthophoto which obtained from CIREN are used. Land productivity classification of the area is summarized as follows.

	Land productivity classification	Area by REA (ha)
I	(No limitation for cultivation)	0.0
II	(A little limitation)	134.2
III	(Necessary to select crops)	593.3
IV	(Serious limitation for cultivation)	315.0
V	(Difficult for farmland)	0.0
VI	(Impossible excluding pasture land)	0.0
VII	(Impossible for farmland)	0.0
VIII	(Impossible for whole land use)	0.0
	Total	1,042.5

(5) Water resource

Irrigation water for the farming plot in the Mallarauco area is conducted through the Canal Mallarauco. Water rights in the Mallarauco irrigation system are settled on 920 *Accións* at intake point. Available irrigation water of 1 *Acción* varies from 4.5 lit./s to 8.0 lit./s. Based on the maximum available irrigation water of 8.0 lit./s and water right, total water requirement amount at headrace of canal is 7.36 m^3/s. Water requirement amount for peak demand period of irrigation can be assured in comparison with the actual intake water amount.

According to the well registration of DGA, 2 wells for agriculture are registered. The irrigation area by using groundwater is estimated 60 ha from the average irrigation area (30 ha/well). Both confined and free groundwater in Mallarauco basin show a tendency to lower the water level.

(6) Agriculture

The results of classification of farmers in the objective area by farming scale is presented in the table below.

Farming Size (ha)	No. of Farmers	Holding Area (ha)	Irrigation Area (ha)	Average Farming Area (ha)	Average Irrigation Area (ha)	Non-Irrigation Area (ha)
0.1 – 15	84	782.9	782.9	9.3	9.3	0
15.1 – 100	7	166.9	104.4	23.8	14.9	62.9
Over 100.1	3	791.1	155.2	263.8	50.9	638.3
Total	94	1740.9	1,042.5			701.2

Average scale of farmers' landholding in the project area is 9.4ha for small scale farmers and 25.3ha for large and medium scale farmers. Among beneficiaries of the project, 89% of the beneficiaries is small scale farmers and 11% of them is a large and medium scale farmers. The beneficiaries who hold land outside of the beneficial area for water quality improvement are only large and medium scale farmers. Most of their land is unirrigated area.

Small scale farmers in Mallarauco area have very wide farming experience and agricultural technology, compared with small scale farmers in the other areas. When export melons were produced in the area in the past, small scale farmers also cultivated them. Small scale farmers started to engage in milk production after quitting melon cultivation by the virus infection and the regulation on vegetable cultivation by contaminated irrigation water. Some of them produce quite high quality milk. Because the milk price decreased, small farmers had to quit milk production. Farming alternative for them is fruits growing but most of them cannot invest enough and remain small scale and low productivity farming.

Present cultivation crops in the objective area are as follows.

Crop	Grains			Vegetable *	Forage Crops	Fruit Trees			Sub total	Forage & Others	Total
	Maize	Wheat	Total			Avocado	Lemon	Total			
Area (ha)	164.7	22	186.7	99.1	225.2	31.3	20.9	52.2	563.2	479.8	1043
%	15.8	2.1	17.9	9.5	21.6	3.0	2.0	5.0	54.0	46.0	100

Note * : Basically indicate Pumpkin, Melon, Watermelon, zucchini and potato

Cultivation crops by farming scale are shown in the table below.

Crops	Grain Crops			Vegetables			Forage Crops	Fruits Trees			Sub total	Pasture & Others	Total
	Wheat	Maize	Sub total	Pumpkin	Watermelon	Sub total	Alfalfa	Avocado	Lemon	Sub total			
Small scale (9.4 ha)	0.28	1.2	1.48	0.4	0.41	0.81	1.83	0.06	0.12	0.18	4.3	5.1	9.4
(%)	2.7	13.0	15.7	4.2	4.4	8.6	19.5	0.67	1.16	1.9	45.7	54.3	100.0
Total Area (ha)	22	102.4	124.4	33.6	34.5	68.1	154.2	5.3	9.2	14.5	361.2	428.8	790.0

Crops	Grain Crops	Vegetables	Forage Crops	Fruits Trees			Subtotal	Pasture & Others	Total
	Maize	Melons	Alfalfa	Avocado	Lemon	Subtotal			
Large / Medium Scale (25.3ha)	6.2	3.1	7.1	2.6	1.2	3.8	20.2	5.1	25.3
(%)	24.5	12.3	28.1	10.3	4.6	14.9	79.8	20.2	100.0
Total Area (ha)	62.3	31.0	71.0	26.0	11.7	37.7	202.0	51.0	253.0

The table below shows agro-processing factories operating near the objective area, María Pinto and Peñaflo. Melipilla, Talagante and Culacaví are located within 10km, 30km and 25 km from the objective area, respectively. Buin, Paine, Linderos and Santiago are located within 60 km from the objective area. Accordingly, it is possible for the objective area to access easily all kinds of agro-processing facilities.

Type of Processing Facilities	No. of Facilities	Capacity
Nuts Processing Facility	1	45,000 kg/ day
Fruits Dehydration Facility	2	10,000 kg/day
Raw Milk Processing	3	N/A
Vegetable Freezing Facility	5	29,500 m^3
Packing Facility	16	135,500 kg/ day
Sterilizing Facility	3	31,000 kg/ day

(7) Agricultural support and farmers' organization

All of agricultural support services in the study area are provided through INDAP-Melipilla. As farmers' organizations in the objective Area, there are three types of organizations; canal association, milk collecting cooperative and citrus group.

As water users' association, there is only one, Mallarauco canal association. This association distributes irrigation water fairly, and maintains canals in the area as a whole. The association can utilize INDAP service systems for improvement and construction of facilities, and also applies for and materializes the project.

Milk collecting cooperative and citrus group are producers' organizations and both of them are organized by INDAP services. The milk collecting cooperative is managed by 15 dairy farms. Its base is a milk collection center, which equipped with a fixed temperature storage by INDAP services. Based on the centers, the cooperative controls animal raising, feed and milking of each farm. Citrus group (Groupo Citricola) is organized by 17 small scale farmers through utilizing SAL program of INDAP. The group intends to increase productivity and control quality of lemons and oranges. This results in establishment of the productions' status in a market and maintenance of quality.

Although there are a few producers' organizations in the area as mentioned above, they have been achieved steadily the results and contribute largely to

improvement of small scale farmers' status and stability of regional society. The ratio of forming organization is still very low. The constraints on organizing small scale farmers are vigorous feeling for self-independence of themselves and mutual distrusts among them. On the other hand, there are lack of public relation on the support system, of basic motivation to form organizations. There is also lack of support organizations for implementing them.

(8) Agricultural marketing

Marketing of farm products in the objective area is divided into two; (a) individual, in which the producer sells his/her products to an intermediary without a contract, generally obtaining low prices, 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. The marketing channels of small producers are intermediaries, direct sale from producers to consumers, a market of agricultural products, and contract production, generally involving agro-industry or packing plants. Small collective milk marketing centers in the objective area include Codigua, Culiprán, Popeta, Puerta and Colorada.

(9) Farm income

Results from the questionnaire survey on economic balance of farm households in the objective area is shown in the table below.

	Small scale farmer				Medium scale farmer			
Item	Area (ha)	Income ($)	Expenses ($)	Result ($)	Area (ha)	Income ($)	Expenses ($)	Result ($)
Farm Area	8.14				18.5			
Used Area	4.39				17.0			
Gross Farm Income		3,164,032				12,133,456		
General Expenses			412,458				1,003,200	
Net Farm Income				2,751,574				11,130,256
Family Labor		75,000						
Off-farm Income		156,000						
Family Expenses			988,625				760,000	
Household Income				1,993,949				10,370,256

The economic results presented above indicate that the small farm is in a difficult situation, requiring off-farm income to make the farm viable.

(10) Agricultural infrastructure

Mallarauco area extends over 7,000ha of farmland and is irrigated by contaminated rive flow of the Mapocho river by urban sewerage. The irrigation water is divided into seven irrigation systems (irrigation areas) in *Comuna* Mallarauco. The details on number of water rights (*Acción*) and users (*Acciónistas*) are as follows.

Irrigation System	User	Water-Right	Discharge (m^3/sec)
1. Pervin	35	140.000	1.120 – 0.630
2. Norte	53	261.160	2.089 – 1.175
3. Sur	91	167.924	1.343 – 0.755
4. Higuerillas	95	193.890	1.551 – 0.872
5. Santa Ana	60	98.916	0.791 – 0.445
6. Italiano	61	107.364	0.858 – 0.483
7. Reforma	78	76.971	0.615 – 0.346
8. Retamo	21	8.000	0.064 – 0.036
Total	494	1,054.225	8.433 – 4.744

Note: Discharge is calculated from water right's discharge (1 *Acción*: 8~4.5 l/sec/ water right)

Although number of water right at the intake points is 920 in the area as a whole, there is also *Acción* at the water source which uses return flow in the downstream basin. Sum of them is 1,054.225. Intake water volume is varied by season, the volume per *Acción* is changed between 8.0 and 4.5lit./sec and distributed. Irrigation method in the area is mostly furrow irrigation in the flat land including orchard. A drip irrigation method by pumping up is applied in the orchard of the sloped land.

The mountains locate in the north and the south of the Mallarauco area and the Higuerillas river flows from the east to the west in the low flat of the center in the area. This river plays a role of a drain that collects rain and excess water of irrigation. However, the flow of river is dammed up at the downstream reach and utilized for irrigation. The river has a function as both irrigation and drainage canals.

Irrigation water of Mallarauco area is taken from the Mapocho river. Water of the Mapocho river is already contaminated by the urban sewage at the intake point of the Mallarauco canal. Thus, the farmers must use contaminated water as irrigation water in the entire area. Accordingly, the problem of contaminated irrigation water is not solved in the area, otherwise sewage is treated in the Santiago city.

Mallarauco canal association manages irrigation facilities from intake facilities to the secondary canals. Maintenance cost is paid according to number of water right (*Acción*) by a holder. The holders of water right are 494 and the maintenance cost per *Acción* is $63,000 annually. Main work of maintenance is canal repair, and the repair schedule is prepared every year. The management cost of the main canal is paid by users of the entire area. After the secondary, the management cost is paid by users concerned. The burden of canal repair cost is large in the canal system which passes through the slope of mountains. Mallarauco canal association manages water and distributes *Acción* flow fairly at each diversion point according to intake water amount.

(11) Rural infrastructure

The present situation of basic infrastructure in the objective area is shown in the table below.

Unit: %

Area		*UV*	Electricity	Water Supply	Sewage System
Mallarauco	UV1	Bollenar	84.9	89.6	10.9
	UV2	Mallarauquito	87.2	90.0	9.2
	UV3	Pahuilma	85.8	90.4	26.7
	UV4	Mallarauco	78.5	82.5	14.4
	Total		83.3	87.6	15.4

On the basic infrastructure in the objective area, installation of electricity and water supply is almost completed. Electricity is supplied by the electric supply company and will be supplied to all households, soon. All drinking water is taken from groundwater. The water supply system is renewing in the entire area by the support of EMOS at present. All households will be able to obtain tap water by the water supply system. Accordingly, installation of electricity and water supply does not have problems at all. On the other hand, installation of sewage systems has almost not proceeded, and there are no sewerage treatment facilities even in the communities where water supply facilities have already installed. Excreta is treated in 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. Mallarauco area extends into the valley and the structure of communities is relatively gathered. Therefore, there are a few constraints on installation of a rural sewage system. It is necessary to promote installation of a

rural sewerage system from the aspect of living and production environmental conservation for inhabitants.

(12) Environment

There is no designated area, such as natural park, in Mallarauco. The results of water quality analysis for irrigation around intake structures are presented in the table below.

Date		7/22	8/11	12/8	12/11	Chilean standard	Chilean standard	Standard for
Item	Unit	St.20	St.20	St.20	C11	for Irrigation	for Recreation	growing specified
pH	-	7.4	7.1	7.7	7.4	5.5-9.0	6.5-8.3	
BOD	mg/l	96.0	59.0	38.0	110.0			
No. of Coliform Group	mg/l	9.2E+06	1.1E+08	1.7E+05	9.2E+08			
No. of Fecal Coliform Group	mg/l	1.7E+06	2.4E+07	3.5E+03	1.1E+07		1000	1000
Cu^{2+}	mg/l	0.003	0.044	0.020	0.069	0.20		
SO_4^{2-}	mg/l	405.0	381.0	324.0	326.0	250.00		
Cl^-	mg/l	257.0	275.1	204.4	224.2	200		

St.20:Rio Mapocho en Canal Mallarauco C11:Canal Mallarauco(en salida del tunel)

Compared to the standard value shown in the table above, both points in all seasons meet the standard requirement of water for agricultural use as to pH and Cu^{2+}, while both points in all seasons exceed the standard as to $SO4^{2-}$ and Cl^-. Concerning fecal coliform, both points in all seasons exceed the standard value of water for recreation use and water for growing the specified vegetables. Accordingly, water contamination in the area is a serious problem.

(13) Problems and development approach in the objective area

Examining the present situation of Mallarauco area, the problems of the area are summarized as contamination of irrigation water, decrepit irrigation facilities, and unstable farming base of small scale farmers. Based on the present problems in Mallarauco area, the measurements to solve these problems and to enjoy its advantage as a food supply base near the metropolitan area are recognized that improvement of production and living environment by improving quality of irrigation water, decrease of O & M cost and alleviation of water shortage at the terminal point by rehabilitation of the existing irrigation facilities. Crop diversification which is resulted from water quality improvement brings about stabilization of farming base by more intensive agriculture and at the same time, the quality improvement of water contributes largely to maintaining favorable health and sanitary condition of farmers.

2.2 Agricultural Development Plan

(1) Basic concept

Mallarauco area was formed by the Higuera river which is a branch of the Puangue river and flows in Melipilla Province. Irrigation water in the area is taken from the Mapocho river after the Zanjon de la Aguada canal, which sewage of Santiago city is concentrated in the Talagante province, joined the Mapocho river. Contamination level of irrigation water taken from the Mapocho river shows extremely high, over 10^5MPN/100ml of coliform groups. However, water of the Mapocho river contaminated by urban wastes must be used continuously as irrigation water under the present situation of Mallarauco area where is no alternative water sources in and out of the area.

Contamination of water quality is to be reduced by step-by-step improvement of sewage treatment plants of EMOS, gradually. Nevertheless, it will take about 25 years until good irrigation water can be taken from the rivers by completing the plants.

Positive measures for water quality improvement from agricultural sector are required to establish sound agricultural production environment and recover the function as the base of perishable food supply which utilizes the characteristics of suburban agricultural area. These measures will also contribute to establishment of agricultural production environment which satisfies the demand of markets and achievement of sound health and sanitary environment for farmers who engage in agricultural production. On the other hand, irrigation facilities in Mallarauco are well managed by canal associations, however the majority of facilities was constructed in 1800s. They have been repaired, repeatedly and used until now. The decrepit facilities has increased the maintenance cost and work. It is time to rehabilitate the entire irrigation system.

The plan for water quality improvement and rehabilitation of the existing irrigation facilities intends to have applicable contents to the other areas as a model project on improvement of deteriorated agriculture environment which metropolitan agriculture is facing at present.

(2) Improvement area of irrigation water quality

Improvement area of irrigation water quality that F/S is to be implemented is selected according to the following standards which focus on appearing improvement effect, considering characteristics of water quality improvement project as a model.

1) Areas are independent on their irrigation and drainage systems
2) Easy diversification of crops by water quality improvement
3) Large number of beneficiaries including small scale farmers

According to the standards mentioned above, three of five areas where are independent on their irrigation and drainage systems are selected because those three areas satisfies the other standards.

Area	Irrigation Area	Area (ha)	No. of Farm household				Crop
			Large Scale	Medium Scale	Small Scale	Total	
Los Carrera	Sur	196	-	-	24	24	Annual
Reforma	Reforma	716	-	3	35	38	Annual
Santa Ana	Mansano	531	3	4	25	32	Annual

(3) Agricultural production plan

Main purpose of water quality improvement plan in the objective area is that producers, especially small scale producers can gain higher income from their farming through making intensive cropping system and crop diversification possible. The second important point in the plan is influence derived from the construction of sewage treatment plants. That is to say, as a result of sewage treatment plants' construction, introduction of technical irrigation systems such as drip irrigation and sprinkler irrigation can realize because water distribution is made by pressure conveyance method using pump facilities. Crop diversification, in reality, boosts vegetable cultivation of prohibited kinds by using contaminated water mainly from the Mapocho river. Introduction of mechanized irrigation system is predominantly reflected in increase of orchards. This result enables small scale farmers to introduce high level intensive cultivation and highly profitable crops (vegetables which are prohibited to grow at present) as well as medium and large scale producers.

Considering distribution of water improvement areas and the purpose of the plan, expected effects of the plan must be important for small scale farmers, and proposed crop cultivation mainly focuses on expansion and diversification of vegetable cultivation. This is because vegetable would be the most profitable crop for small scale producers if water quality improvement is possible. Fruit tree growing requires

capital and production scale which small scale farmers cannot afford. Actual prices of milk products cannot make high profit under management scale and technical level of small scale farmers. Based on the consideration above, a proposed cropping system for small scale farmers is shown in the table below.

Crop	Cereal	Traditional	Vegetable					Forage	Fruits Tree			Pasture		
	Wheat	Potato	Swiss chard	Onion	Cabbage Melon	Broccoli Cauliflower	Total	Alfalfa	Avocado	Lemon	Total	Subtotal	& Others	Total
Small Scale Farmer (ha)	0.5	0.5	1	1	1	1	4 (6)	2	0.2	0.2	0.4	7.4	2.0	9.4 (11.4)
%	5.3 (4.6)	5.3 (4.4)	10.6	10.6	10.6	10.6	42.4 (52.6)	21.2 (17.5)	2.2	2.2	4.3 (3.5)	78.6	21.4	100

Among proposed vegetables, three of them, Swiss chard, cabbage and cauliflower, are prohibited to cultivate under the present situation but have highly marketability. The other three vegetables and potato are indirectly affected by water quality. On vegetable selection for Reforma area, there is a constraint against vegetable cultivation that drainage is relatively poor, compared with the other areas. Alfalfa is important in the meaning of that it can be included in land rotation and is a rational and highly profitable crop. Cereal crops which are represented in wheat is also important crop for completing the crop rotation and self-consumption for small scale farmers. Fruit growing has an effect mainly as a kitchen orchard.

In case of average medium and large scale farmers in irrigation areas, orchards are given priority on water use, considering advantage of improved water quality. The proposed cropping system for medium and large scale farmers is described in the table below.

Crop	Cereal	Vegetable	Fruits tree			Seed production	Sub total	Pasture & Other	Total
	Maize	Melon	Avocado	Lemon	Total				
Large/ Medium Scale Farmers (ha)	2.0	3.0	9.0	7.0	16.0	2.3	23.3	2.0	25.3
%	7.9	11.9	35.5	27.7	63.2	9.0	92.1	7.9	100

Gross income in the cropping plan by farming scale is presented in the table below.

Small scale farmers (Average farming area; 9.4ha)	$	9,710,500
Large and medium scale farmers (Average farming scale; 25.3ha)	$	29,600,000

(4) Agricultural support

In order to promote socio-economic self-independence of the area, forming organizations of farmers, who are beneficiaries, is indispensable. The core for regional agricultural development is established by realizing diversification of agricultural production through improvement of water quality for irrigation. The irrigation water is improved by implementing water quality improvement project through organizing farmers in the area. Establishment of the organization system of beneficiaries, who are the recipients of the project, is indispensable to promote the project implementation in the objective area and effective use of irrigation water whose quality is improved. Based on the mutual consensus on the improvement of the present situation, following two organizations are to be established as basic systems of beneficiaries.

- Organization for water quality improvement

  In Mallarauco area, because whole irrigated area is managed by *Asc. Canalista Mallarauco*, it does not need to establish new organization to promote the project. This canal association is utilized as the organization to promote the project. Nevertheless, as for operation and maintenance

of water quality improvement facilities, an independent organization in the canal association is established for smooth operation of facilities.

- Organization for effective use of facilities

  Technical and financial support services for producers' groups on utilization of improved irrigation water at the field level are provided by using the INDAP's service system. Various producers' groups are expected to be organized due to diversification of crops by water quality improvement. An advisor is to be employed through OMPC's arrangement for organizing producer's groups. On the promotion of the INDAP's project implementation , SAL, SAP or SAE is to be applied according to the level of organization for highly-advanced production cooperatives.

Moreover, Communication Center for *Unidad Vecinal* (CECUV: *Centro de Communicación para Unidad Vecinal*) is constructed in each *Unidad Vecinal* as the core facility of activities to vitalize *Unidad Vecinal* and promote smooth communication among regional inhabitants and support activities for farmers. Among agricultural support activities, promotion of uniting, enlightenment 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). CECUV is constructed in two sites in the area.

(5) Agricultural infrastructure improvement plan

Three areas, Los Carrera, Reforma and Santa Ana, are selected as the agricultural development areas by water quality improvement, and the rehabilitation of existing irrigation facilities will also be planned along with the water quality improvement. Irrigation area, duty of water and irrigation methods of the proposed areas are as follows.

Area	Irrigation Area (ha)	Water-Right		Irrigation Method
		No. of *Acción*	Water requirement (l/sec)	
Los Carrera	135.2	15.6488	125.19	Furrow
Reforma	488.5	67.9325	543.46	Furrow
Santa Ana	418.7	53.7163	429.73	Furrow
Total	1,042.5	137.2976	1,098.38	

Note: Irrigation Area is measured from 1/10,000, Water requirement is based on 8 l/sec/Right

Reforma area takes water by damming-up the Higuerillas canal, which is the drainage canal of Mallarauco irrigation system and distributed irrigation water by three canals, Norte, Centro and Sur of the irrigation area. Among these, a confluent section of the Sur canal is not included in the proposed area for water quality improvement because it joins with the other water system in the downstream reaches.

Sewage treatment plants to improve water quality are basically to be constructed around the present intake structures. Because the canals in Los Carrera and Santa Ana areas are located in higher position than the proposed irrigation area, the plant sites are selected according to the plan of treated water distribution by gravity method. In both Reforma and Santa Ana areas, because the canals are located in the lower portion and irrigation areas are flat land, treated water needs to be conveyed to the existing canals by pumping up.

Treatment capacity of the plant is determined by treatment capability. Thus, the planned treatment capacity is set the discharge of water right mentioned above. Up

to the burden of inflow discharge, it is adjustable to a certain level of discharge change by selecting number of treatment tanks.

Intake facilities from the existing main canals are planned to be rehabilitated with the construction of new sewage treatment plants including increase of intake capability. Treated water at the sewage treatment plant is distributed through a regulation reservoirs to canals (pipeline) for adjustment of time-lag between treatment and irrigation. Drip and micro-sprinkler can be used in the field level because 1.0 kg/m^2 pressure water from tap of the pipeline can be obtained.

(6) Rural infrastructure improvement 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, infrastructure whose installation is behind; connecting roads (6 routes, 26.2km), water supply facilities (4 sites), rural sewage treatment facilities (8 sites), and meeting facilities (2 sites), is planned to be improved based on the analysis of the present situation.

(7) Environmental conservation plan

According to the construction plan of the sewage treatment plants in Santiago city by EMOS, three plants will be completed along the Mapocho river in 2024 and then the treated water of approximately 25 m^3/sec will be discharged into the Mapocho river. Consequently, water quality of the Maipo river joining the Mapocho river will be greatly improved. However, according to the predicted quality of water for irrigation in the priority project area in the target year of the project (2010), water quality of the Mapocho river will be more improved than the present, the BOD value predicted by EMOS will exceed 20mg/l in 2010 with the exception at the time of minimum discharge, despite the fact that a part of the construction of the treatment plants will be completed at that time.

The purpose of the water quality improvement project in Mallarauco is to improve the contaminated water for irrigation by means of the sewage treatment plants and to create the model area for agricultural development by improvement of the rural environment and diversification of crops. It is preferable to ameliorate water in the BOD and SS values, both of which are the index of water contamination, up to the lowest value as possible, and to discharge the water. The present project, however, the object values of BOD and SS are set as 20mg/l and 30mg/l respectively, both of which are the same as the planned values in the sewage treatment plant over the Metropolitan Region. The object group number of fecal Coliform is set at 1000MPN/100ml as the domestic standard, though in this project, it is set at 23MPN/100ml which is the standard number for crops for export.

The design water quality of inflow to the treatment plant is set at 300mg/l of BOD and 300mg/l of SS. The design capacity of water to be treated is supposed to the maximum volume of water rights in the proposed area. The treatment method is designed with the conventional activated sludge method in the case where the amount of water to be treated corresponds to 0.2m^3/sec or more, or the sequencing batch reactor process which is suitable for the middle- or small-sized plant in the case where water volume is less than 0.2m^3/sec. The disinfection method by chlorine or by ultraviolet rays is known as the method to disinfect coliform bacilli. In the project, adopted is the method by ultraviolet rays by which no chlorine is remained because the treated water is directly used for irrigation water. On the basis of the methods above, the sequence of sewage treatment and list of facilities are as follows:

Conventional Activated Sludge Method:	Inflow- Sand Basin- Pump Well- Primary Settling Tank- Reaction Chamber- Final Settling Tank- Disinfection Chamber- Outflow
Sequencing Batch Reactor Process:	Inflow- Sand Basin- Pump Well- Batch Reactor - Disinfection Chamber- Outflow
Design inflow quality:	BOD 300 mg/l SS 300 mg/l (1.1E+07 MPN/100 ml of fecal coliforms)
Amount of sewage treated:	0.15 m^3/sec in Los Carrera (140 ha irrigated) 0.45 m^3/sec in Santa Ana (420 ha irrigated) 0.55 m^3/sec in Reforma (490 ha irrigated)
Design treated water:	BOD 20 mg/l SS 30 mg/l (23 MPN/100 ml of fecal coliforms)
Processing method:	Conventional activated sludge method in Santa Ana and Reforma Sequencing batch reactor process in Los Carrera
Disinfection method:	Method using ultraviolet rays
Site area	Los Carreras 1.5 ha Santa Ana 2.5 ha Reforma 5.0 ha

O & M of the sewage water treatment plant is to be carried out by the Mallarauco canal association.

After the construction of the plants proposed in this project, those plants will be managed by the canal association. However, at the points where canals pass through communities, it may be considered that the canals will be damaged and irrigation water contaminated by wastes, domestic sewage, and stock-farming wastes. In this project, a campaign for enlightenment and public relations are planned on the-community-basis with respect to the environmental conservation to keep high quality of water. The promotion campaign of environmental education is also planned by recommending a member of the youth group of *UV* or other groups, and farmer's groups to have a qualification to be engaged in the environmental conservation.

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

EIA System in Chile provides the object to be assessed from the environmental view. The related items in the system to the EIA System selected as the priority project for development in Mallarauco is "in case of the sewage treatment plant construction." Environmental assessment with regard to the EIA System is conducted by the Chile side when the implementation of this project is determined definitely.

2.3 Project Cost

The construction period of the project is to be 7 years including detailed design, preparation of contract and tender documents, tendering procedure, and construction works. The project cost is estimated at the prices level as of December, 1998 based on the results of field survey on costs of labor, construction materials and equipment. Construction works are executed by contractors under contract. Summary of the project cost is estimated at $26.4 billion as presented in the table below.

Unit: Thousand Pesos.

Component	F.C	L.C	Total
1. Preparation cost	590,845	360,008	950,853
2. Water quality improvement / Irrigation facility improvement cost			
Sewage treatment plant facilities	11,114,356	7,123,208	18,237,564
Irrigation facility improvement	692,540	276,956	969,496
3. Rural infrastructure and Agricultural support facility development cost	624,530	838,323	1,462,853
4. Land acquisition and compensation cost		15,442	15,442
5. Engineering and administration cost	861,169	1,416,907	2,278,047
6. O&M equipment cost	121,577	45,000	166,577
7. Physical contingency (10%)	1,391,470	1,007,279	2,398,743
8. Total	15,306,167	11,080,070	26,386,171

2.4 Project Implementation Schedule

The Plan is defined as the project which farmers apply for. The project is executed within government subsidy law system for irrigation project. Therefore, the project executive organizations are divided into two based on the project scale. Water quality improvement project is executed by DOH in accordance with Government ordinance No.1123 and the irrigation facility improvement project is executed by CNR in accordance with Law No.18450. Regarding construction of sewage treatment plant, proposed standard of water quality and structure, and water quality examination after completing the construction are managed and implemented under the guidance of CONAMA. Among these projects, in case of sewage treatment facility construction, maximum 70% of the project cost is paid by national government subsidy under Government ordinance No. 1123 and the rest of it is paid by beneficiaries. Nevertheless, according to the financial analysis of farm households, the project cost needs to be subsidized at least 90%. On the burden the project cost, the burden of Santiago City which is a polluter and also the nation should be examined.

O & M of canals and water management are carried out by Mallarauco canal association. The present works and roles of Mallarauco canal association are management of canal facilities and diversion, but O & M of the plant facilities and water quality management mentioned above are added. Annual O & M cost is estimated at $360 million.

2.5 Development Impact and Evaluation

The project evaluation is made by internal rate of return of the project. The benefits are estimated by increase of agricultural products and impact of BOD reduction. The costs for evaluation are used by the results of the project cost estimation.

Economic net present value of the entire project and economic internal rate of eturn (EIRR) are estimated at $8,030.6 million and 20.5%, respectively at 12% of discount rate. Implementation of the project is expected to bring about following socio-economic impacts beside direct benefits estimated by economic evaluation.

Creation of the solidarity among inhabitants
Diversification of agricultural products
Impact of water quality improvement
Increase of job opportunity
Increase of intention for working
Activation of socio-economic activities
Development of regional economy
Impact on the environment

Accordingly, implementation of the project is justified.

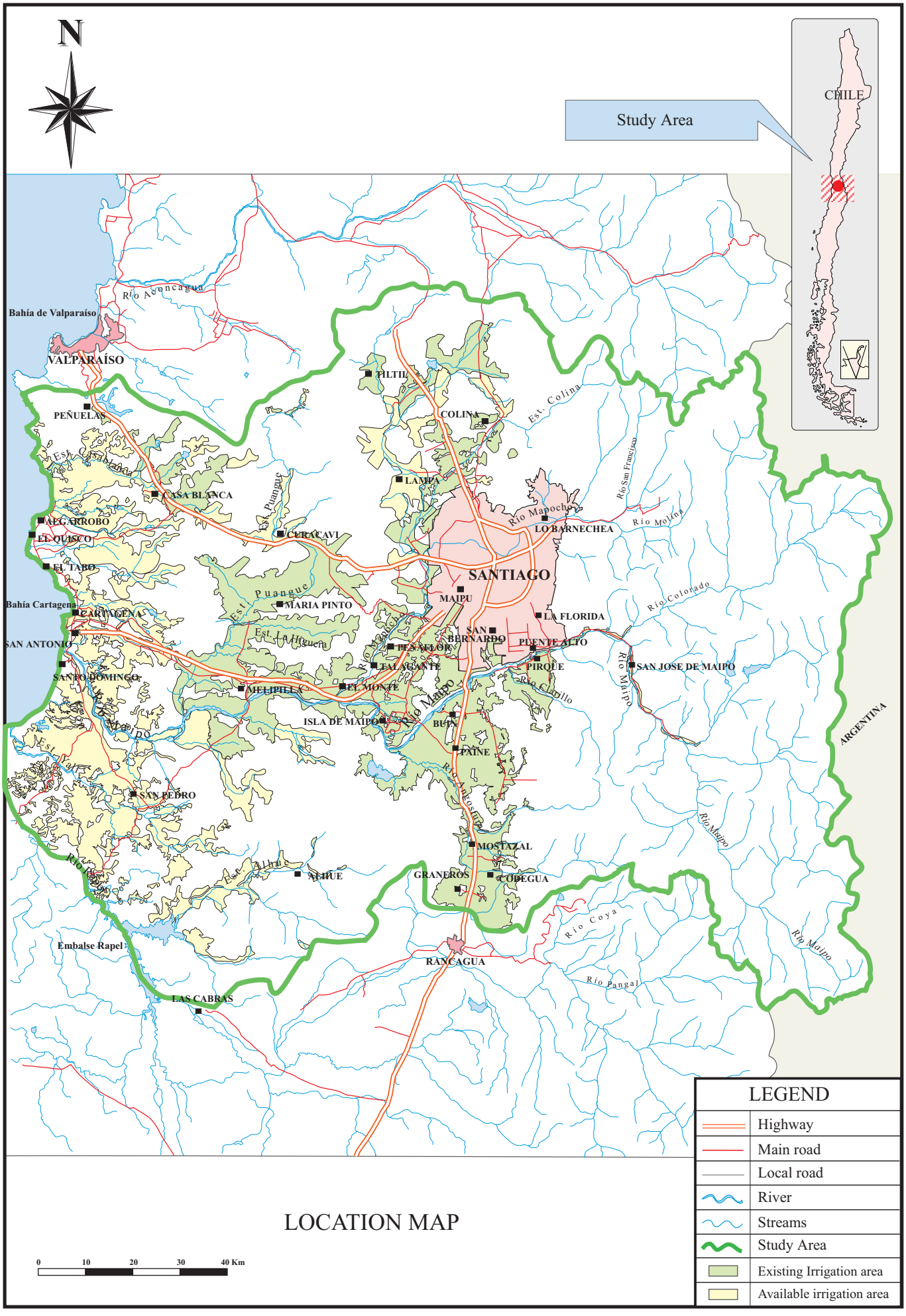
2.6 Conclusion and Recommendation

(1) The project implementation benefits directly to the improvement on farming and farming condition of the farmers in the projected area. Because the sanitary environment surrounding production of perishable food has become international interest, infrastructure improvement for agricultural production is an urgent problem in order to expand agricultural export. The water quality improvement project is recommended as a pilot project based on the understanding stated above. On the other hand, required cost of water quality improvement is large and it is hard to be established as the project in the range of direct benefit which usually can be measured. From the results of financial analysis of farmers, subsidy of 90% on investment costs is required to promote the project execution. Taking these condition into account, the burden of Santiago City, which is the cause of pollution and also the nation, should also be examined. Accordingly, it is recommended for early implementation of the project that subsidy methods for initial investment should be established in the frame of existing or new subsidy system of government, considering the project advantage.

(2) As Government ordinance No.1123 is applied to the Project under the frame of the present project support system, close cooperation between CNR and DOH is necessary at each stage such as adoption of the project by DOH, approval of the project and execution of the project. Guidance of CONAMA is required at the stage of the project promotion because the project includes water quality improvement relevant to environmental issues. Therefore, it is recommended that a project promotion committee which consists of CNR, DOH, and CONAMA should be established.

(3) The beneficiary of the project is the existing canal association, Mallarauco canal association. As O & M of sewage water facilities handed by the association, it is proposed that the section of O & M for sewage treatment facilities should be established in the present Mallarauco canal association.

Part I Master Plan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Study Area
CHILE
Río Aconcagua
Bahía de Valparaíso
VALPARAÍSO
PEÑUELAS
Est. Casablanca
CASA BLANCA
ALGARROBO
EL QUISCO
EL TABO
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MOSTAZAL
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CODEGUA
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RANCAGUA
Río Pangal
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Main road
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LOCATION MAP
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AGRICULTURAL DEVELOPMENT AND WATER MANEGEMENT IN METROPOLITAN AREA

MASTER PLAN STUDY

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CHAPTER 1

INTRODUCTION

1 INTRODUCTION

1.1 Authority

This Draft Final Report (the Report) is prepared according to the Scope of Work for the Study on "Agricultural Development and Water Management in Metropolitan Area, Chile" (the Project) agreed upon between the National Irrigation Commission of the Republic of Chile and Japan International Cooperation Agency (JICA) in November, 1997.

The study of the Project was conducted in two steps; Phase I and II. During the Phase I study from June to October in 1998, the Master Plan of the agricultural development of the entire study area was formulated on the basis of the field survey and study results of the present situation on the study area, then, priority project areas were subsequently identified. The Phase II study was executed from November 1998 to March in 1999 and development plan of the priority areas was formulated through the feasibility study on the priority areas.

The Report consists of the Main Report and Annexes. The Main Report comprises development plan formulated, results of detailed analysis and survey through the field and home office works carried out Phase I and Phase II studies. The Annexes describe the results of study and analysis on present situation of each field and of the formulation on the development plan in detail.

1.2 Background

In the late 19th century, the Republic of Chile stood above the other South American countries in economic field through the production of silver, copper, and niter, and the industrial development thanks to these mineral resources. Yet, the process of economic and social modernization in Chile was not easy after the era above. There was intensive political transition which depicts the demand of Chilean people for the social and economic development. There is the accumulation of much experience on these developments through the transition.

In the beginning of the 20th century, deterioration of Chilean economy started with the crisis that led by the attempt on producing niter artificially during the World War I. Then, the World Depression in 1929 hit the national economy, and made it worse. After the severe depression in the 1930s, the government promoted the import-substitution industrialization strategy. However, since 1973, the government has evolved to take the free economy and open-market policies. The Chilean economy has been making smooth progress through overcoming "Oil Shock" twice and the Debt Crisis in the late 1980s which hit the other Latin American countries as well. The Free Cabinet has made effort to facilitate economic development based on social equality and to overcome poverty founded on the political and economic stability achieved by the former Aylwin Cabinet. In Chile, agricultural sector occupies 6% of GDP, 14% of total employment, and 10% of total value of export in 1997. Thus, the agricultural sector takes the second position, which is next to mining industry, in the national economy. Agricultural development policy of the government toward 2000 puts stress on improvement of irrigation system so as to increase the productivity. The improvement of irrigation system assumes to lead the increase of agricultural production for domestic demand and export. The policy also aims at the balanced development of agriculture through assistance and strengthening of medium and small scale farmers. The government intends to give supports and subsidies on irrigation and processed agricultural product, and to extend the farming technique such as countermeasures against the disease and insect pest.

Since the late 1970s, the metropolitan economic block has been expanded drastically with population growth and industrial development in the capital city of Santiago. This resulted in the disappearance of suburban farmland which forms the particular urban scenery. At the same time, the water demand for domestic water supply, electric generation, and industrial uses has boosted. Thus, water utilization has become tighten. Moreover, the contaminated river flow which is running through the metropolitan area has become noticeable. Accordingly, sanitary condition has been deteriorating and the kinds of crop cultivation are partly limited.

Various water demand in the metropolitan area depends on surface runoff and groundwater in the Maipo river basin originated in the Andes mountains. According to the situation mentioned above, the evaluation of available water resources, optimum allocation of water, and the conservation of the basin environment have been recognized their necessities.

Reflecting these situations, the government of Chile has been started the study on "Maipo Project" in 1979 by the National Irrigation Commission as the competent authorities. Major objectives of the project were the water source development for the new irrigation scheme, the overall basin irrigation study contributing to the coordination and the management of the present water utilization on the Maipo river basin. The study consisted of four stages; to grasp the natural condition of the basin, to grasp the water demand of the basin, to establish the water utilization plan of the basin and evaluate the project. The first stage had been completed, however, the study had been suspended by the domestic affairs. Review of the first stage study results and the execution of the further stages are the urgent issues

The Government of Chile requested the Government of Japan to undertake a study on "Agricultural Development and Water Management in Metropolitan Area, Chile" in July 1996. The study aims mainly to formulate a master plan for agricultural development and water management reflecting upon environmental conditions in metropolitan area, Chile and to conduct a feasibility study for the agricultural development plan(s) in the priority project area(s). The study forms a part of the "Maipo Project" and covers 3,200 km^2 of farm land located in outskirts of Santiago metropolitan area. In response to the request, the Government of Japan dispatched the Preparatory Study Team from November 3, 1997 to November 21, 1997 through JICA, and agreed on the Scope of Work for the Study.

1.3 Objectives of the Study

The objectives of the study are;

(1) To formulate a master plan for agricultural development and water management reflecting upon environmental conditions in metropolitan area, Chile.
(2) To conduct a feasibility study for the agricultural development plan(s) in the priority project area(s).
(3) To carry out technology transfer to the Chilean counterpart personnel through on-the-job training in the course of the study.

1.4 Study Area

The study covers metropolitan areas comprising the Metropolitan Region located in the center of Chile and the part of V and VI Regions. Total area for the master plan is about 3,200 square kilometers which consists of actual and potential irrigated areas.

1.5 Scope of the Study

The Study consists of two phases, Phase I and Phase II. Scope of the Study in each phase is summarized as follows;

Phase I (Master Plan Study)
- Collection and analysis of data and information and field survey, - Review of development plan at national and sector levels, - Analysis on the project executing system, - Analysis on potential water resources, regarding with surface runoffs and groundwater, - Execution of initial environment assessment, - Formulation of water supply and demand plan, - Formulation of agricultural development plan, - Selection of priority area/projects, - Conclusion and recommendation.
Phase II (Feasibility Study)
- Collection of additional data and information, and field survey, - Formulation of agricultural development plan in the priority area considering the environmental conservation, - Environmental conservation plan, - Preliminary design on major structures, - O & M plan on infrastructures, - Project implementation plan, - Estimation of the project cost and benefit, - Project evaluation, - Conclusion and recommendation.