CHAPTER 4

THE PROJECT

CHAPTER 4: THE PROJECT

4.1 PROJECT FORMULATION

4.1.1 Problem Identification

The Study Area has played the important role as one of the main production areas of cereals. However, the rainfed cultivation has become difficult due to the decrease of rainfall in recent years. At present, only 26% of the total farm land are irrigated in the Study Area and the amount of irrigation water is not enough. Furthermore, the expansion of the irrigation area is practically impossible due to the limited water resources around the Area.

The farm lands of the large-scale farmers and plantation farmers in the Study Area are equipped with irrigation facilities even though the amount of irrigation water is not sufficient in some of the farm lands. They can easily obtain the agricultural credit and their farming technique is generally high. Some of them have modernized irrigation facilities. In one word, the agricultural productivity of them is high. On the other hand, almost all the small and medium-scale farmers have no irrigation facilities. Even the farmers who have irrigation facilities are suffering from the water shortage problem. Therefore, the agricultural productivity of these farmers is very low.

Under these circumstances, the economy in the Area has retarded and many of the small and medium-scale farmers who have no irrigation facilities have temporarily worked away from home or abandoned agriculture.

Concerning the farming technology, the application of fertilizers, chemicals, etc is comparatively widely performed by small and medium-scale farmers. But it is very difficult for them to purchase the improved seeds and to receive the agricultural supporting services such as technical extension services. These are also other main causes of the low agricultural productivity in small and medium-scale farms.

The large-scale farmers are organizing the cooperatives (Centro Agricola) and buying agricultural inputs cheaper through the cooperatives. However, the small and medium-scale farmers are disadvantageous in respect of procurement of agricultural inputs, technical extension services, shipment of products, etc.

4.1.2 Basic Development Concept

The Project aims at the stability of the regional economy by the stable agricultural production through the stable supply of irrigation water by the improvement of water resources development facilities and irrigation facilities in order to solve one of the big impedimental causes against the development of the Study Area; that is, shortage of irrigation water.

In order to maximize the effect of irrigation farming, the strengthening or improvement of the following matters which are the other causes of the agricultural low productivity in the small and medium-scale farms are also very important:

- the strengthening of agricultural supporting services such as technical extension services;
- the strengthening of organization of farmers;
- the improvement of shipping facilities of agricultural products; and
- the strengthening of production and supply of improved seeds

Through the improvement of irrigation and farming facilities, the diversification of crops, introduction of the crops suitable for the respective field conditions and rational cropping will become possible. Furthermore, the effective utilization of land resources and contribution to the conservation of soil will also become possible.

The basic development concept mentioned above is summarized in Fig. 4.1.1.

4.1.3 Land Use Plan

In the Pre-F/S Report prepared by INERHI, it is recommended that land classes 1 - 4 be used as agricultural land, because of the constraint in land classification being mostly "slope". In the preparation of land use plan of the Project, it is also considered that the land of class 4 is to be utilized as agricultural land, in general, in addition to lands of classes 1 - 3.

The land use plan is prepared by classifying the land characteristics into the following 8 zones based on the results of land classification. The areas of respective zones are summarized in Table 4.1.1 and the distribution of them is shown in Fig. 4.1.2.

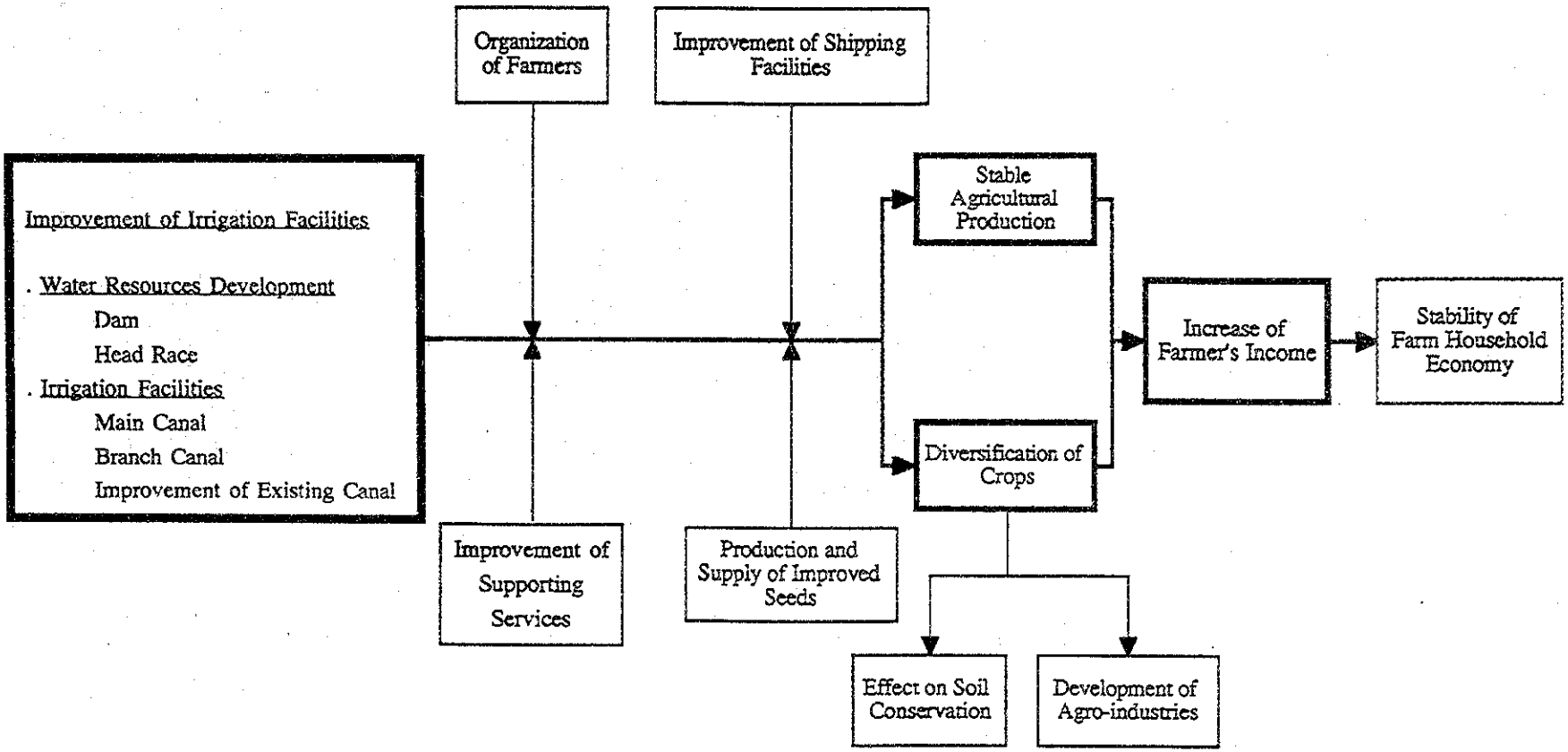


Fig. 4.1.1 Basic Development Concept

Zone I: The area where the large-scale upland cultivation is possible by introducing agricultural machines (classes 2 and 3-s by land classification)

Zone II: The area where the upland cultivation is possible, even though the use of agricultural machines is impossible due to the topographic conditions of the area (class 3-t)

Zone III: The area which can be used for pasture only due to the shallow soil layer of the land (class 4-p)

Zone IV: The area which can be used for cultivating fruit trees only due to high contents of gravel in soil (class 4-k)

Zone V: The area which can be used for pasture land or fruit tree field (class 4-t)

Zone VI: The area the soil of which is good for cultivation but the economical supply of irrigation water is difficult due to its topographic condition (class 5)

Zone VII: The area where the irrigation farming is practiced presently even though the slope of land is very steep (a part of class 6)

Zone VIII: The area which can not be used as agricultural land and requires the land protection like reforestation (land excluding Zones I to VII and Urban Areas)

Table 4.1.1 Summary of Land Use Area

Zone	I	II	III	IV	V	VI	VII	VIII	Urban	Total
Area (ha)	5,976	1,281	714	630	841	206	85	3,032	35	12,800
Ratio (%)	46.7	10.0	5.6	4.9	6.6	1.6	0.6	23.7	0.3	100.0

The objective development area in the Project is 9,527 ha in total by excluding the areas of Zones VI and VIII and urban area (3,273 ha in total) from the total Study Area of 12,800 ha. The objective irrigation area (total cropped area) is set as 8,574 ha, which is 90% of the objective development area.

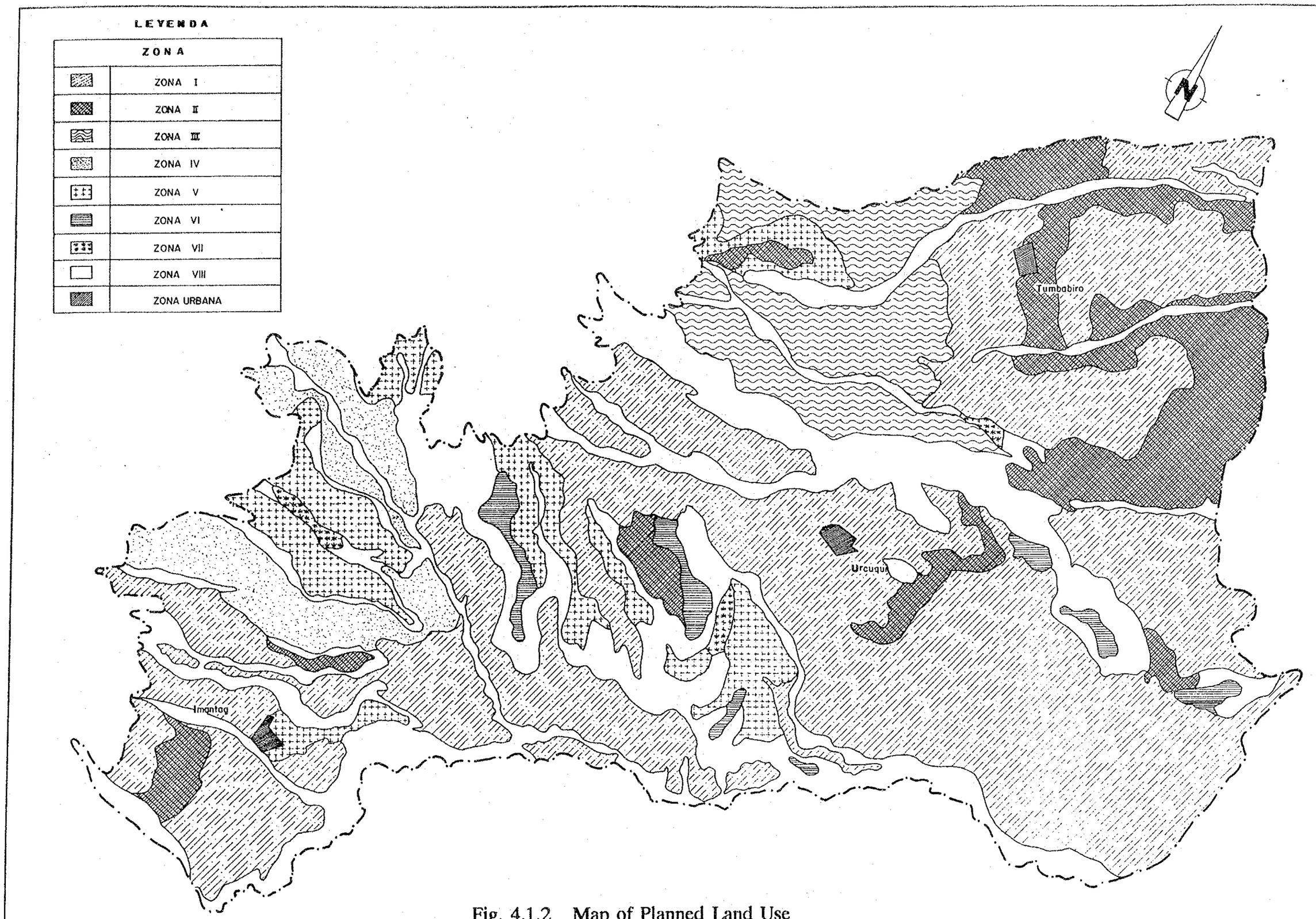


Fig. 4.1.2 Map of Planned Land Use

4.1.4 Irrigation Plan

(1) Objective Irrigation Area

The objective irrigation area is determined to be 8,574 ha which have been selected from the total Study Area of 12,800 ha in consideration of present soil condition, land classification, etc. of the area.

The Main Canal is located at the altitude of 2,540 m due to the location of the Head Race and proposed construction site of the Cariyacu Head Works. Therefore, the high lands higher than this altitude which are scattered in the Project Area cannot be irrigated with gravity irrigation method. These high lands are excluded from the objective irrigation area because of a few farm fields existing in these high lands as a result of the field investigation and the discussions with INERHI.

(2) Irrigation Water Requirements

1) Crop Water Requirements (ETc)

a. Evapotranspiration (ETo)

The evapotranspiration (ETo) is estimated with Penman method using the meteorological data (temperature, humidity, wind speed, sunshine time) from 1969 to 1991 of Tumbabiro Gauging Station based on the proposed cropping pattern of the proposed crops mentioned in Section 4.2.1. The estimated monthly evapotranspiration in the Project Area is shown in Table 4.1.2.

Table 4.1.2 Monthly Evapotranspiration (ETo)

Month	ETo(mm/month)	Month	ETo(mm/month)
Jan	109	Jul	121
Feb	106	Aug	132
Mar	110	Sep	123
Apr	105	Oct	109
May	101	Nov	110
Jun	105	Dec	111
Ave	112 mm/month		

b. Monthly Crop Water Requirements (ETc)

The crop water requirements (ETc) are estimated in the following equation :

ETc = kc x ETo

where : kc: Crop coefficients which are set for respective stages of crop growing

ETo: Evapotranspilation

The crop coefficients are estimated in consideration of the proposed farming practice and cropping pattern based on the Technical Paper No 24 "Crop Water Requirements", FAO as shown in Table 4.1.3.

Table 4.1.3 Monthly Crop Water Requirements (ETc)

Month	ETc(mm/month)	Month	ETc(mm/month)
Jan	88.6	Jul	95.4
Feb	78.5	Aug	58.3
Mar	69.7	Sep	58.2
Apr	68.4	Oct	72.1
May	82.1	Nov	96.2
Jun	94.5	Dec	107.0
Ave	80.8 mm/month (2.7 mm/day)		

2) Irrigation Method

The irrigation method is generally decided in consideration of natural conditions like topography and soil, farming conditions like kind of crops and farming system, field preparation conditions like shape/size of farm field and irrigation facilities, etc.

In the Project Area, the furrow irrigation is practiced for many years by the irrigation farmers, even though the slope of their fields is comparatively steep and the fields are consolidated and equipped to the ones suitable for furrow irrigation.

In the Project, the furrow irrigation is also adopted in due consideration of the following:

- It is judged that the expected productivity will sufficiently be obtained for the proposed crops by furrow irrigation

- Furrow irrigation has well been practiced by the farmers in the Project Area

However, the cultivation of the fruit trees which are proposed to introduce may be made in the sloped area where the furrow irrigation is not practicable. In this case, other irrigation methods like drip irrigation should be considered in the future in compliance with their profitability.

3) Effective Rainfall

The effective rainfall is estimated with SCS method mentioned in Technical Paper No 25 "Effective Rainfall", FAO, using rainfall data observed at the Tumbabiro Gauging Station. The effective rainfall estimated based on the average monthly rainfall (1968 – 1984) is shown in Table 4.1.4 for reference.

Table 4.1.4 Effective Rainfall (Ave of 1968 – 1984)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rainfall	65.8	63.8	68.9	85.3	53.1	19.2	19.1	23.2	29.7	61.3	85.5	75.1	650.0
Effective Rainfall	43.2	42.0	47.1	55.2	35.3	14.2	14.6	17.5	21.4	42.2	55.3	48.0	436.0

4) Irrigation Efficiency

The proposed irrigation efficiency is set as below through the discussions with INERHI based on the guideline prepared by FAO in consideration of the topography of the area, structure of canals, distribution system, irrigation method, etc.

$Ep = Ea \times Eb \times Ec = 0.5$

where :
- Ep : Irrigation Efficiency
- Ea : Field Application Efficiency (0.7)
- Eb : Distribution Efficiency (0.8)
- Ec : Conveyance Efficiency (0.9)

5) Irrigation Water Requirements

The monthly irrigation water requirements are estimated based on the factors above and the proposed farming plan. The result of the estimation is shown in Table 4.1.5. Based on the result, the maximum gross irrigation water required is estimated to be 6.851* m^3/s (December). Furthermore, the irrigation probability is set as 4/5 (80 %) which is widely adopted in Ecuador and other surrounding countries.

Table 4.1.5 Monthly Irrigation Water Requirements (Wrq)

Month	Wrq(mm/month)	Month	Wrq(mm/month)
Jan	107.2	Jul	177.4
Feb	119.8	Aug	110.8
Mar	49.2	Sep	46.4
Apr	11.6	Oct	34.0
May	21.6	Nov	137.2
Jun	181.4	Dec	214.0
Ave	110.9 mm/month (3.4 mm/day)		

6) Irrigation Time

The irrigation time to supply irrigation water to respective farm fields is set as 24 hours in the Project in due consideration of the following :

a. Operation of irrigation during day time only is preferable for both operation/maintenance agency and farmers. The control of irrigation water is surely easier. However, in this case, facilities to control irrigation water (farm ponds are most common) are required to be constructed and it causes the increase of the Project cost and also the decrease of the irrigation area of high elevation, even though it is not big.

* $(214.0 \times 10^{-3} \times 8{,}574 \times 10^{4}) / (31 \times 86{,}400) = 6.851\ m^3/s$

b. In the case of the Project, it is very difficult to secure the land for constructing the required control facilities due to topographic condition of the areas.Therefore, the construction cost of these facilities will become very much higher than that of other projects.

c. In the case of the Salinas Project adjacent to the Project, 24-hour irrigation operation is adopted. However, any remarkable confusion has not been reported.

d. If the realization of the Project is considered as the first priority, the minimization of the Project cost is badly required. It is the first step for the realization of the Project to adopt 24-hour irrigation operation with the cooperation of the persons and organizations concerned especially farmers.

e. There are no technical problems in adjusting the irrigation time for the respective farmers to provide control facilities in their respective farm lots, if they want. This adjustment matter can be settled even after the completion of the Project facilities.

(3) Irrigation Water Distribution Plan

1) Basis of the Plan

The irrigation water (max. 5.171 m^3/s) conveyed from the Piñán Dam into the watershed of the Cariyacu River through the Head Race is discharged to the Cariyacu River at El 2,900 m. Then it is intaken at the Cariyacu Head Works (El 2,540 m) 3.5 km downstream of the discharge point together with the available river water of the Cariyacu watershed (0.960 m^3/s in rainy season and 0.640 m^3/s in dry season), and distributed to the respective fields through the canals of main, branch and tertiary. The maximum irrigation water intaken at the Head Works is 6.131 m^3/s in rainy season and 5.811 m^3/s in dry season. The irrigation water is conveyed and distributed from the dam to the fields with gravity flow only.

The Main Canal is constructed at El 2,540 – 2,524 m. The discharges of 5 streams which cross the Main Canal are added to the canal water in consideration of the effective use of the available water resources. The total available water of these streams is 0.720 m^3/s in rainy season and 0.480 m^3/s in dry season.

The objective irrigation area is divided into two parts (south part and north part)

by the Cariyacu River. They are further divided into some independent irrigation blocks by the small rivers/streams flowing in the area as shown on Fig. 4.1.3. In general, each block becomes wider at the lower part, forming a fan-shaped area (the width of the area: approx. 500 m at the upper part and approx. 2.5 km at the lower part).

Therefore, the location of the Branch Canals is determined in consideration of rational distribution of water to these independent blocks. The existing irrigation canals (acequia) are utilized as the Branch Canals with repair or improvement of them as much as possible in the case that they are situated at the convenient locations and altitudes.

The standard of construction limit of the canals adopted by INERHI is also applied in the Project. That is; the construction of the canal by the Project is limited upto the boundary of the farm for the large and medium-scale farmers, and upto the field for the small-scale farmers.

The definition of respective canals is as follows:

a. Main Canal: The canal from the Cariyacu Head Works to the Branch Canal. It runs at the upper part of the Project Area (El 2,540 - 2,524 m) in north - south direction.

b. Branch Canal: The canal connecting the Main Canal with the Tertiary Canal. In general,one Branch Canal is located in each independent block.

c. Tertiary Canal: In the case that there is the existing canal (for large and medium-scale farmers), the canal connecting the Branch Canal with the existing canal. In the case that there is no existing canal (for small-scale farmers), the canal between the Branch Canal and the field (approx. 3 ha).

2) Irrigation System

The planned conveyance system of the irrigation water is as shown on Fig. 4.1.4. The planned detailed irrigation canal network together with covering areas and water amounts for respective canals is shown on Fig. 4.1.5.

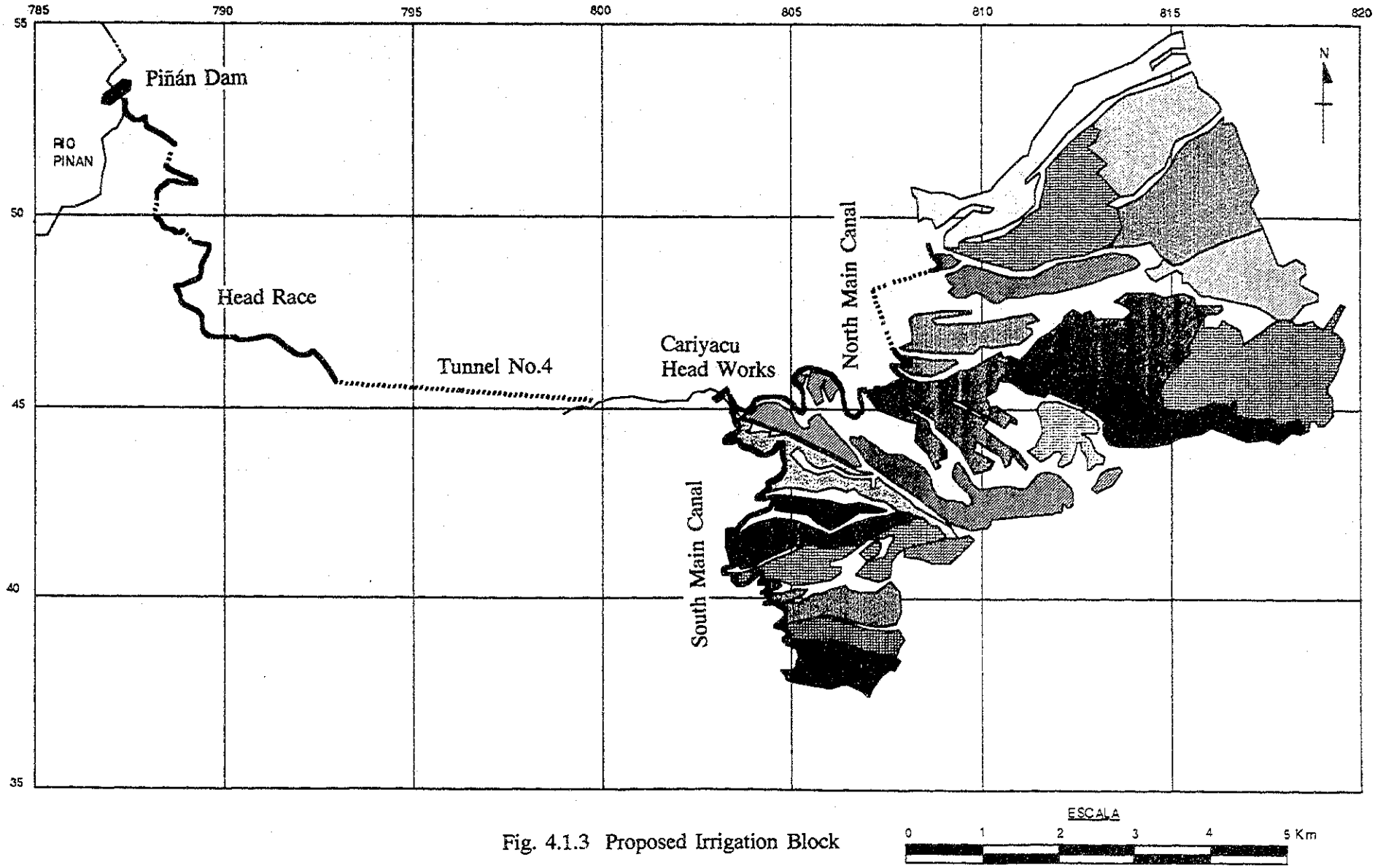


Fig. 4.1.3 Proposed Irrigation Block

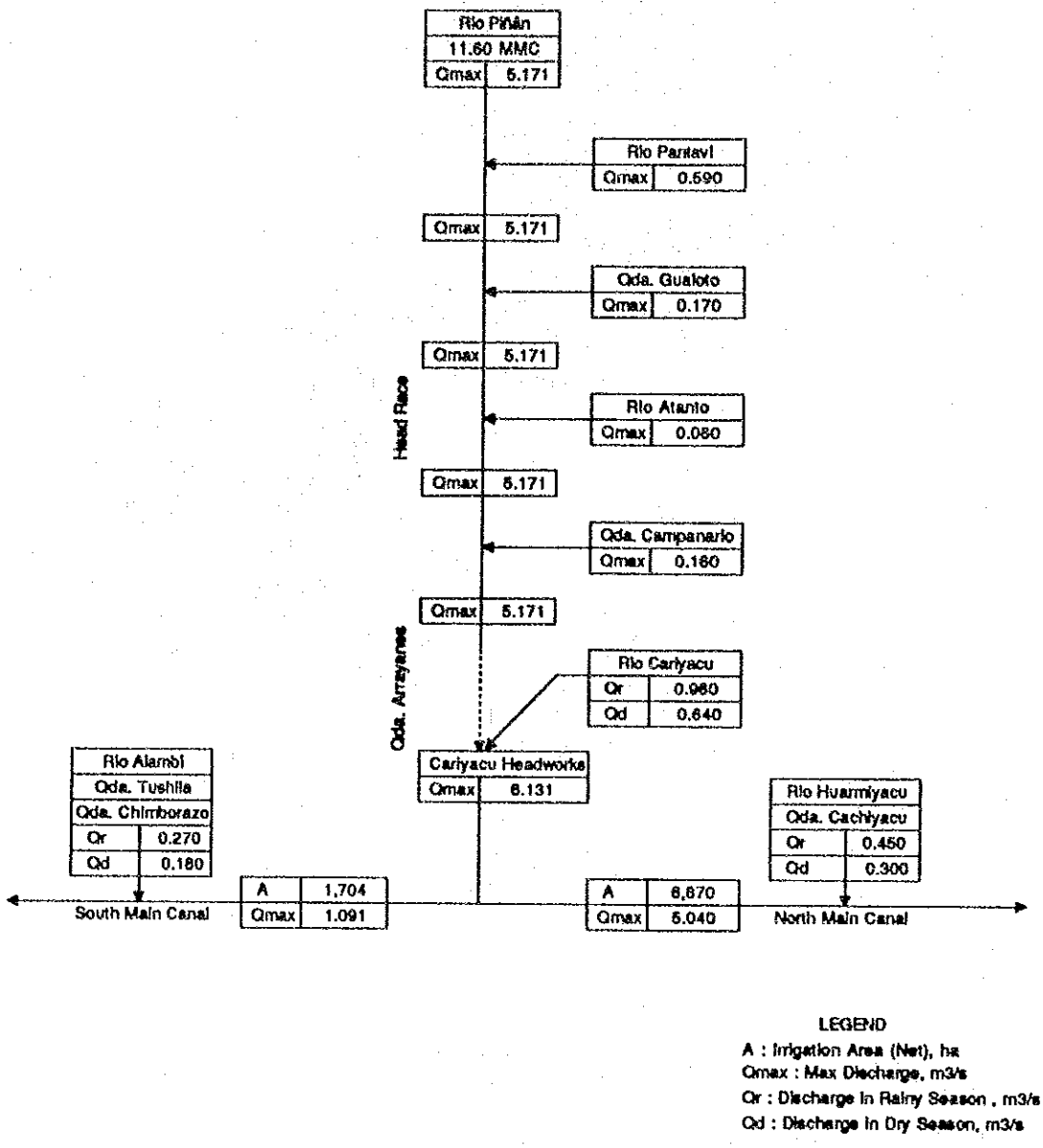


Fig. 4.1.4 Proposed Irrigation Water Conveyance System

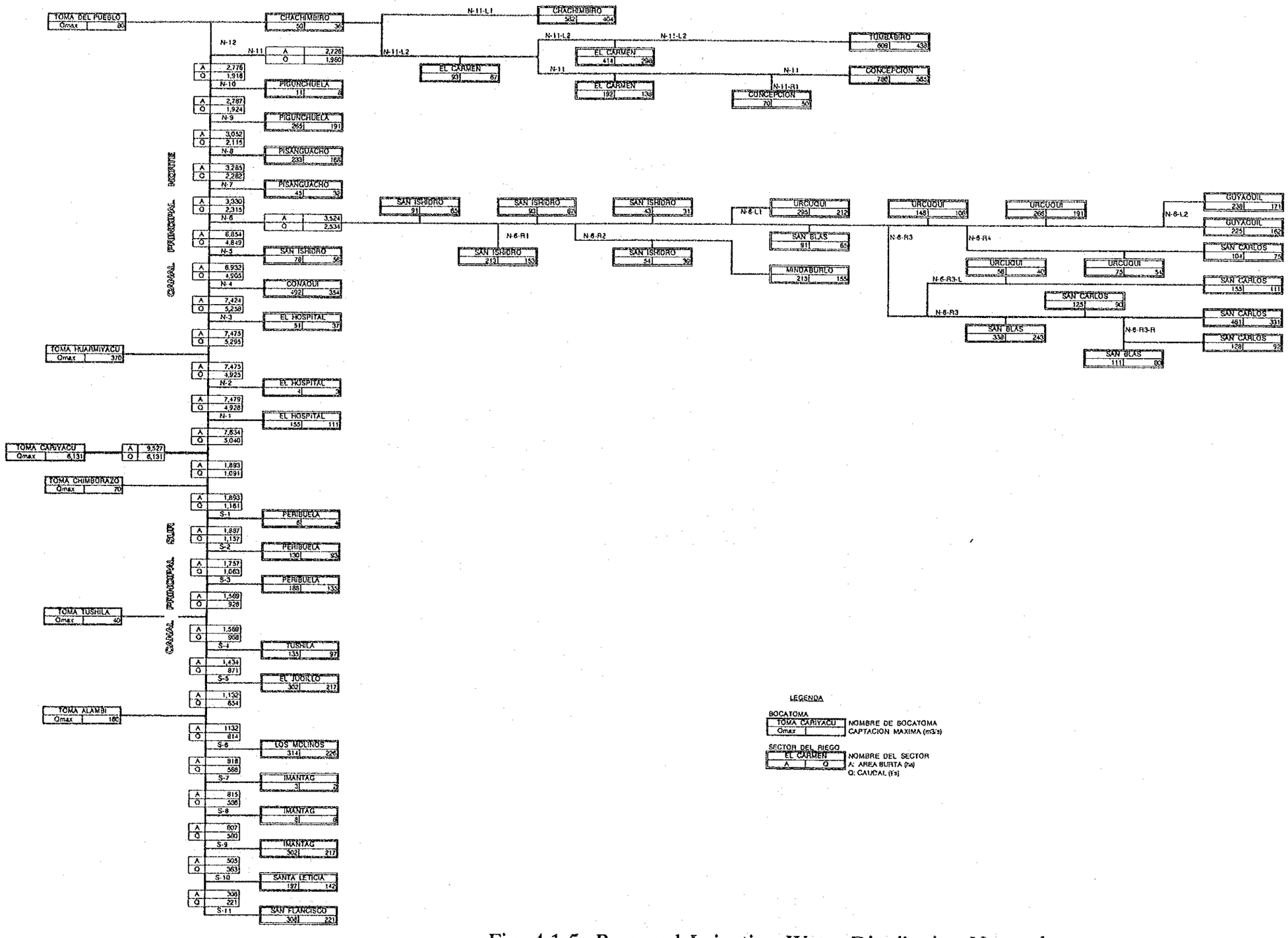


Fig. 4.1.5 Proposed Irrigation Water Distribution Network

4.1.5 Water Resources Development Plan

(1) Basic Plan

This water resources development plan aims at the irrigation water development for the objective irrigation area of 8,574 ha. The proposed water resources development plan has been prepared in consideration of the development possibility and problems of the following two resources and mixed development of them.

a. Reallocation of the existing available water resources at the Project Area side.

b. New water resources development in order to supplement the shortage of required irrigation water.

The flow of the analysis is as shown in Fig. 4.1.6.

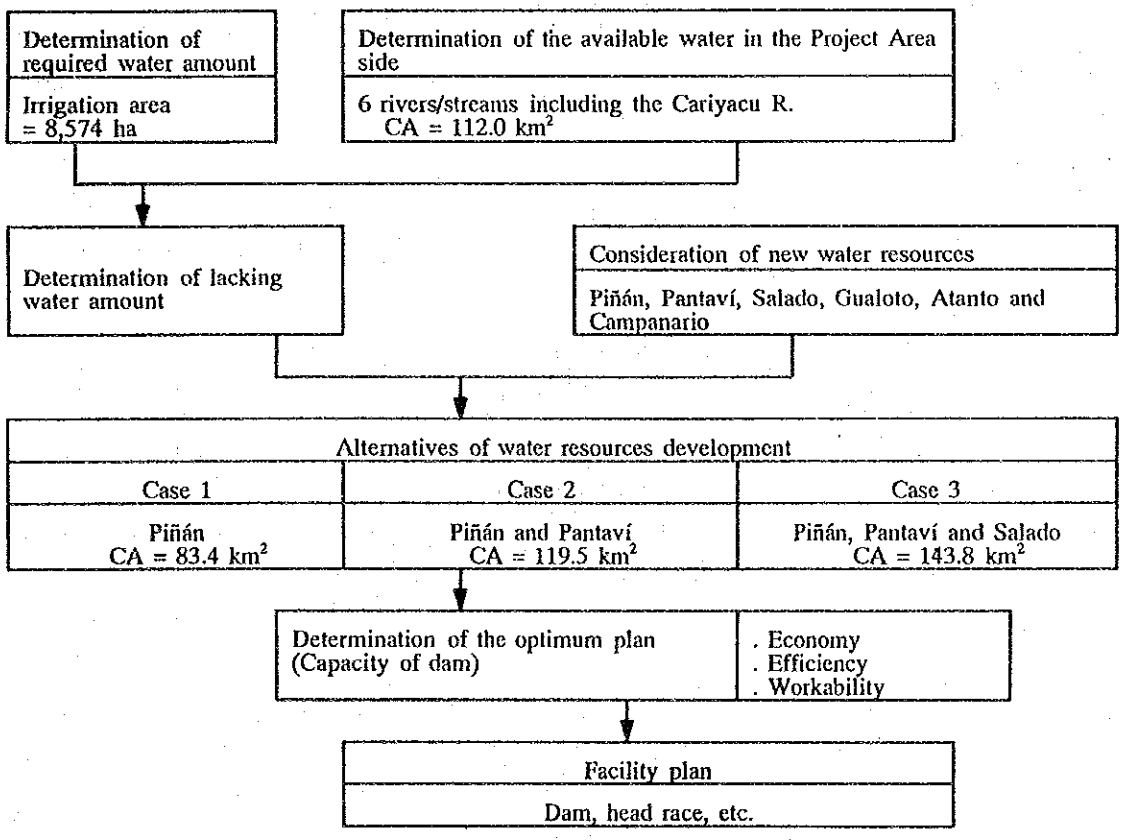


Fig. 4.1.6 Flow Chart of Water Resources Development Plan

(2) Available Water in Existing Water Resources

The sources of the existing irrigation water are only the streams which flow through the upper part of the Project Area. Some of the farmers in the Project Area are practicing the irrigation with these stream waters by constructing irrigation canals by themselves. In the Project, these stream waters are to be utilized as much as possible by reallocating the present water rights mostly owned by the large-scale farmers.

The available discharges of the streams are estimated using the 1991 – 93 discharge data of the streams and canals located in the surrounding areas as shown in Table 4.1.6.

Table 4.1.6 River Discharges in Existing Water Resources

Name of Stream	Catchment Area (km^2)	Discharge in Rainy Season (m^3/s)	Discharge in Dry Season (m^3/s)
Rio Cariyacu	53.12	0.960	0.640
Que Cachiyacu	9.37	0.080	0.060
Rio Huarmiyacu	20.34	0.370	0.240
Que Chimborazo	7.61	0.070	0.050
Que Tushila	4.20	0.040	0.030
Rio Alambí	17.37	0.160	0.100
Total		1.680	1.120

In the plan, 1.680 m^3/s in rainy season and 1.120 m^3/s in dry season are adopted as the available irrigation water in the existing water resources at the Project Area side.

On the other hand, the max. required irrigation water is estimated to be 6.851 m^3/s in rainy season (December) and 5.807 m^3/s in dry season (June). Therefore, irrigation water is still lacking by 5.171 m^3/s in rainy season and 4.687 m^3/s in dry season in maximum.

Due to the above, the new water resources are necessary in addition to the streams located at the upper part of the Project Area.

(3) Available Water in New Water Resources

1) Water Resources

As the new water resources which can be led to the Project Area, the following

rivers located at the mountainous area of the Pacific Ocean side where comparatively much rain falls are picked up:

i) The Piñán and Pantaví Rivers located approx 50 km NNW of the Project Area;

ii) Three small rivers (Gualoto, Atanto and Campanario) which cross the Head Race to be constructed for leading the river waters of Piñán and Pantaví to the Project Area side ; and

iii) The Salado River of the Lita River system which is located at the upper part of the Piñán River.

The available discharges of the respective rivers are determined by eliminating the following river maintenance flow (5% of the average discharge) from the river discharges.

. The Piñán River : 0.2 m^3/s
. The Salado River : 0.1 m^3/s
. Other rivers : 0.1 m^3/s in total

2) River Discharge

The available discharges of the above rivers are estimated using the observed data of respective rivers or the data of surrounding areas in case of no direct data available. The estimated discharges are as shown in Table 4.1.7.

Table 4.1.7 River Discharges in New Water Resources

Name of Stream	Catchment Area (km^2)	Discharge in Rainy Season (m^3/s)	Discharge in Dry Season (m^3/s)
Rio Piñán	83.4	2.774	1.951
Rio Pantaví	36.1	0.590	0.491
Que Gualoto	10.4	0.170	0.141
Rio Atanto	4.9	0.080	0.066
Que Campanario	9.8	0.160	0.133
Rio Salado	24.3	0.246	0.151
Total		4.020	2.933

From the above, even all the discharges of these rivers are not enough for covering the lacking irrigation water. Therefore, the storage facility (dam) to store the river discharge is necessary in order to secure the required irrigation water. The monthly estimated river discharges of respective rivers are compiled in Annex.

3) New Water Resources Development Plan

The new water resources development plan is studied based on the construction of a dam on the Piñán River which is the main water resources in the area. In this case, the following three cases have been considered:

Case 1: A dam to store the discharge of the Piñán River and direct intake of the Pantaví River discharge

Case 2: A dam to store the discharges of the Piñán and Pantaví Rivers

Case 3: A dam to store the discharges of the Piñán, Pantaví and Salado Rivers

In all the cases, the discharges of the small rivers of Gualoto, Atanto and Campanario are utilized by directly intaking them to the Head Race, and 5% of the annual average discharge of all the rivers are planned to flow down without use as the maintenance flow of the river course.

Fig. 4.1.7 shows the schematic drawing of alternative plans for the respective cases. The results of water balance analysis of a dam for those cases are shown on Figs. 4.1.8 to 4.1.10.

As a result of the analysis, the required storage capacities of the dam for respective cases are as shown in Table 4.1.8.

Table 4.1.8 Required Dam Capacity

(Unit: 10^6 m^3)

Case	Effective Capacity	Dead Capacity	Total Capacity
1	11.22	1.5	12.72
2	11.54	1.5	13.04
3	10.55	1.5	12.05

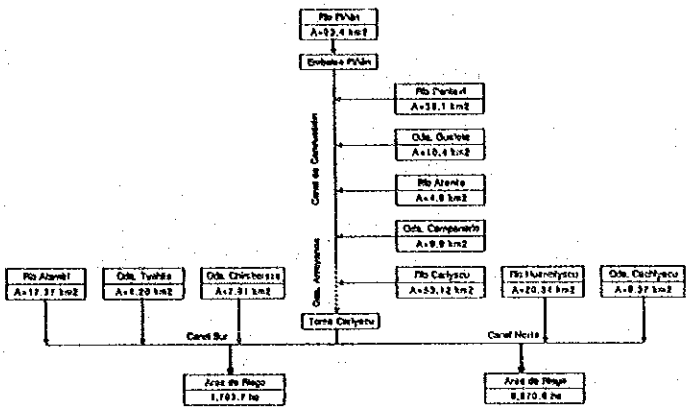
Schematic Drawing	Outline
Case 1 	. A dam to store the discharge of the Piñán River and direct intake of 4 river discharges which cross the head race . Facilities: Dam Head Race: Dam – Project Area Intake: 10 places

Fig. 4.1.7(1) Schematic Drawing of Alternative Plan

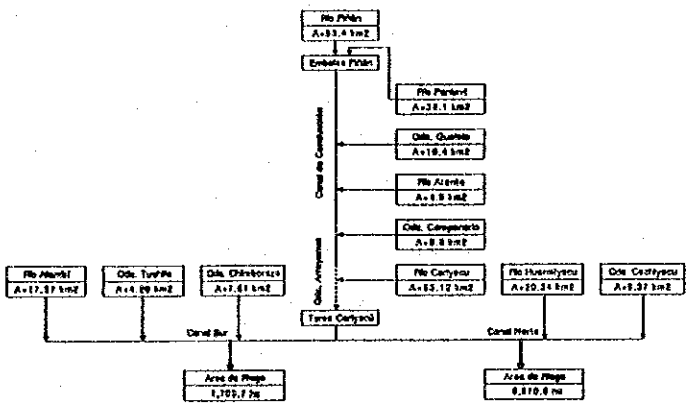
Schematic Drawing	Outline
Case 2 	. A dam to store the discharges of the rivers of Piñán and Pantaví, and direct intake of 3 river discharges which cross the head race . Facilities: Dam Head Race: Dam – Project Area Dam – Pantaví river Intake: 10 places

Fig. 4.1.7(2) Schematic Drawing of Alternative Plan

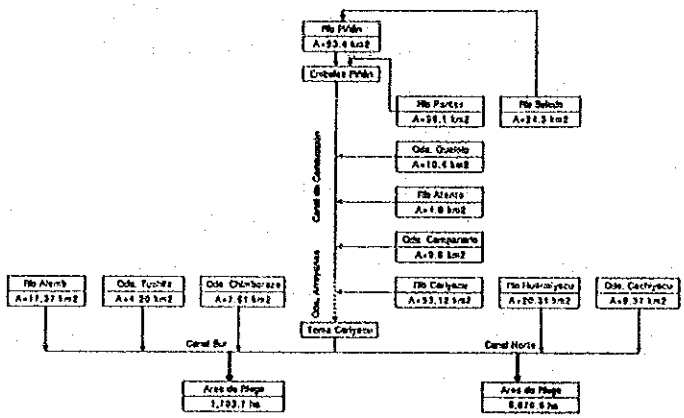
Schematic Drawing	Outline
Case 3 	. A dam to store the discharges of the rivers of Piñán, Pantaví and Salado, and direct intake of 3 river discharges which cross the head race . Facilities: Dam Head Race: dam – Project Area dam – Pantaví river Salado river – Piñán river Intake: 10 places

Fig. 4.1.7(3) Schematic Drawing of Alternative Plan

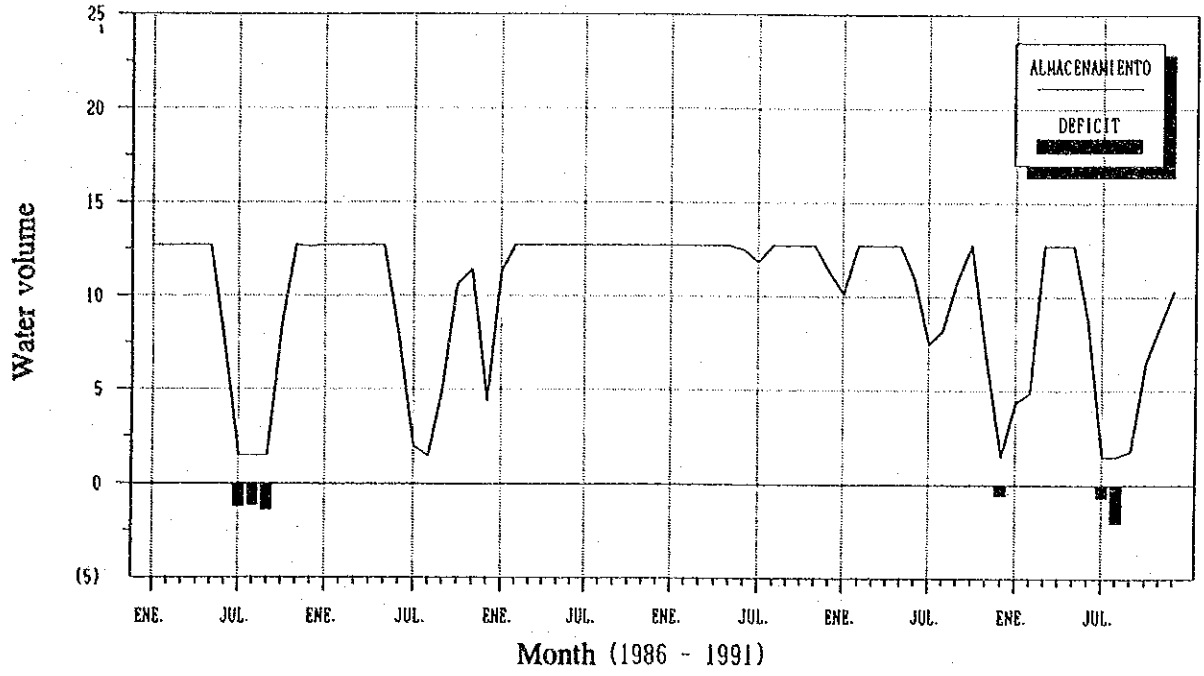


Fig. 4.1.8 (1) Change of Reservoir Volume (Case 1)

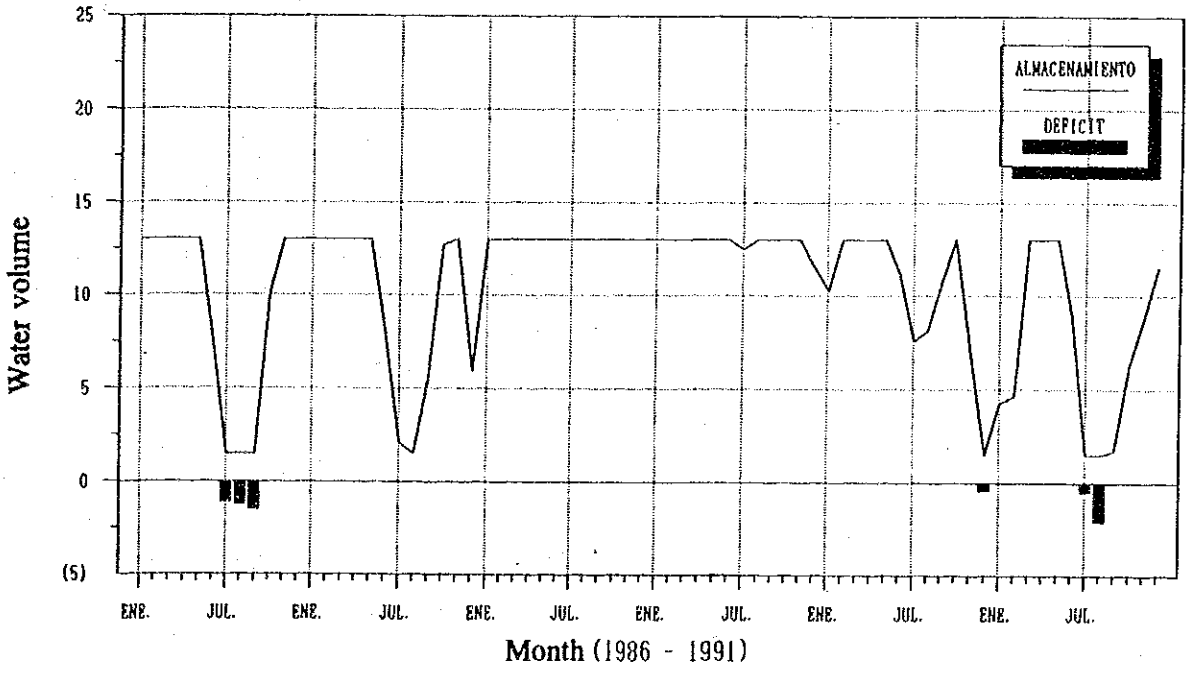


Fig. 4.1.8 (2) Change of Reservoir Volume (Case 2)

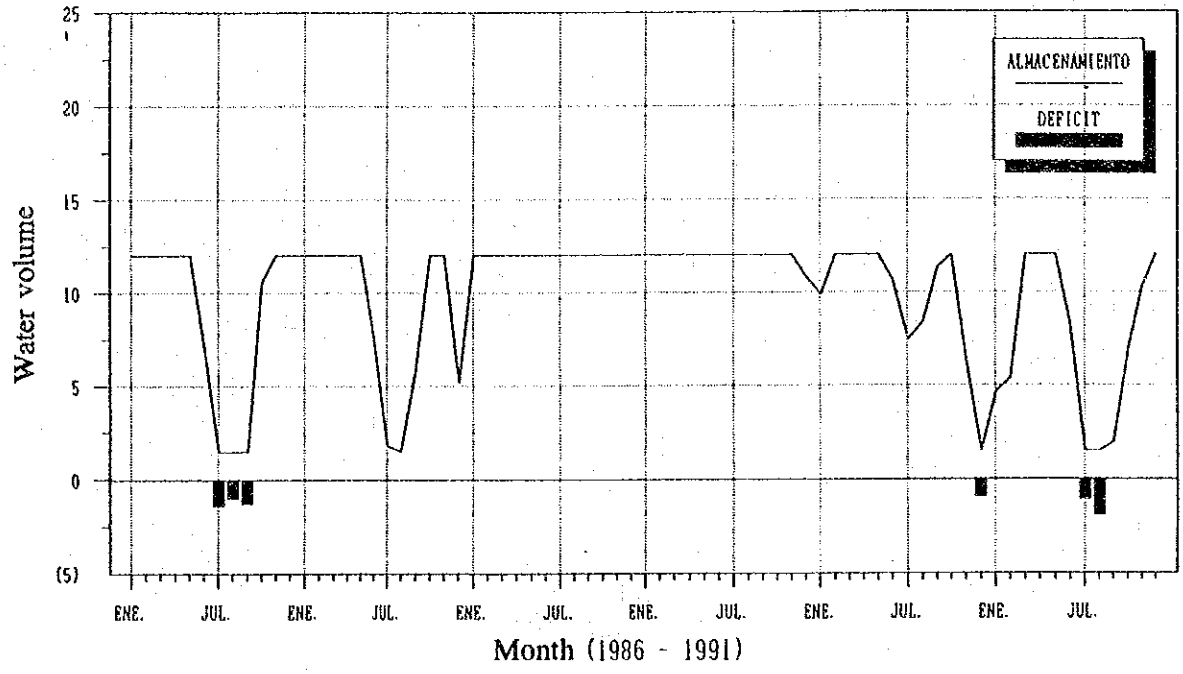


Fig. 4.1.8 (3) Change of Reservoir Volume (Case 3)

The main dimensions of the required dam for the respective cases are as shown in Table 4.1.9.

Table 4.1.9 Dimension of the Required Dam

Case	Dam Height (m)	Crest Length (m)	Dam Volume (10^3m^3)
1	48.0	220.0	350.0
2	48.0	220.0	350.0
3	47.5	220.0	343.0

The remarkable difference in the related facilities for respective cases is as follows:

Related Structure	Case 1	Case 2	Case 3
Head Race (Dam – Project Area)	Required	Required	Required
Head Race (Pantaví River – Dam)	No	Required	Required
Head Race (Salado River – Piñán River)	No	No	Required

The above fact means that it is not effective to store the discharge of the Pantaví River (Case 2) and that the storage capacity can be reduced by 0.67 x 10^6m^3 by storing the discharge of the Salado River (Case 3). However, in the case of Case 3, the construction of a head race of 12 km long (including a tunnel of 2 km long) is required in order to convey the Salado River discharge to the Piñán River. The construction cost of the head race is much higher than the reduced construction cost of the dam in connection with the reduction of its storage capacity. Therefore, "Case 1", a dam to store the discharge of the Piñán River and direct intake of the discharges of the rivers of Pantaví, Gualoto, Atanto and Campanario, is judged to be the best.

(4) Water Resources Development Plan

According to the result of the new water resources development analysis mentioned above, the Project has adopted the plan of Case 1; that is, to construct a dam across the Piñán River in order to store the discharge of the Piñán River only and directly to intake the discharges of 4 rivers (Pantaví, Gualoto, Atanto and Campanario) which cross the head race connecting the dam and the Project Area.

Fig. 4.1.9 shows the overall water resources development system.

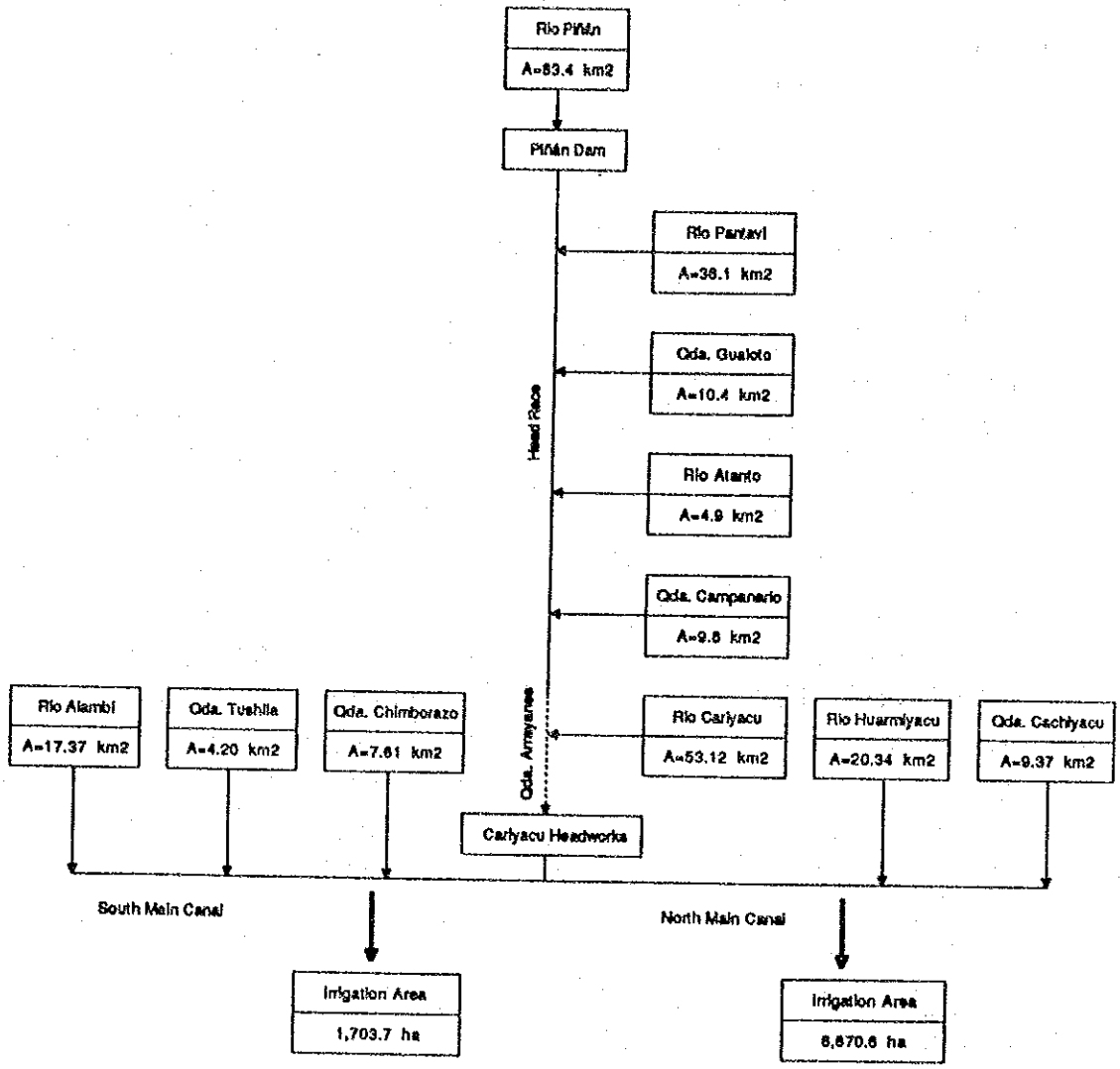


Fig. 4.1.9 Overall Water Resources Development System

4.2 PROPOSED DEVELOPMENT PLAN FOR AGRICULTURE

4.2.1 Agricultural Production Plan

(1) Selection of Crops to be Introduced

The Project Area has been playing an important role as the production area of basic foods such as maize, kidney bean, potato, wheat and barley which are widely cultivated in the area. The Project aims at further strengthening this role in the future and also diversifying the crops by the increase of the irrigated farm field.

In the selection of the crops to be introduced with the completion of the irrigation facilities, the following matters have been considered:

a. Crops suitable for the natural conditions of the area

   The altitude of the Project Area expands from 1,700 m to 2,540 m. Therefore, the suitability of crops for the altitude of the objective area is one of the important factors in the selection of crops to be newly introduced. Fig. 4.2.1 shows the general standard in selecting the altitudewise cultivable crops.

b. Crops which have high profitability

c. Crops useful for the protection of soil erosion on the sloped land and cropping system of them

   The Project Area includes much sloped land and has high possibility of its soil erosion. The protection of soil erosion by means of mixed cropping (to reduce the period during bare land by cultivating fruit trees and pasture) is also important for the success of the Project.

d. Crops which have high marketability in and out of the country

   In the selection of exportable crops, the marketability in other countries especially in the countries within the Andes Agreement has been considered.

e. Crops substitutable for imported foods

f. Crops cultivation technique of which corresponds to that of the farmers in the area

or will be obtainable for the farmers through the technique extension services in the future

The crops selected for the Project in consideration of the above are as shown in Table 4.2.1.

Table 4.2.1 Crops Introduced in the Project

	Domestic demand	Possibility for exportation	Import substitution	Possibility for agro-industry	Profit-ability	Experience *
Main Crop						
Maize(Seco)	◎					A
Maize(Choclo)	◎				○	A
Potato	◎				○	A
Kidney bean	○	◎			○	A
Green pea	○			○		A
Wheat	◎		◎			A
Barley	◎		◎			A
Sugarcane	◎	○	○	◎	○	A
Vegetable						
Tomato	◎	○		◎	◎	A
Red pepper	○			◎		A
Carot	○			○		A
Cabbage	○				○	A
Asparagus	○	○		◎		B
Welsh onion	◎				○	A
Cucumber	○	○		○	○	B
Cauliflower	○			○	○	B
Beet	○				○	A
Radish	○				◎	A
Onion	◎				○	A
Fruit tree						
Grape	◎		○	◎		B
Avocado	◎	○			○	A
Babaco	○			○	◎	A
Fig	○			○		A
Cherimoya	○				○	A
Tree tomato	◎			○	◎	A
Peach	◎		○	◎	◎	B
Blackberry	○			◎		A
Apple	◎		○	◎	◎	B
Pasture						
Alfalfa	◎			◎	◎	A

◎>○

*:Crops have cultivated in the area.

A = Cultivated by many farmers B = Cultivated by only some farmers for test

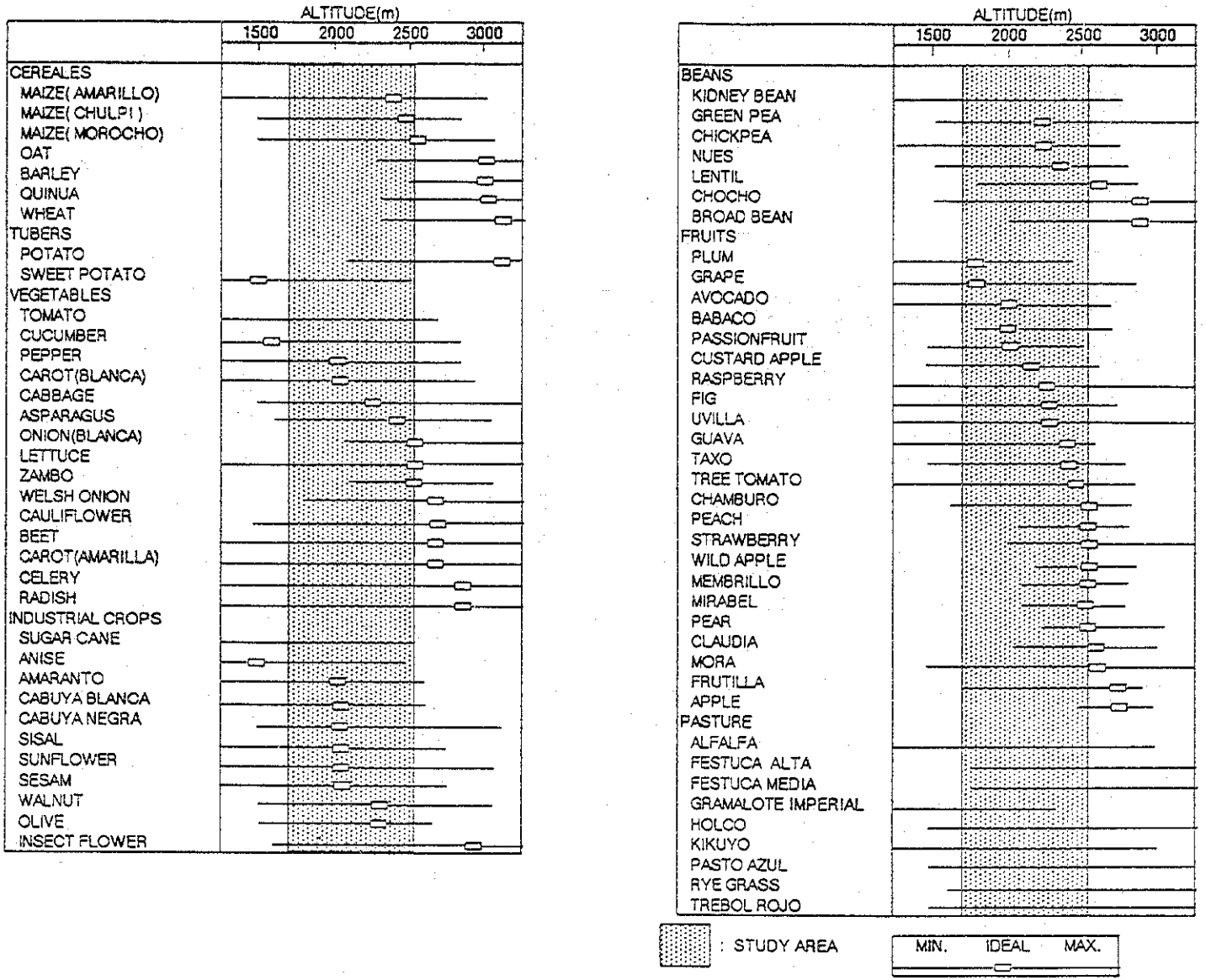


Fig. 4.2.1 Altitudewise Cultivable Crops

(2) Cropping Pattern

The cropping pattern of the selected crops has been set in due consideration of the effective use of rainfall in the area as shown on Fig. 4.2.2.

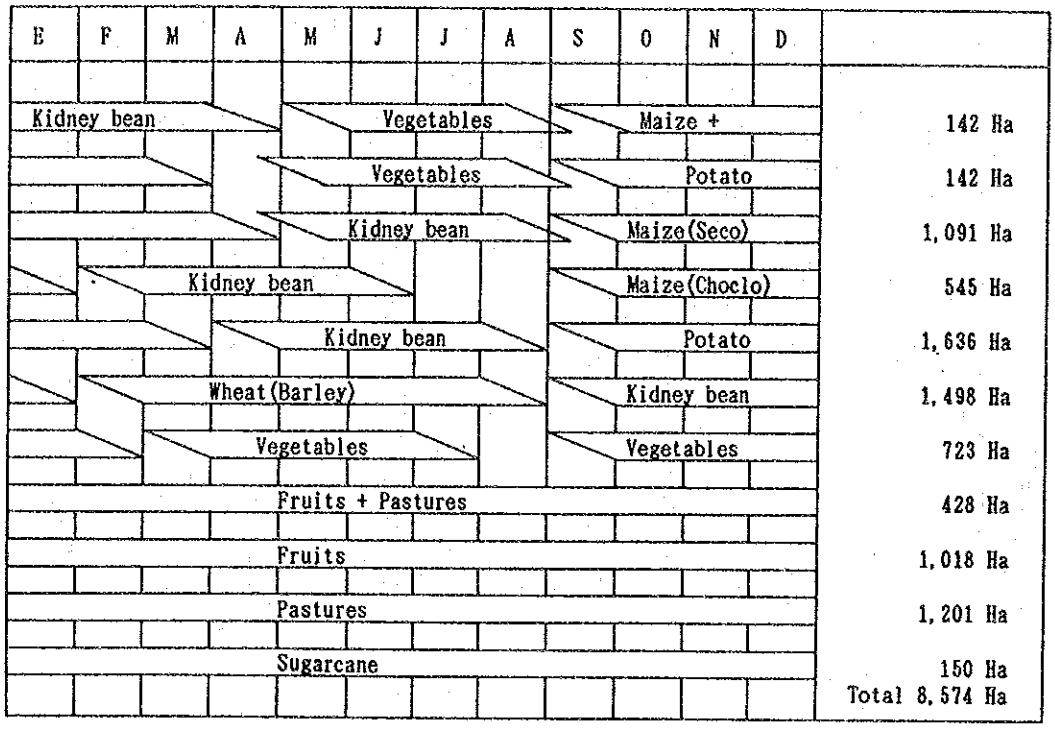


Fig. 4.2.2 Proposed Cropping Pattern

(3) Cropwise Cultivation Area

The proposed cultivation areas by crop have been set in consideration of the farm size in the area as mentioned below:

Furthermore, the cultivation areas by cropping pattern and crop are shown on Fig. 4.2.2 and in Table 4.2.2, respectively.

1) Small-scale Farm (less than 3 ha)

- Farm (less than 1 ha)

  To cultivate self-consumptive crops in the first term and vegetables as cash crops in the second term

- Farm (1.1 – 3 ha)

  The average cropped area for one farm is 1.7 ha, of which 0.25 ha are used for the cultivation of vegetables, 0.5 ha for fruit trees and remaining 0.95 ha for basic foods. The cultivation of fruit trees is to be performed by mixed cultivation with pasture in order to improve the profitability of land and to protect the soil erosion of land.

2) Medium-scale Farm (3.1 – 10 ha)

   The average cropped area for one farm is 4.9 ha, of which 0.5 ha are used for the cultivation of vegetables, 1.0 ha for fruit trees and remaining 3.4 ha for basic foods. The cultivation method for fruit trees is the same in the case of Farm (1.1 – 3 ha).

3) Large-scale Farm (10.1 – 20 ha) and Plantation Farm (more than 20.1 ha)

   The average cropped area for one farm is 70 ha and the total cropped area is 6,440 ha. The present sugarcane cropped area is to be maintained and the pasture area is to be reduced to 50% of the present area in consideration of the increase of its productivity due to the introduction of irrigation system to the area.

   The remaining areas are to be divided into the following three categories by adopting the present Provincial areawise ratio for crops: Vegetables: 10%, Fruit trees: 20%, Basic foods: 70%

Furthermore, in the Project, maize and potato have been selected as basic foods for the area of lower than El 2,200 m and that of higher than El 2,200 m, respectively. The ratio of the areas is set as 50% each.

Table 4.2.2 Proposed Cropwise Areas

Crop	Area (ha)	Crop	Area (ha)
Maize and Kidney Bean	142	Wheat	749
Maize (Seco)	1,091	Barley	749
Maize (Choclo)	545	Vegetable	1,730
Potato	1,778	Fruit Tree and Pasture	428
Kidney Bean	3,180	Fruit Tree	1,018
Green Peas	1,590	Pasture	1,201
		Sugarcane	150
		Total	14,354

The proposed unit yields of crops to be introduced in the Project are set as follows:

. Basic food and vegetables: Yield data for irrigated farms in the Project Area collected by DPA-Imbabura

. Fruit tress: Yield data collected at the Experimental Farm, INIAP

Based on the above proposed crop areas and unit yields, the proposed production for respective crops is estimated as shown in Table 4.2.3.

Table 4.2.3 Proposed Crop Production

Crop	Area (ha)	Production (ton)							
		1st year	2nd year	3rd year	4th year	5th year	6th year	7th year	8th year
Maize (Seco)	1,162	2,562	3,111	3,660	3,660	3,660	3,660	3,660	3,660
Maize (Choclo)	545	5,073	6,160	7,247	7,247	7,247	7,247	7,247	7,247
Potato	1,778	22,403	27,203	32,004	32,004	32,004	32,004	32,004	32,004
Kidney bean	4,841	6,100	7,407	8,714	8,714	8,714	8,714	8,714	8,714
Wheat	1,498	3,303	4,011	4,719	4,719	4,719	4,719	4,719	4,719
Sugarcane	150	15,750	19,125	22,500	22,500	22,500	22,500	22,500	22,500
Tomato	865	30,880	37,498	44,115	44,115	44,115	44,115	44,115	44,115
Onion	865	12,715	15,440	18,165	18,165	18,165	18,165	18,165	18,165
Alfalfa	1,417	133,906	162,601	191,295	191,295	191,295	191,295	191,295	191,295
Peach	411	0	0	3,286	5,750	6,571	8,214	10,268	12,321
Avocado	411	0	0	0	2,136	3,559	5,339	8,543	10,678
Apple	411	0	0	3,696	4,928	6,982	8,214	11,500	14,374
Total	14,354								

(4) Demand and Supply of Crops to be Produced in the Project

The self-sufficiency ratio (demand/supply) of foods for the whole of the country in 1991 is as shown in Table 4.2.4.

Table 4.2.4 Demand-Supply of Foods

	Self-sufficiency Ratio		Production	Consumption	Consumption per Capita	
	1985 %	1991 %	1985-1991 % / Year	1985-1991 % / Year	1991 Kg / Year	1985-1991 % / Year
Whole Food	144	123	4.3	7.1	447	-0.5
Cereals	108	77	13.9	20.6	81	-3.6
Tubers	114	100	-5.7	-3.7	35	-9.3
Legume	168	90	-18.5	-9.5	4	-10.7
Vegetables	112	100	-0.8	1.2	17	-2.7
Fruit Tree	237	228	5.3	6.0	106	-6.7
Meats	106	100	-15.1	-14.2	134	7.5
Oil	94	94	12.8	12.8	27	7.2
Sugar	119	100	5.2	8.4	33	1.4
Others	1,412	178	-0.7	40.3	10	4.9

Source: MAG

The self-sufficiency ratio of the whole foods in 1991 was 123%, but had the tendency of decreasing. More than 90% of the surplus food were occupied by the export food like banana. In case that the export food was excluded from the computation, the self-sufficiency ratio of foods in 1991 came down to 94% and the self-sufficiency was not achieved. The annual production of each crop has changed greatly. The production of the objective crop has been greatly affected by its demand tendency of the past.

1) Cereals

The self-sufficiency ratio of cereals in 1991 was only 77% and had the tendency of decreasing. Wheat and barley were seriously lacking and the imported quantities of them were increasing annually. The self-sufficiency ratio of maize was 100% for each year. But this was resulted from its demand affected by its annual supply. In consideration of the increase of population in the future, the demand of maize will increase. Therefore, the demand for the cereals to be produced in the Project is judged to be sufficient.

2) Tubers

Both production and consumption (both in total and per person) to tubers had the decreasing tendency. This was due to the fact that the production of cassava became less than one half during 1985 and 1991. On the other hand, the production of potato was increased by 1.3%/year during that time. Consequently, the self-sufficiency ratio of tubers in 1991 was 100%. Therefore, the demand for tubers to be produced in the Project will be sufficient.

3) Legume

The production of legume had been seriously decreased recently and the self-sufficiency ratio in 1991 decreased to 90%. Furthermore, almost all the kidney bean produced in and around the Project Area have been exported to Colombia recently. The possibility of export of kidney bean in the future will still be high. Therefore, the demand for resume will be sufficient.

4) Vegetables

Even though the production of vegetables was decreasing, the consumption of them was increasing. The self-sufficiency ratio of them had been decreased and that of 1991 was 100%. In consideration of the population increase in the future, the demand for vegetables will further increase. Therefore, the demand for them will be sufficient.

5) Fruit trees

Most of the fruit trees being produced are banana and pineapple. The self-sufficiency ratio of them was high and the exportation of them was also much. Therefore, the self-sufficiency excluding the exported goods became 94%. Grape, peach and apple which are to be introduced in the Project were imported. Due to the above, the demand for fruit trees to be introduced in the Project will be sufficient.

4.2.2 Marketing Plan

As stated in the preceding clauses, with the implementation of the Project, the agriculture with irrigation will be realized in the Project Area. On the basis of the proposed cropping pattern and increase of crop unit yield, it will make a marked increase in crop production compared with the present situation. Traditional crops like maize, kidney beans and potatoes will be increased to the amount of 50,288 tons, vegetables to 62,280 tons and fruits to 37,374 tons as new crops, and alfalfa to 191,295 tons.

Table 4.2.5 Production of Farm Products

(Unit: ton)

Crops	Present	Proposed	Increase
Maize (dry)	1,458	3,660	2,202
Maize (choclo)	-	7,247	7,247
Potato	2,164	32,004	29,840
Kidney bean	677	8,714	8,037
Wheat	1,757	4,719	2,962
Tomato	-	44,115	44,115
Onion	-	18,165	18,165
Peach	-	12,321	12,321
Avocado	-	10,678	10,678
Apple	-	14,375	14,375
Alfalfa	-	191,295	191,295
Sugarcane	4,802	22,500	17,698

In order to secure farmers' income by averting a middleman in the present distribution system, the system shown in Fig. 4.2.3 is proposed.

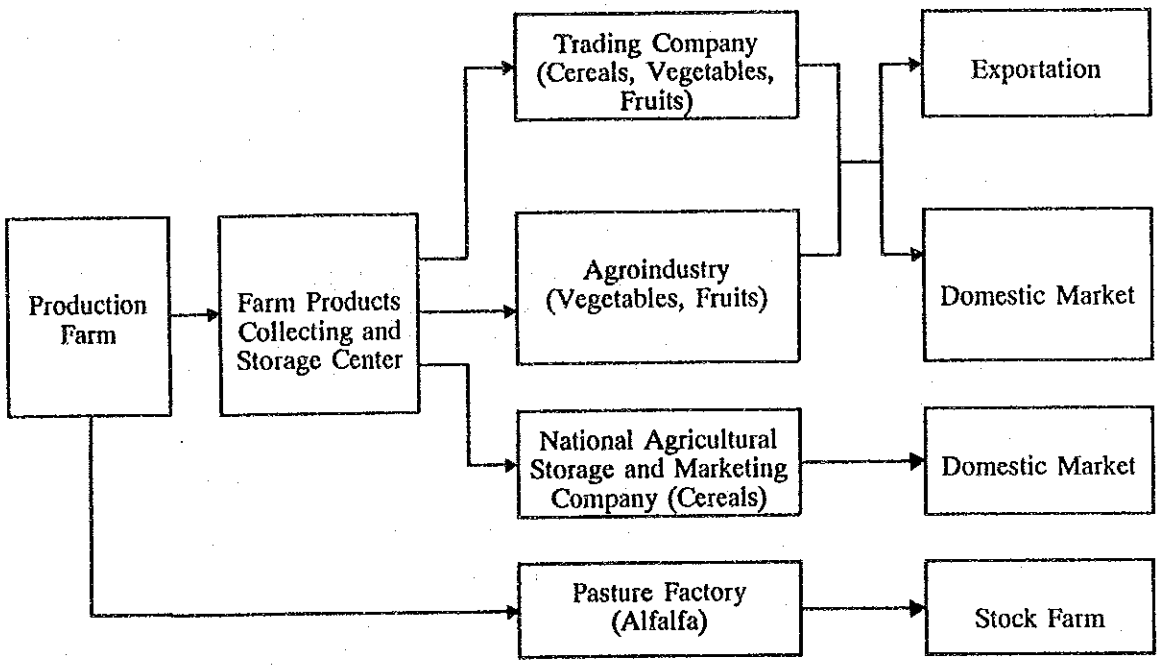


Fig. 4.2.3 Proposed Distribution and Marketing System

a. To install three collecting and storing centers operated by small and medium-scale farmers' organizations in Tumbabiro, Urcuqui and Imantag (See 4.2.5).

b. To deal in cereals such as maize and kidney beans directly between the National Agricultural Storage and Marketing Company, Ibarra Office (ENAC-Ibarra) and the above centers by the strengthening of funds and expansion of facilities of the Company (present storage capacity is 20,000 quintals (= 900 ton), but current use is only 1/5 of its space (See 4.2.3).

c. To deal in vegetables as new crops on favorable conditions for the farmers with agroindustries and/or wholesalers through the above centers (see 4.2.3).

d. To deal in fruits with the same system as for the vegetables due to high demand in the fresh fruit markets. MAG guides the farmers in the improvement of technology and simplification of distribution system by forming the groups of the fruit-growing farmers in order to secure a stabilized market in the agroindustry and local markets (see 4.2.3).

4.2.3 Agro-industry Plan

The main farm products shipped to agroindustry among the proposed crops in the Project are as follows:

a. Vegetables:

Asparagus	:	bottled for export
Gherkin	:	bottled pickles for export
Tomato	:	tomato ketchup and puree for local consumption
Chili	:	chili sauce for local consumption

b. Fruits:

Apple	:	preserves, concentrated juice and baby food for both export and local consumption
Peach	:	juice and canned for both export and local consumption
Blackberry	:	juice and preserves for both export and local consumption
Grape	:	wine and concentrated juice for both export and local consumption

c. Hay:

Alfalfa : dry pellet for local consumption

With the implementation of the Project, the factories of agroindustry in Ibarra City will be expanded and revitalized; likewise to find inroads of agroindustry into fruit-production areas (Provinces of Tunguahua and Pichincha) in the highland (Sierra) region. Moreover, it is expected that self-renewal into the integrated agroindustry projected by a leading company (IANCEM) in Imbabura Province will be realized and that it will contribute to the development of the regional economy in the future. In addition, Ibarra City has some factories of agroindustry and is located in an important place of commerce and transport in the northern region of Ecuador and near the border with Colombia which has big market within the Andean countries. On this account, it may be further developed in terms of quality by revitalizing agroindustry.

Under these circumstances, the majority of products for agroindustry produced in the Project Area will possibly be shipped to the factories of agroindustry. Consequently, it will also make possible the stabilization of markets and the leveling of producer prices. In order to realize the above, contracted cultivation between farmers and factories of agroindustry is proposed as one of the systems.

In villages of Imantag Parroquia within the Project Area, farmers have the intention of installing small-scale rural industries to produce cheese in the future. With the Project, the realization of this plan will be accelerated.

Judging from the above, new agro-processing facilities will not be contemplated in the Project.

4.2.4 Agricultural Supporting Plan

In order to achieve the aim of the Project, it is important that the agricultural support to the small and medium-scale farmers through the related institutions is carried out sufficiently. Therefore, the supporting system shown on Fig. 4.2.4 is proposed:

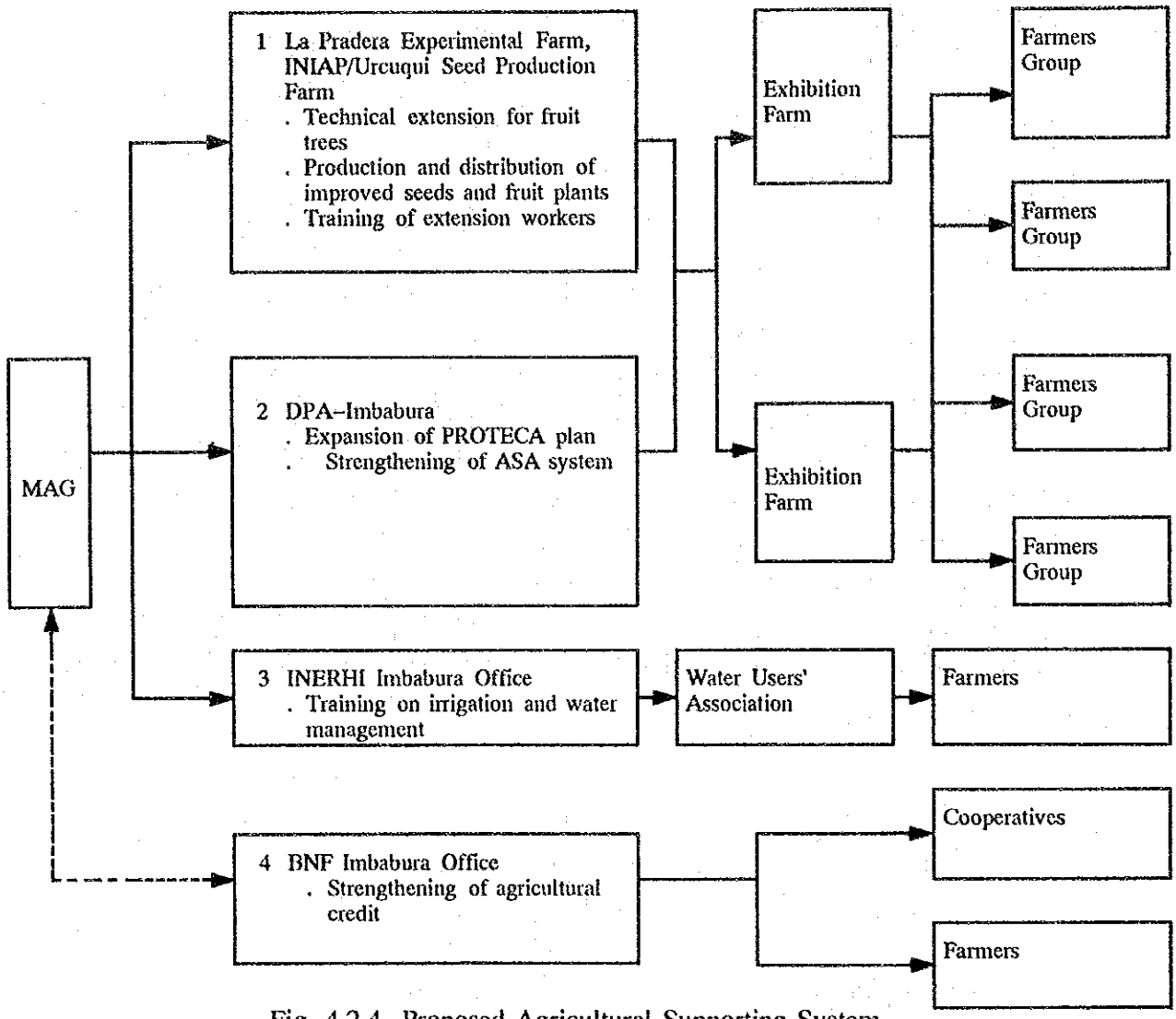


Fig. 4.2.4 Proposed Agricultural Supporting System

1 La Pradera Experimental Farm, National Institute of Agricultural Research (INIAP)/Urcuqui Seed Production Farm

a. La Pradera Experimental Farm

Production of Seed and Seedling

In the Provinces of Imbabura and Carchi, the following services based on the Fruit-growing Program (Programa de Fruticultura) shall be executed:

- Production of fruit plants

- Distribution of fruit plants
- Organization of fruit-growing farmers
- Technical guidance to fruit-growing farmer's group through the model orchards
- Diffusion of fruit-growing through the model orchard in Urcuqui
- Short courses in farm management for fruit-growing farmers
- Marketing support to fruit-growing farmers

Extension Services

Retraining of the extension workers of DPA for improving their technique and knowledge shall be expanded. Furthermore, the demonstration farm in the Project Area shall be improved.

b. Urcuqui Seed Production Farm

With the Project, introduction of new crops is planned. However, production of improved seeds is insufficient at present. Therefore, a vegetable seed production farm and vegetable seed multiplication center shall be established in Urcuqui by improving the existing Seed Production Farm which is situated in a favorable place of transport within the Project Area, and the production and distribution of vegetable seeds produced in the center shall be executed.

2 Agriculture and Livestock Provincial Directorate of Imbabura (DPA-Imbabura)

Through the expansion of the function of ASAs and PROTECA, transfer of technology for farmer groups with the cooperation of INIAP shall be executed.

3 National Institute of Water Resources (INERHI)

Through the water users' associations formed by the beneficiaries in the Project Area, water management shall be oriented by INERHI.

4 National Development Bank (BNF)

For the farmers in the Project Area, BNF shall strengthen the agricultural financing support.

4.2.5 Farmer's Organization Plan

The Project aims at the improvement of agricultural productivity by means of an organized irrigation system. In order to attain agricultural production aimed by the Project, the organization of farmers is indispensable. Furthermore, it is important to set up the water users' association by beneficiaries to carry out operation and maintenance of the Project irrigation facilities.

(1) Farmers' Organization

In order to obtain the agricultural supporting services from public institutions, the organization of the farmers is an essential condition. Therefore, an organization such as an association or cooperative of small-scale farmers who have no organizations at present shall be established in each village.

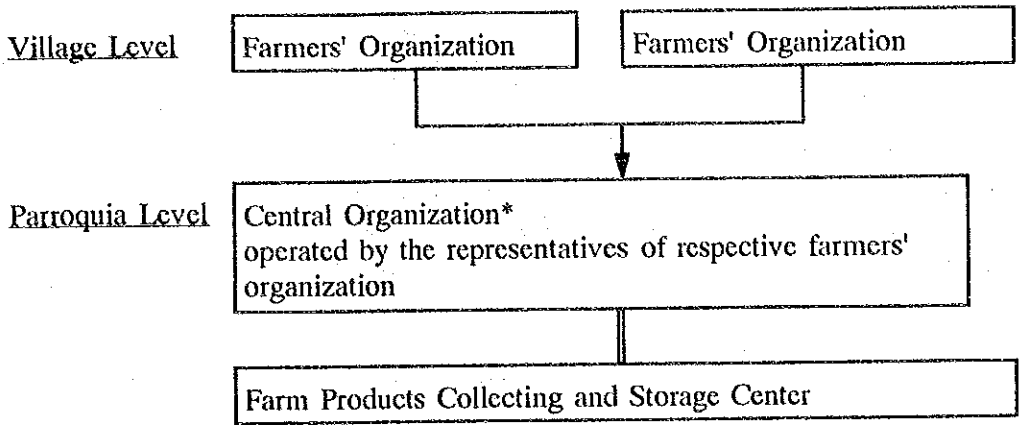
These organizations shall establish the central organizations in Tumbabiro, Urcuqui and Imantag, and the functions of the central organization are to secure the advantage of farmers and to obtain institutional agricultural support (financing, technical guidance, commercialization, etc.)

With a view to smoothing of the distribution of farm products, a collecting and storage center (Centro de Acopio) with fruit selecting shops and cool rooms shall be set up. The center belongs to each central organization.

The organization shown in Fig. 4.2.5 is proposed in connection with the above.

(2) Water Users' Association

In order to carry out the operation and maintenance of the canals (Branch and Tertiary) constructed by the Project, the water users' association in each Branch Canal shall be established by beneficiaries and carry out water distribution and operation and maintenance of the canals. The association shall be formed by reorganizing the present system (See 5.4).



* Central Organization: Tumbabiro– Tumbabiro Parroquia
Urcuqui – Urcuqui Parroquia
San Blas Parroquia
Imantag – Imantag Parroquia

Fig. 4.2.5 Proposed Farmers' Organization

4.3 INFRASTRUCTURE FACILITIES PLANNED

4.3.1 Summary

The main facilities planned in the Project are summarized below:

(1) Piñán Dam

1) Dam

. Dam type	:	Facing-type Rockfill Dam
. Height of Dam	:	48.0 m
. Crest Length	:	220.0 m
. Elevation of Crest	:	El 3,005.5 m
. Crest Width	:	10.0 m
. Slope	:	Upstream 1:2.0, Downstream 1:1.8
. Volume of Dam	:	350 x 10^3 m^3
. Design Flood Discharge	:	200 m^3/s

2) Reservoir

. Name of River	:	Piñán River
. Catchment Area	:	83.4 km^2
. Normal Full Water Level	:	El 3,001.5 m
. Lowest Water Level	:	El 2,982.0 m
. Total Capacity	:	13.1 x $10^6 m^3$
. Effective Capacity	:	11.6 x $10^6 m^3$
. Dead Capacity	:	1.5 x $10^6 m^3$
. Reservoir Area	:	870 x 10^3 m^2
. Max. Intake Capacity	:	5.171 m^3/s

(2) Cariyacu Head Works

. Location	:	Cariyacu River
. River Width	:	75 m
. Design Flood Discharge	:	65.0 m^3/s
. Height of Fixed Weir	:	6.5 m
. Total Length of Weir	:	56.5 m
. Elevation of Crest	:	El 2,547.7 m
. Length of Apron	:	14.1 m
. Intake Gate	:	3.50 m x 3 spans
. Max. Intake Capacity	:	6.131 m^3/s
. Sand Sluiceway Gate	:	3.00 m x 2 spans
. Settling Basin	:	38.00 m x 3.00 m x 2 lines

(3) Canals

1) Head Race

. Total Length	:	23.31 km including tunnels 8.89 km
. Max. Flow Capacity	:	5.171 m^3/s
. Canal Type	:	Concrete flume
. Maintenance Road	:	4.00 m wide, gravel pavement
. Related Structures	:	Siphone, Conduit, Stream intake, End outlet, etc.

2) Main Canal

. Total Length	:	29.37 km including a tunnel 3.13 km
. Max. Flow Capacity	:	5.295 m^3/s
. Canal Type	:	Concrete flume
. Related Structures	:	Siphone, Diversion works, Stream intake, etc.

3) Branch Canal

. Total Length	:	110.58 km including pipeline 10.22 km
. Max. Flow Capacity	:	2.534 m^3/s
. Canal Type	:	Concrete flume
. Related Structures	:	Diversion works, etc.

4.3.2 Dam

(1) Location of Dam

The basic requirement for the proposed dam site is that the altitude of the intake at the dam site shall be more than El 2,700 m in consideration of the altitude of the Project Area (1,700 - 2,540 m) and the hydraulic head loss to be induced though the Head Race of about 23 km.

Considering the above, the watershed of the Pitura River which is located 25 km northwest of the Project Area across the mountains of 4,000 m high has been selected. Within this watershed, the following two valleys across the Piñán River, one of the branch rivers of the Pitura River, have been selected as the dam sites for the further study:

a. A narrow valley about 2 km downstream of the Piñán Village (2 km Valley)
b. A narrow valley about 5 km downstream of the Piñán Village (5 km Valley)

Both valleys are sharp and narrow, and have gently sloped open land in their upstream sections. Therefore, both of them have the effective storage capacity and are suitable for the proposed dam site. However, "2 km Valley" has been omitted from the further study in consideration of the expected inundation of the village and probable social problems in connection with such inundation.

At "5 km valley", the following two sites can be selected as the dam site for

consideration:

. Site A : at the section 300 m downstream of the valley mouth
. Site B : at the section immediately downstream of the valley mouth

The river gradient at the downstream section of Site A is steep (1/30) and Site A is the downstream limit for the dam site (Fig 4.3.1).

Site A has the following disadvantages in comparison with Site B. Therefore, Site B has been selected as the proposed dam site.

a. Site A is disadvantageous from the view point of reservoir efficiency due to the downstream edge of the gently sloped land which will become the reservoir being the immediately upstream of Site B.

b. Excavation volume at Site A will be more than that of Site B due to the steep gradient of the river (1/30) from the immediately downstream of Site A and sharp slope of the valley at its both sides.

c. Construction works at Site A will be harder.

d. In the case of Site A, the construction road will become longer and construction yard will not be sufficient.

(2) Dam Type

As the type of the proposed dam, a fill dam has been selected in consideration of the following:

a. In the case of a concrete gravity dam, the foundation rock must be hard enough to bear the dam body, water pressure, etc. However, the rocks at the dam site may be weathered up to the deep section (10 – 15 m at both slopes).

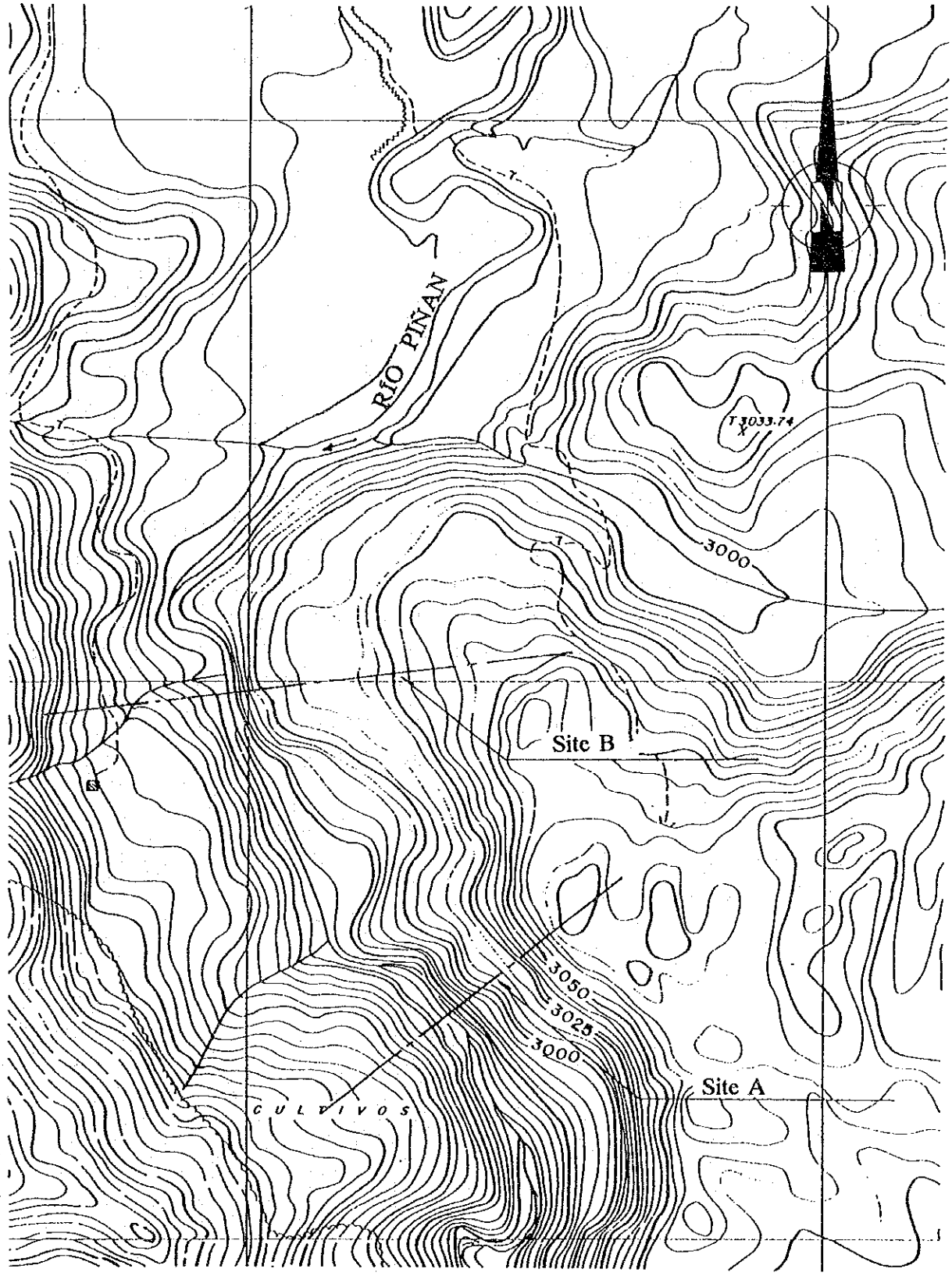


Fig. 4.3.1 Compared Dam Sites

The deteriorated section at the boundary between granodiorites and andesite lava may exist in between the rocks at the left bank of the river. Therefore, further detailed investigations and analysis of the rocks are required in adopting a concrete gravity dam.

b. On the other hand, in the case of a fill dam, required hardness of the foundation rock is not serious in comparison with a concrete gravity dam. The degree of weathering of the rocks at the site will not be troublesome for a fill dam. Shallow removal of weathered portions will be enough for the dam foundation except for the portions of core waterproof and gallery. Judging from the reconnaissance survey, fill material will be obtained around the dam site and the construction of a fill dam will be more economical.

As the fill material, granodiorites distributed at the right bank of the river can be recommended because of its quality, strength and uniformity. However, even though there is core material (having suitable water proofiability and workability) around the site, its quantity is not enough. Furthermore, there will be restriction against construction works of the core due to the big quantity and frequency of rainfall at the site. Therefore, it is judged not to be practicable to adopt a zone-type fill dam. An asphalt facing type dam will be most suited for the proposed dam. Although the dam site is located right on the equator, a dam of this type will not have any bad effects on it because of the altitude of the site being 3,000 m, annual average temperature being 12°C and the quality of river water being good.

Furthermore, the spillway is to be constructed on the left bank of the dam in due consideration of its workability, stability of excavated slope, excavation volume, etc. through the comparison study on both banks.

(3) Dimensions of Dam

The dimensions of the proposed dam are as follows:

- Type of Dam	:	Asphalt-facing type rockfill dam
- Elevation of Crest	:	El 3,005.5 m
- Normal Full-water Level	:	El 3,001.5 m
- Lowest Water Level	:	El 2,982.0 m
- Height of Dam	:	48.0 m
- Length of Crest	:	220.0 m
- Slope	:	Upstream 1:2.0, Downstream 1:1.8

- Total Capacity : 13.1×10^6 m^3
- Effective Capacity : 11.6×10^6 m^3
- Dead Capacity : 1.5×10^6 m^3

(4) Design Conditions

1) Design Flood Discharge

The design flood discharge of the Piñán River is estimated using the formula used by INERHI. In the estimation, the safety factor in the case of a fill dam of 1.2 and the flood return period of 200 years are considered. Furthermore, allowance of 20% is added considering that the characteristics of river discharge in the area are not clarified.

$$Q = \{1.2 \times (25 \times A \times k) / (A + 57)^{1/2}\} \times 120\%$$

where : Q : Design flood discharge (m^3/s)
A : Catchment area (74.1* km^2)
k : Factor (in case of 1/200 : 0.84)

Therefore;

$$Q = \{1.2 \times (25 \times 74.1 \times 0.84) / (74.1 + 57)^{1/2}\} \times 120\% = 200 \text{ m}^3/\text{s}$$

In connection with temporary drainage, the discharge during the construction shall be drained through the temporary canal (tunnel and open canal) to be constructed at the left side of the dam. This canal will be used as the intake canal of irrigation water and outlet of low water.

The temporary flood design discharge is estimated in consideration of return period of 10 years and allowance of 30% as follows:

$$Q_t = 0.8 \text{ m}^3/\text{s/km}^2 \times 74.1^* \text{km}^2 \times 130\% = 80 \text{ m}^3/\text{s}$$

---

* In the estimation of sediment and flood discharges, the objective watershed is set as 74.1 km^2 excluding the closed area of Donoso Lake of 9.3 km^2 (83.4 – 9.3 = 74.1)

2) Sediment

A remarkable landslide or collapse has not occurred except for some landslides in the limited small areas due to the stable topography of the watershed including the expected submerged area. The watershed is gently sloped and is covered with dense pasture (Paramo), providing the watershed with the remarkable infiltration capacity. From the facts mentioned above, it is judged that the sediment in the reservoir will be little.

The design sediment volume is estimated in consideration of the observed flowsand volume in the Piñán River of 110 m^3/year/km^2 as follows:

200 m^3/year/km^2 x 74.1 km^2 x 100 years = 1.5 x 10^6 m^3

3) Earthquake

A remarkable earthquake has not occurred in Ecuador, even though it is located on the outer boundary of the Pacific Ocean Earthquake Belt and some remarkable ones have occurred in Peru and Colombia which are located beside Ecuador. Normal earthquakes have occurred around the beach areas near Peru and Colombia and along the volcanic belts like Cotopaxi.

The earthquake factor in this design is set as 0.18 g (probable occurrence: 1/100) which is estimated based on the observed values between 1951 and 1990.

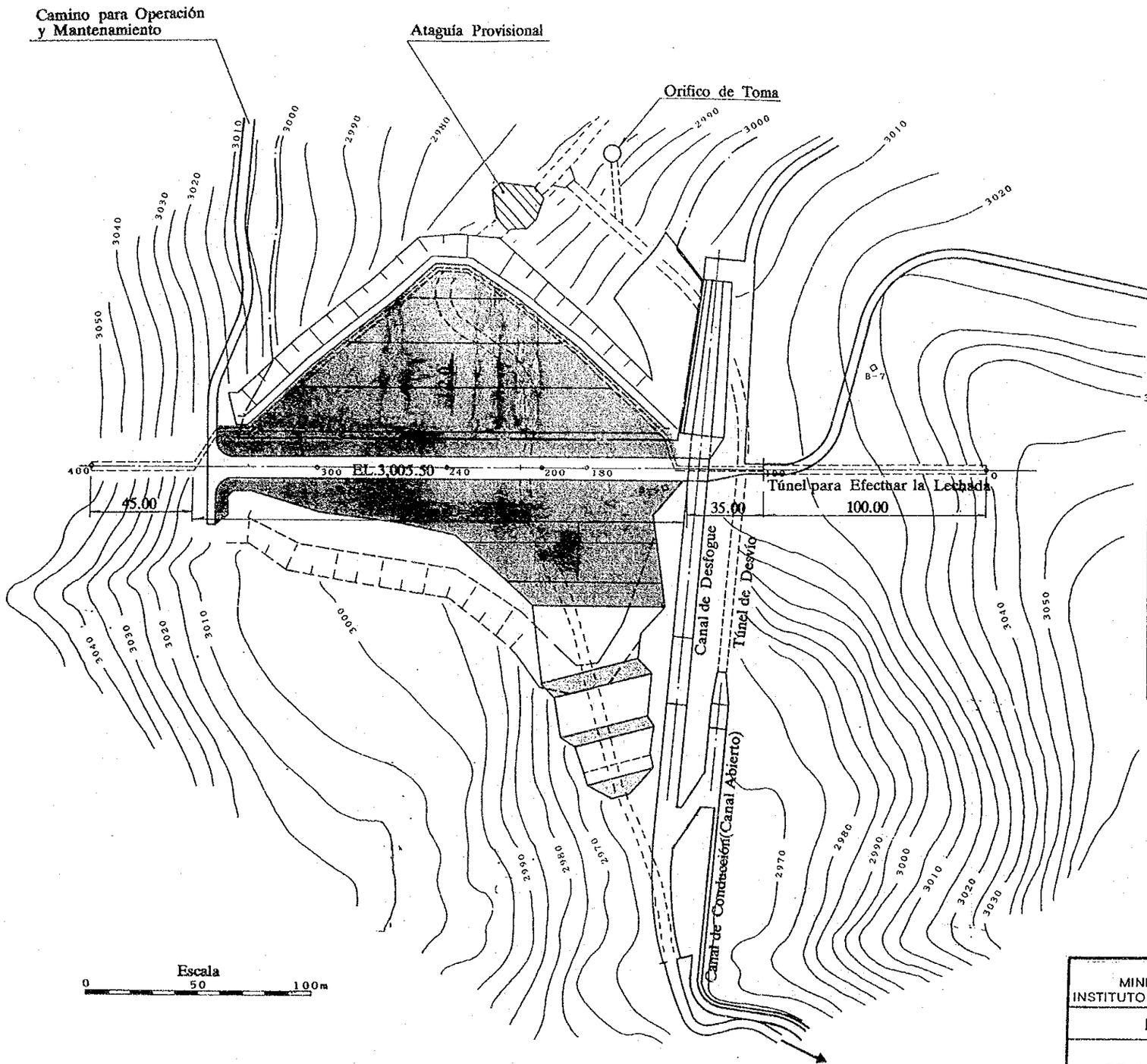
4) Construction Equipment, etc.

The temporary construction equipment like concrete plant shall be installed at the open area around the dam site. A temporary road to the dam site shall be newly constructed in order to transport the excavated and/or embankment materials. The valley located at the left bank immediately upstream of the dam shall be used for a disposal area of the excavated material. The power for construction equipment shall be diesel--generated. Communication equipment shall be newly provided. Access road from Ibarra city to the dam site, 57 km long, gravel paved, was completed in Nov. 1992. However, its partial improvement and relocation are necessary for the transportation of heavy equipment.

5) Others

The following submerged lands in connection with the dam construction are owned by a farm, Hacienda El Hospital, and any financial compensation is not required.

- Reservoir Area : Approx. 90 ha (mostly pasture)
- Submerged house : 2
- Submerged road : 3 km



DIMENSIONES DE PRESA

Tipo de presa	:	Presa de escollera
Altura de presa	:	48.0 m
Longitud de la presa	:	220.0 m
Elevación de la presa	:	El 3,005.5 m
Ancho de la cresta	:	10.0 m
Pendiente	:	Aguas arriba 1 : 2.0
		Aguas abajo 1 : 1.8
Volumen de la presa	:	350 x 10^3 m^3
Caudal de avenida de diseño	:	200 m^3/s

REPUBLICA DEL ECUADOR
MINISTERIO DE AGRICULTURA Y GANADERIA (MAG)
INSTITUTO ECUATORIANO DE RECURSOS HIDRAULICOS (INERHI)

PROYECTO DE IRRIGACION TUMBABIRO

PLANO GENERAL DE LA PRESA

FEBRERO DE 1994

AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON

Fig. 4.3.2 Plan of Proposed Dam

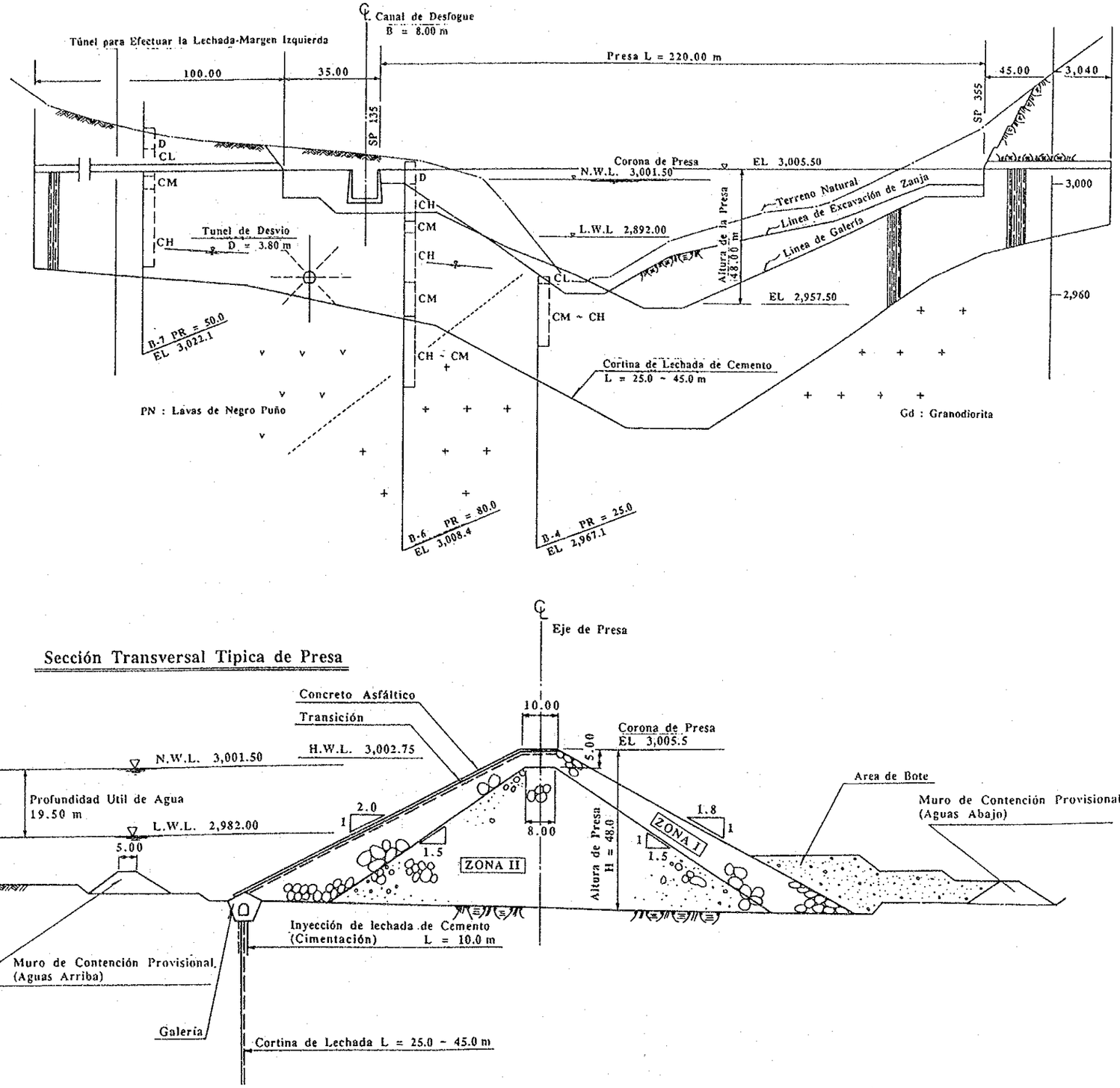


Fig. 4.3.3 Profile and Section of Proposed Dam

4.3.3 Head Race

The Head Race is constructed along the steep slope of about El 2,900 m in the mountainous area from the Piñán Dam to the Cariyacu River. Its total length is 23.31 km including five siphones and four tunnels due to the severe topography through its route.

(1) Open Canal

The design discharge of the Head Race is changed on monthly basis and the maximum design discharge is 5.171 m^3/s in December. In consideration of the reduction of the possible high construction cost of the canal due to the steep slope (max. 40°) of the construction area, the design capacity of the canal is set as 80% of the maximum design discharge (4.137 m^3/s) which has been determined based on the design discharges for 6 years of the design years. The maximum design discharge can be flown through the designed canal safely with use of the free board of the canal. According to the water balance analysis, the monthly design discharges which exceed the design capacity of the canal have occurred 11 times (11 months) for 6 design years (72 months).

As a result of the comparison of canal types; concrete flume type, trapezoid-shape concrete lining type and stone wet masonry type, the concrete flume type has been selected for the open canal of the Head Race in due consideration of economy, workability and excavated earth volume in connection with the canal construction. In determining the canal section and gradient, the merits on hydraulics, structure and construction works have been considered. The proposed canal section is shown on Fig 4.3.4 and its gradient is set as 1/1,500. Furthermore, in consideration of the site topography, the construction of the construction road along the canal prior to the construction of the canal itself is indispensable. This construction road is to be used as the maintenance road of the canal.

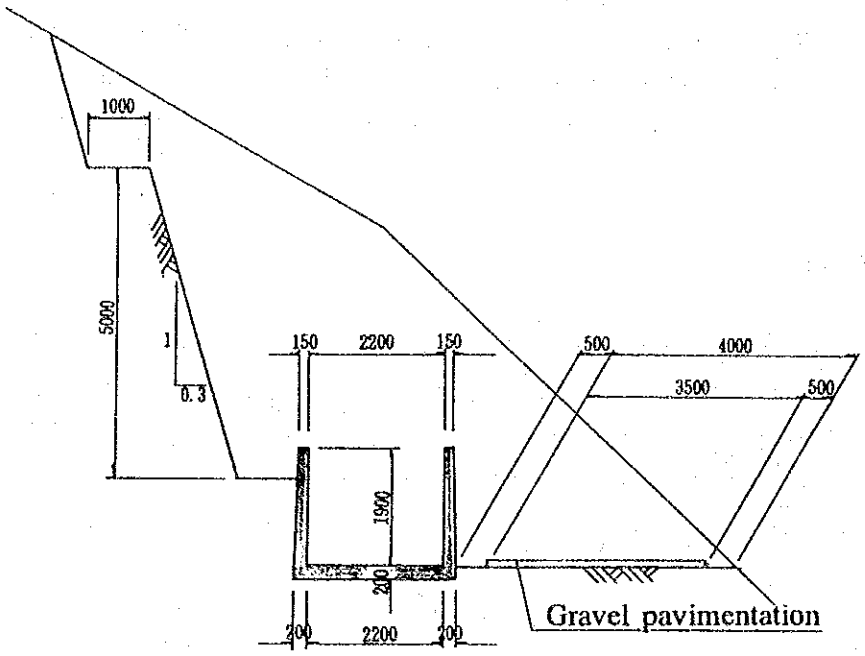


Fig. 4.3.4 Standard Section of Open Canal (Head Race)

(2) Tunnel

Through the route of the Head Race, the following 4 tunnels are planned in consideration of the topography along the route. Among these tunnels, Tunnel No.4 is a long tunnel (7.37 km) crossing the Andes Mountains (approx. El 4,000 m).

Tunnel No.1	:	880 m
Tunnel No.2	:	320 m
Tunnel No.3	:	320 m
Tunnel No.4	:	7,370 m

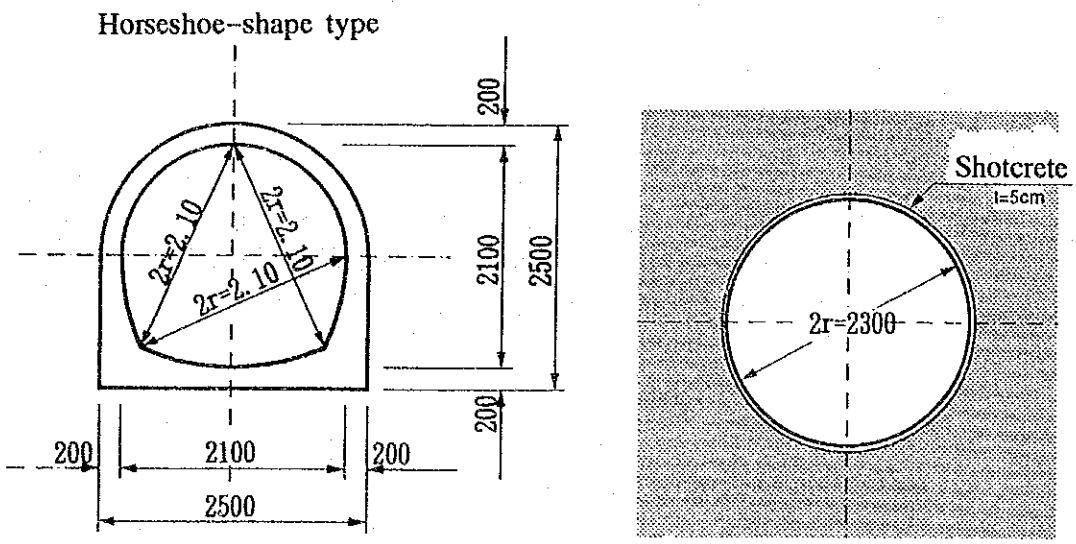
The tunnel sections are determined in consideration of the hydraulic, structural, constructional and economic view points as follows:

a. Tunnels No.1, 2 and 3 : Standard horseshoe-shape type (2r = 2.10 m)
b. Tunnel No.4 : Cylinder type (2r = 2.30 m)

In the case of Tunnel No.4, the machine excavation method is adopted in consideration of its expected long construction period. Furthermore, the excavation from the both ends is considered for Tunnel No.1 due to its length. The tunnel

gradient is set as 1/800 in consideration of the gradient at open canal section and its workability. In addition, a discharge works is necessary at the outlet of Tunnel No.4.

The access roads to respective tunnels are required during the construction works. These access roads may be used for the access to the maintenance road of the Head Race after completion of the construction works. In addition, the countermeasures against flood, cave-in, etc. which may occur during the construction works should be taken from time to time when required.



Tunnels No.1, 2 and 3 Tunnel No.4

Fig 4.3.5 Standard Section of Tunnels (Head Race)

(3) Siphone

The Head Race passes many valleys. In planning the profile of the Head Race, siphone works are excluded as much as possible in consideration of the economy of the works except 5 sites. The total length of these siphones varies from 73 m to 23 m.

Considering the design maximum discharge, hydraulic head loss and workability of the construction works, a steel pipe of 1,900 mm diameter or cast-in-place concrete box culvert is adopted.

(4) Conduit

The concrete box culverts (W: 2.30 m x H: 2.00 m) are planned at the sections crossing small rivers. The minimum earth cover at the river bed section is set as 2.0m.

(5) Stream Intake

In addition to the irrigation water intaken from the dam, the flows of the streams which cross the Head Race (Pantavi, Gualoto, Atanto and Companario) are to be used as a part of the necessary irrigation water. At the upstream side of the cross section with the Head Race, the intake structures are constructed across the streams to receive the necessary water amount.

(6) End Outlet Works

At the outlet of Tunnel No.4 located at the end of the Head Race, an end outlet works is constructed in order to discharge the irrigation water to the Arrayanes River, one of the branch rivers of the Cariyacu River.

(7) Maintenance Road

The construction road which is constructed along the Head Race is to be used as the maintenance road of the Head Race after the completion of the construction works. The total width of the road is set as 4.0 m in order to allow the passage of a maintenance vehicle and heavy equipment in case of necessity. The road is paved with gravel.

4.3.4 Head Works

The irrigation water discharged to the Arrayanes River, one of the branch rivers of the Cariyacu River, is intaken again at the Cariyacu Head Works to be constructed newly across the Cariyacu River together with the available river water in the watershed of the Cariyacu River itself.

(1) Topography and Geology

The slopes of both banks of the Cariyacu River at the proposed site for the Head Works are steep and form a deep valley. The river bed consists of gravel deposit

layers and has no serious problems as the foundation of a head works.

(2) Location

In selecting the location of the proposed head works, the following points have been considered:

- Easiness of the construction of the head works and related works
- Easiness of operation and maintenance of the facilities after their completion
- The altitude of the site shall be as high as possible

The selected site is located 150 m upstream of the existing concrete bridge across the Cariyacu River. Its altitude is 2,545 m at the river bed and the width of the river is approx. 60 m.

(3) Type

The proposed head works (total width: 56.5 m) consists of a fixed weir (48.5 m) and a gated weir (8.0 m), and has a sand sluiceway and an intake at the left bank. The settling basin is placed 100 m downstream of the intake due to the availability of its site. The gated diversion works is constructed immediately downstream of the settling basin and the irrigation water is distributed to the North and South Main Canals. The foundations of the Head Works is of floating type due to the expected deep foundation rocks. The design flood discharge is set as 65.0 m^3/s in order to cope with the discharge of 25 year return period.

(4) Outline of the Structure

The typical section of the proposed head works is as shown on Fig 4.3.6.

1) Fixed Weir

The elevation of crest of the weir is set as El 2,547.7 m in consideration of the altitude of the Project Area and hydraulic head loss from the Head Works to the Project Area. An energy dissipator and riprap are designed at the downstream side of the weir.

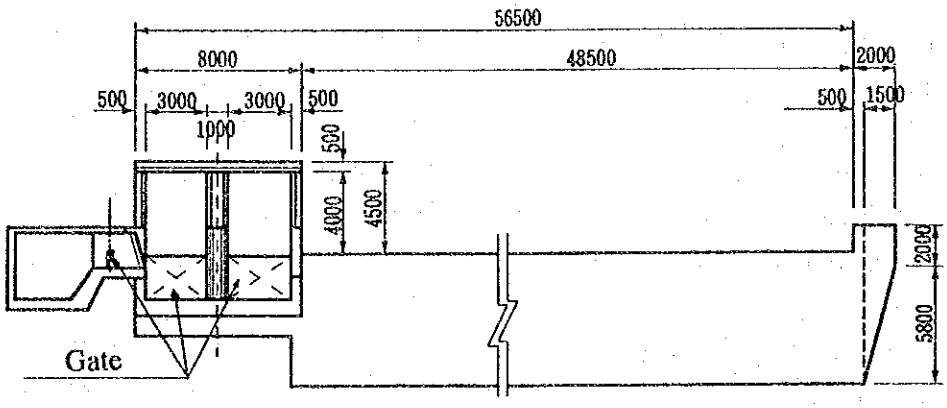


Fig. 4.3.6 Typical Section of Head Works

2) Intake

The base height of the intake is determined to be 1.50 m higher than that of the river bed in order to protect the intrusion of the river sand which will increase due to the increase of discharge of the Cariyacu River because of the discharge from the Piñán Dam. The velocity at the intake is designed to be less than 1.0 m/s in the case of the design intake volume of 6.131 m^3/s. The width of the intake is 3.5m x 3 spans.

3) Sand Sluiceway

The sand sluiceway is designed to flow down the gravels of maximum diameter of 30 mm judging from the size of river deposits. Its width is 3.0 m x 2 spans.

4) Settling Basin

The design size of the objective sand is set as 0.3 mm and the design velocity in the basin is set as 0.2 m/s. The basin has symmetrical shape and is divided into two rooms by partition wall. The width and gradient of each room are 3.0 m and 1/50, respectively. The settled sand is discharged to the Cariyacu River through the disposal gate by gravity.

5) Distribution to Main Canal

The irrigation water treated at the settling basin is distributed to the North and South Main Canals through the diversion works located downstream of the settling basin. At the diversion works, the distribution volume is controlled monthly. The south main canal crosses the Cariyacu River by siphone immediately after the diversion of irrigation water.

4.3.5 Main Canal

The objective of the Main Canal is to distribute the irrigation water to the respective Branch Canals through the North and South Main Canals. The Main Canal is located along the contour line from El 2,540 to El 2,520 m. Its total length is 29.37 km (South Main Canal: 14.82 km and North Main Canal: 14.55 km). The design discharges are 1.091 – 0.221 m^3/s for the South Main Canal and 5.295 – 1.916 m^3/s for the North Main Canal. The Main Canal includes some siphones and conduits and one tunnel.

(1) Open Canal

The design conditions adopted in designing the open canal for the Main Canal such as design capacity, section, gradient and construction road are basically the same as for the Head Race. In its construction works, the access to the construction site will be more easily secured than that for the Head Race due to the topography and the existing road network around the site.

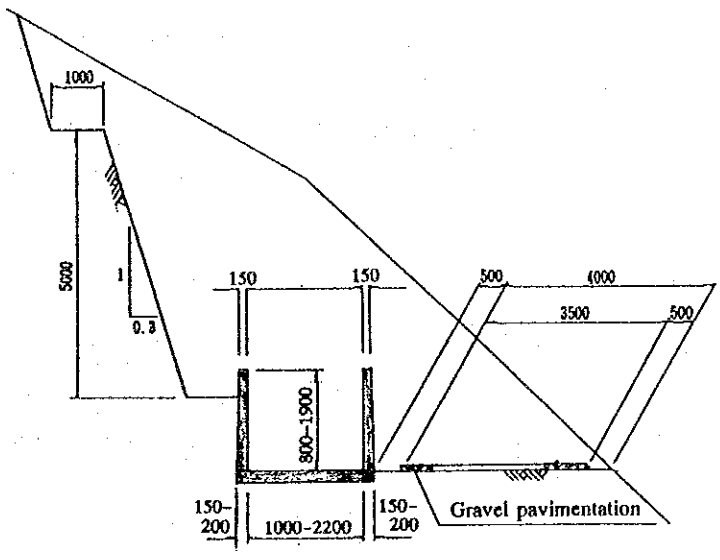


Fig. 4.3.7 Standard Section of Open Canal (Main Canal)

(2) Tunnel

Tunnel No.5 is to be constructed near the end of the North Main Canal. The section of the tunnel is determined to be of single-circle hood type (3r-V-H) shown on Fig 4.3.8 from the view points of design capacity (2.115 m^3/s), workability and economy. The gradient of the tunnel is set as 1/800.

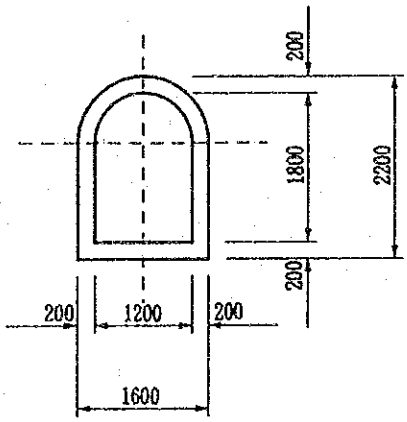


Fig 4.3.8 Standard Section of Tunnel No.5 (Main Canal)

(3) Diversion Works

Some diversion works are installed on the Main Canal in order to distribute the irrigation water to the Branch Canals.

In order to adjust and measure the irrigation water amount to be distributed to the respective Branch Canals, a steel-made water control gate and a parcel flume (measuring device) on the Branch Canal side, and a steel-made flap gate for controlling the water level on the Main Canal side.

(4) Stream Intake

Likewise the Head Race, the stream intakes are constructed across five streams (Pueblo, Huarmiyacu, Chimborazo, Tushila and Alambí) which cross the Main Canal in order to take the stream water into the Main Canal as additional irrigation water. The system and structure of the intake works for the Main Canal are the same as those for the Head Race.

4.3.6 Branch Canal

The objective of the Branch Canal is to distribute the irrigation water to respective Tertiary Canals in the field.

The control area of a Branch Canal is determined in consideration of the existing field conditions and topography, and one control area is basically more than 50 ha. There exist some irrigation canals (acequia) in the Project Area. Therefore, in the Project, these existing canals are used as the Branch Canals as much as possible by improving them. The total length of these improved Branch Canals is 54 km in the total Branch Canal of 150 km.

(1) Type

Almost all the Branch Canals are located at a right angle to the contour lines due to the topography of the area. Because of the average gradient of land being 1/20, the gradient of the Branch Canal becomes steep and the velocity of water is high. The canal structure is of concrete flume in consideration of this high velocity. However, at the section when the gradient is more than a/10, a pipeline is adopted in stead of open canal due to the accurate diversion of water. In this case, the diameters of the pipe are 100 – 600 mm.

An asbestos cement pipe and unplasticized polyvinyl chloride pipe are used for the sections of diameter being 450 mm and more and less than 450 mm, respectively, due to the price of pipes and availability of them.

(2) Diversion Works

The locations of diversion works on the Branch Canals are selected in consideration of the topography and field conditions in the area.

Each diversion works covers approx. 50 ha and more due to the adopted irrigation system, arrangement of Tertiary and field canals, etc. The diversion works on the Branch Canals are equipped with energy dissipators in consideration of the expected supercritical flow through the Branch Canals due to the topography of the area where the Branch Canals are located. Furthermore, the discharge control gates are installed on both inlet and outlet sides of the diversion works. These gates are operated and maintained by respective farmers or cooperatives.

4.3.7 Tertiary Canal

The Tertiary Canals are planned in order to connect the Branch Canals to the existing irrigation canals or the field canals. The type of the Tertiary Canal is an earth lining canal. Its density is set as approx. 40 m/ha.

4.3.8 Related Facilities

The main following security and safety facilities are planned for the Head Race, Main Canal and Branch Canal, respectively.

(1) Canal Cover

The concrete slab covers are planned to provide over the canals at the sections where much soil and/or other obstructive materials are expected to fall down over the canals.

(2) Drainage Works

The rainwater from the side slope along the canals is to be collected into the side ditch of the canals and it is drained out to the valley safely through the canal-cross drains installed every 250 m.

(3) Slab Bridge

In consideration of the proper operation and maintenance of the canals, concrete slab bridges are provided over the canals every 500 m.

CHAPTER 5

PROJECT IMPLEMENTATION AND OPERATION & MAINTENANCE

CHAPTER 5: PROJECT IMPLEMENTATION AND OPERATION & MAINTENANCE

5.1 CONSTRUCTION SCHEDULE

The implementation period of the Project construction works is set as 90 months in total consisting of the detailed design phase of 18 months and the construction phase of 72 months. During the detailed design phase, the topographic survey and geological investigation of the sites proposed for the main structures, detailed design work, preparation of tender documents, etc. are to be performed.

During the construction phase, the acquisition of land for the proposed structures, tendering, construction works of the Project facilities, procurement of operation/maintenance equipment, etc. are to be conducted (Fig. 5.1.1).

5.1.1 Detailed Design

(1) Advance Survey

Prior to the detailed designing work, the detailed site survey and geological investigation of the sites proposed for the main facilities shall be conducted.

a. Detailed Site Survey

The detailed topographic survey including longitudinal and cross levelling at the proposed sites for the dam, outlet and inlet of tunnels, head works and diversion works shall be performed. The total area to be surveyed will be approx. 50 ha. The longitudinal and cross levelling including plan along the routes of proposed head race, main and branch canals and access roads shall be performed. Total length to be surveyed will be approx. 200 km.

b. Geological Investigation

The geological investigation at the proposed sites for the dam, tunnels, head works etc. necessary for the detailed designing work shall be conducted.

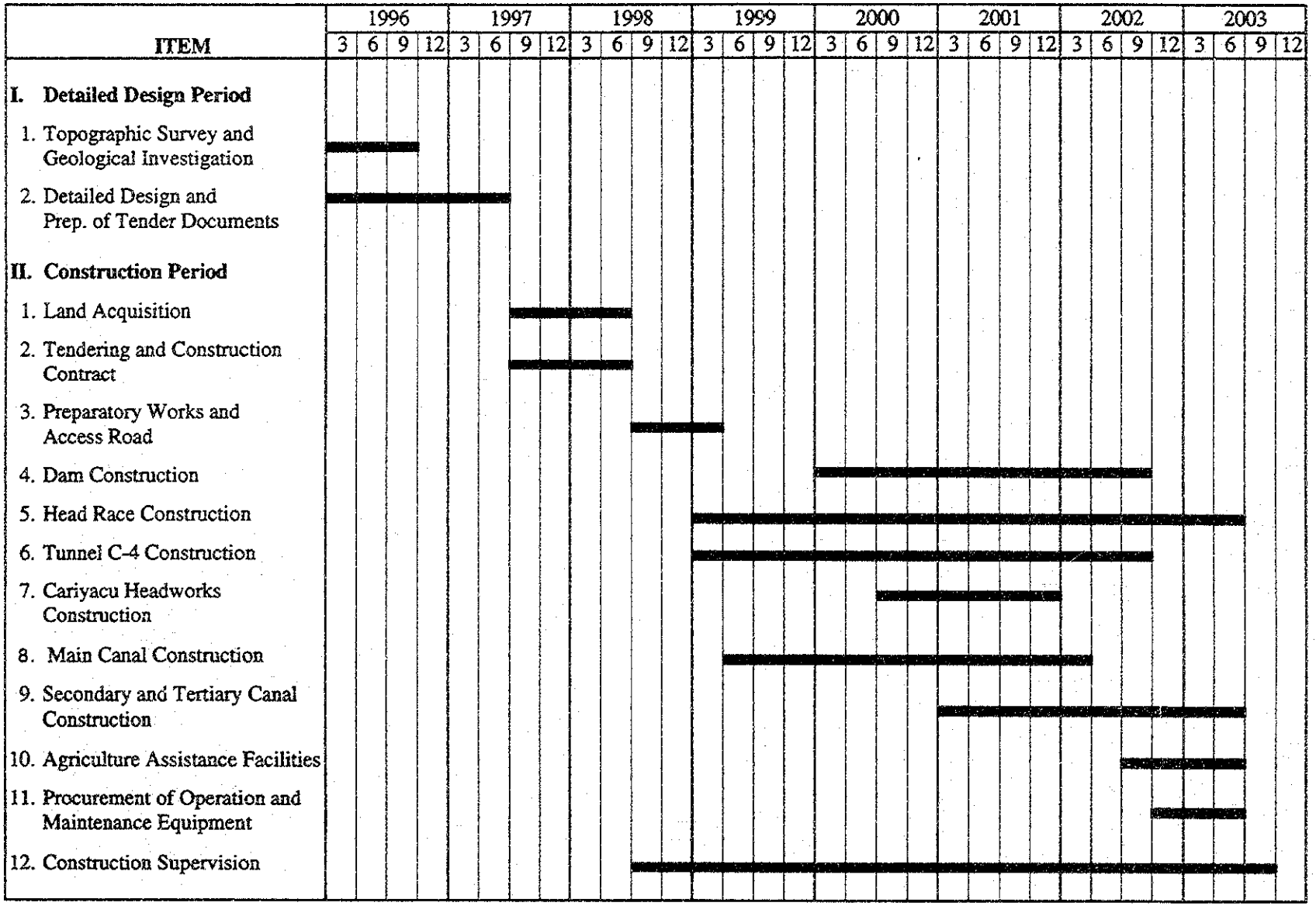


Fig. 5.1.1 General Construction Schedule

(2) Detailed Design and Preparation of Tender Documents

Based on the results of the advance survey mentioned above, the detailed design of the required Project facilities is to be conducted. After the detailed design, the following documents necessary for the Tendering of the Project construction works are to be prepared. The period required for the detailed design is set as 18 months.

- General Specifications
- Special Specifications
- Technical Specifications
- Tender Drawings
- Bill of Quantities
- Cost Estimation
- Construction Schedule
- Others

5.1.2 Construction Works

(1) Land Acquisition

Prior to the commencement of the construction works, the Government of the Republic of Ecuador through INERHI has to acquire the lands necessary for the Project construction works such as a dam, head race, head works and main/branch canals.

(2) Tendering and Contract

After the completion of the detailed design of the required facilities, the pre-qualification and short listing of the interested contractors are to be conducted. Tendering shall be conducted for the above prequalified contractors and the contractor to perform the construction works shall be selected from them. The tendering shall be done on the basis of the international competitive bidding and contract procedures. The period required for the tendering, tender evaluation and contract signing is set as 12 months.

(3) Implementation of Construction Works

In order to realize the expected effects by the Project as soon as possible, the construction period shall be shortened by overlapping the construction of respective works in due consideration of the anticipated inconvenience by the overlapping. The

construction works of the Dam, open canal portion of the Head Race and Tunnel No.4 have the key factor on the total construction period. Therefore, the overlapped construction of these works is important for shortening the total construction period. The proposed general construction schedule is as shown on Fig. 5.1.1.

5.2 PROJECT IMPLEMENTATION SYSTEM

5.2.1 Project Implementation Method

The Project Implementation Agency shall execute the detailed design of the Project facilities, tendering and tender evaluation, selection of the contractor, signing the contract, and supervision of the construction works with the assistance of the Consultants to be contracted prior to the commencement of the Project. The Consultants shall assist the Implementation Agency mainly for the technical matters included in the duties of the Implementation Agency.

The construction works shall be performed on the contract basis with the successful contractor. The construction machinery shall be prepared by the contractor. The materials necessary for the construction works shall be procured from domestic and/or international markets under the responsibility of the contractor.

5.2.2 Project Implementation Agency

(1) General

The Implementation Agency for the Project shall be INERHI. INERHI is the responsible agency for the implementation of the irrigation and drainage projects in the whole country, and has much experience in the implementation and operation/maintenance of the similar projects.

The Imbabura Provincial Office of INERHI shall have the general responsibility for the Project implementation in consideration of the Project site being located in the Imbabura Province. However, the independent Project Office shall be established in the Provincial Office for the successful implementation of the Project considering much work to be done.

(2) Project Office

The proposed staff members of the Project Office are as shown in Table 5.2.1. This Project Office shall be used as the Operation and Maintenance Office of the Project after the completion of the construction works of the required facilities.

Table 5.2.1 Proposed Staff of the Project Office

Personnel	Number
Officer in charge	1
Civil Engineer	2
Asst. Civil Engineer	2
Secretary	1
Driver	3

(3) Consultants

The Consultants shall provide the Project Implementation Agency with the technical services on the contract basis. The consulting services involve the detailed design in the detailed design phase and evaluation of tendering and supervision of construction works such as their workmanship, programming and safety control in the construction phase. The Consultants will be composed of highly qualified engineers and experts specialized in project planning, detailed design, construction, hydrology, geology, etc. The Consultants are also expected to undertake the technology transfer to local engineers of the Implementation Agency. Above all, the seminar on the quality control of workmanship and irrigation water management will be included in the scope of the consulting services. The estimated man-months for the consulting services are 342 mon-months (M/M) and 275 M/M for foreign and local components, respectively, totaling 617 M/M (Table 5.2.2).

Table 5.2.2 Estimated Months for Consulting Services

(Unit: M/M)

Detailed Design Phase			Construction Phase			Total		
Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
126	59	185	216	216	432	342	275	617

5.3 PROJECT COST

The Project cost consists of the construction cost, land acquisition cost, operation/maintenance equipment procurement cost, environment improvement cost, administration cost, advance survey cost, consulting services cost, and physical and economic contingencies.

5.3.1 Conditions for Cost Estimates

The estimation of the Project Cost is made based on the following conditions:

a. The basic costs such as labour cost, material cost and equipment cost are based on the unit costs presented in the document "Precios Unitarios Referenciales" published by INERHI in March 1993. However, the market prices as of July 1993 are adopted for the prices not included in the document.

b. The requirements per unit work are based on the standard adopted by INERHI.

c. The prices of domestic materials are based on those including transportation of materials to the site. The prices of imported materials are based on the material CIF Guayaquil price plus domestic transportation cost and import tax.

d. The construction costs are estimated with foreign and local components. In the unit costs for respective work items, indirect cost is included. The indirect cost is set as 39% of the direct cost in accordance with the Standard of INERHI.

e. The current exchange rate of 1 US$ = 1,883 Sucre as of July 1993 is adopted.

f. The physical contingency is set as 10% of the construction cost and other costs. The economic contingency is set as 3.8% per annum for foreign currency (the average of the consumer price indexes for the past 3 years in developed 5 countries) and 43.8% for local currency (the average of the consumer price indexes for the past 10 years in the urban areas of Ecuador).

5.3.2 Project Cost

(1) Construction Cost

The total construction cost is 214.0 x 10^9 S/. which includes the foreign portion of

167.4 x 10^9 S/. (78.2%) and local portion of 46.6 x 10^9 S/. (21.8%) (Table 5.3.1)

Table 5.3.1 Construction Cost

(Unit: 1,000 S/.)

Item	Local currency portion	Foreign currency portion	Total
1. Preparation Works	902,847	3,271,000	4,173,847
2. Construction Road	814,743	5,000,323	5,815,066
3. Dam			
(1) Temporary drainage canal	945,772	2,221,474	3,167,246
(2) Dam body	7,493,482	36,993,083	44,486,565
(3) Fill material	878,350	5,133,900	6,012,250
(4) Foundation treatment	937,841	15,433,907	16,371,748
(5) Spillway	1,998,380	4,486,102	6,484,482
(6) Intake etc.	86,269	2,860,362	2,946,631
(7) Transportation of equipment	340,695	7,762,580	8,103,275
(8) Temporary facilities	822,830	4,144,780	4,967,610
Sub-total	13,503,619	79,036,188	92,539,807
4. Head Race	7,528,299	13,797,381	21,325,680
5. Tunnel No.4	3,673,917	48,214,358	51,888,275
6. Head Works	1,030,180	517,834	1,548,014
7. Main Canal			
(1) South main canal	2,819,658	3,290,497	6,110,155
(2) North main canal	6,584,150	7,203,233	13,787,383
Sub-total	9,403,808	10,493,730	19,897,538
8. Branch Canal			
(1) South branch canal	774,614	581,692	1,356,306
(2) North branch canal	8,193,180	5,908,483	14,101,663
(3) Tertiary canal	220,000		220,000
Sub-total	9,187,794	6,490,175	15,677,969
9. Supporting Facilities	550,500	550,500	1,101,000
Total	46,595,707	167,371,489	213,967,196

(2) Land Acquisition Cost

The construction areas for the dam, head race and head works are located in the land owned by Hacienda El Hospital (a private farm) and the land acquisition costs are not required. However, the acquisition costs of land necessary for the construction of the Main and Branch Canals and their related facilities only are prepared as land acquisition cost. The required amount is 100 x 10^6 S/. in total, and allotted by the local portion.

(3) Operation/Maintenance Equipment Procurement Cost

The O/M equipment is to be procured by the Project Implementation Agency at the final year of the construction period and it shall be renewed at times when its durable period is expired. The procurement cost of the O/M equipment is 1.1 x 10^9 S/. and they are allotted by the foreign portion.

Table 5.3.2 O/M Equipment

Name	Spec.	No.	Main Purpose
Bulldozer	11 ton	1	Head Works, Road
Back Hoe	0.6 m^3	1	Head Works, Road, Canal
Dump Truck	6 ton	1	Canal, Road
Motor Grader	2.2 m	1	Road
Road Roller	8 ton	1	Road
Pick-up Truck	2 ton	4	Dam, Head Works, Canal and Office
Auto-bicycle	125 cc	2	Canal
Concrete Mixer	0.5 m^3	1	Canal
Motor Boat	100 HP	1	Dam
Communication System		3	Dam, Head Works and Office

(4) Environment Improvement Cost

The environment improvement cost is the cost to be used for the improvement of the construction sites and their surroundings which will be disturbed and/or demolished with the implementation of the required construction works. This cost is to be allotted locally.

(5) Administration Cost

The administration cost necessary for the operation of the Project Implementation Office involves, procurement of office supplies, payment to the staff, general expenses, etc. The annual administration cost is summed to be 110 x 10^6 S/., and to be allotted locally.

(6) Advance Survey Cost

The advance survey cost involves the topographic survey cost and geological investigation cost necessary for the detailed design of the required facilities. This cost are summed to be 2.59 x 10^9 S/. consisting of 0.49 x 10^9 S/. for topographic survey

and 2.10 x 10^9 S/. for geological investigation. This cost is to be allotted locally.

(7) Consulting Services Cost

The cost for the provision of the consulting services is 23.25 x 10^9 S/. consisting of 7.83 x 10^9 S/. for the detailed design phase and 15.42 x 10^9 S/. for the construction phase. The proportion of the foreign component is 69.7% and local component 30.3% (Table 5.3.3).

Table 5.3.3 Estimated Cost for Consulting Services

(Unit: 10^6 S/.)

Detailed Design Phase			Construction Phase			Total		
Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1,982	5,849	7,831	5,056	10,366	15,422	7,038	16,215	23,253

(8) Project Cost

The total Project Cost is estimated to be 1,397 x 10^9 S/., the foreign component of which represents 268 x 10^9 S/. (19.2%) and local component 1,129 x 10^9 S/. (80.8%). However, the total Project Cost excluding economic contingency is 271 x 10^9 S/. which consists of 203 x 10^9 S/. (75.0%) for the foreign component and 68 x 10^9 S/. (25.0%) for the local component.

Table 5.3.4 Project Cost

(Unit : 10^6 sucre)

Description	L/C	F/C	Total
1. Construction Works	46,596	167,371	213,967
2. Land Acquisition	100	0	100
3. Procurement of O/M Equipment	0	1,104	1,104
4. Environment Improvement	4,279	0	4,279
5. Administration	802	0	802
6. Advance Survey	2,592	0	2,592
7. Consulting Services	7,038	16,215	23,253
Sub-total (1 - 7)	61,407	184,690	246,097
8. Physical Contingency (10%)	6,141	18,469	24,610
Sub-total (1 - 8)	67,547	203,159	270,706
9. Economic Contingency	1,061,307	65,007	1,126,313
Total (1 - 9)	1,128,854	268,166	1,397,020
9' (Economic Contingency)	8,828	65,007	73,834
Total (1 - 9')	76,375	268,166	344,541

Note: Economic contingency in ( ) shows the modified local currency portion based on the economic contingency rate of 1.7% per annum instead of 43.8% which has been obtained in adding the average exchange rate between US$ and Sucre for the past 10 years.

The disbursement of the Project Cost is to be made in 7 years and 6 months. The proportions of the disbursement for each year are 1.3% for the first year, 0.6% for the second, 1.8% for the third, 8.3% for the fourth, 16.2% for the fifth, 34.7% for the sixth, 25.3% for the seventh and 11.7% for the eighth (Table 5.3.5).

Table 5.3.5 Annual Disbursement Schedule

		1	2	3	4	5	6	7	8	(unit 1000 S/.)
I T E M		1996	1997	1998	1999	2000	2001	2002	2003	合計
I. Etapa de Diseno Detallado										
1 Estudio Topografico y Geologico	L/C	2.591.808								2.591.808
	F/C	0								0
	Total	2.591.808								2.591.808
2 Diseno Detallado y Redaccion de Documentos Para Licitacion	L/C	1.387.422	594.609							1.982.031
	F/C	4.094.177	1.754.647							5.848.824
	Total	5.481.599	2.349.257							7.830.855
II. Etapa de Construccion										
1 Expropiacion del Terreno	L/C		50.000	50.000						100.000
	F/C									0
	Total		50.000	50.000						100.000
2 Licitacion y Contrato de Construccion	L/C		421.323	421.323						842.645
	F/C		863.849	863.849						1.727.699
	Total		1.285.172	1.285.172						2.570.344
3 Obras Preparatorias y Camino de Acceso	L/C			1.030.554	687.036					1.717.590
	F/C			4.962.794	3.308.529					8.271.323
	Total			5.993.348	3.995.565					9.988.913
4 Construccion de Presa	L/C					3.375.905	7.291.954	2.835.760		13.503.619
	F/C					19.759.047	42.679.542	16.597.599		79.036.188
	Total					23.134.952	49.971.496	19.433.359		92.539.807
5 Construccion de Canal de Conduccion	L/C				2.258.490	1.505.660	1.505.660	1.505.660	752.830	7.528.299
	F/C				4.139.214	2.759.476	2.759.476	2.759.476	1.379.738	13.797.381
	Total				6.397.704	4.265.136	4.265.136	4.265.136	2.132.568	21.325.680
6 Construccion de Tunel C-4	L/C				918.479	1.396.088	1.102.175	257.174		3.673.917
	F/C				12.053.590	18.321.456	14.464.307	3.375.005		48.214.358
	Total				12.972.069	19.717.545	15.566.483	3.632.179		51.888.275
7 Construccion de Obra de Toma Rio Cariyacu	L/C					339.959	690.221			1.030.180
	F/C					170.885	346.949			517.834
	Total					510.845	1.037.169			1.548.014
8 Construccion de Canal Principal de Riego	L/C				2.821.142	3.103.257	3.103.257	376.152		9.403.808
	F/C				3.148.119	3.462.931	3.462.931	419.749		10.493.730
	Total				5.969.261	6.566.188	6.566.188	795.902		19.897.538
9 Construc. de Canal Secundario y Terciario	L/C						3.675.118	3.675.118	1.837.559	9.187.794
	F/C						2.596.070	2.596.070	1.298.035	6.490.175
	Total						6.271.188	6.271.188	3.135.594	15.677.969
10 Facilidades de Asistencia Agricola	L/C							275.250	275.250	550.500
	F/C							275.250	275.250	550.500
	Total							550.500	550.500	1.101.000
11 Provicion de Equipos para Operacion y Mantenimiento	L/C							0	0	0
	F/C							441.446	662.169	1.103.615
	Total							441.446	662.169	1.103.615
12 Supervision de la Construccion	L/C			421.323	842.645	842.645	842.645	842.645	421.323	4.213.226
	F/C			863.849	1.727.699	1.727.699	1.727.699	1.727.699	863.849	8.638.493
	Total			1.285.172	2.570.344	2.570.344	2.570.344	2.570.344	1.285.172	12.851.719
III. Conservacion del Medio Ambiente	L/C			427.934	855.869	855.869	855.869	855.869	427.934	4.279.344
	F/C			0	0	0	0	0	0	0
	Total			427.934	855.869	855.869	855.869	855.869	427.934	4.279.344
IV. Administracion del Proyecto	L/C	106.653	106.653	106.653	106.653	106.653	106.653	106.653	55.331	801.900
	F/C	0	0	0	0	0	0	0	0	0
	Total	106.653	106.653	106.653	106.653	106.653	106.653	106.653	55.331	801.900
Sub-Total (I ~ IV)	L/C	4.085.882	1.172.585	2.457.786	8.490.314	11.526.036	19.173.551	10.730.281	3.770.227	61.406.661
	F/C	4.094.177	2.618.497	6.690.492	24.377.151	46.201.494	68.036.973	28.192.295	4.479.041	184.690.120
	Total	8.180.059	3.791.081	9.148.279	32.867.465	57.727.530	87.210.524	38.922.575	8.249.268	246.096.781
V. Imprevistos Fisicos (10 %)	L/C	408.588	117.258	245.779	849.031	1.152.604	1.917.355	1.073.028	377.023	6.140.666
	F/C	409.418	261.850	669.049	2.437.715	4.620.149	6.803.697	2.819.229	447.904	18.469.012
	Total	818.006	379.108	914.828	3.286.746	5.772.753	8.721.052	3.892.258	824.927	24.609.678
Sub-Total (I ~ V)	L/C	4.494.471	1.289.843	2.703.565	9.339.345	12.678.639	21.090.906	11.803.309	4.147.249	67.547.327
	F/C	4.503.594	2.880.346	7.359.542	26.814.866	50.821.643	74.840.671	31.011.524	4.926.946	203.159.132
	Total	8.998.065	4.170.189	10.063.107	36.154.211	63.500.283	95.931.577	42.814.833	9.074.195	270.706.459
VI. Imprevistos Economicos (L:43.8 %/Ano) (F: 3.8 %/Ano)	L/C	8.856.170	4.217.832	13.891.390	73.067.551	148.136.755	363.463.736	297.564.017	152.109.467	1.061.306.917
	F/C	533.166	463.406	1.508.700	6.724.879	15.161.071	26.018.757	12.369.449	2.227.093	65.006.522
	Total	9.389.337	4.681.238	15.400.090	79.792.430	163.297.826	389.482.493	309.933.466	154.336.560	1.126.313.439
TOTAL	L/C	13.350.641	5.507.675	16.594.954	82.406.896	160.815.394	384.554.641	309.367.326	156.256.716	1.128.854.244
	F/C	5.036.761	3.343.752	8.868.242	33.539.744	65.982.715	100.859.428	43.380.973	7.154.039	268.165.654
	Total	18.387.402	8.851.427	25.463.197	115.946.641	226.798.109	485.414.069	352.748.299	163.410.755	1.397.019.898
(Imprevistos Economicos) (L: 1.7 %/Ano) (F: 3.8 %/Ano)	L/C	231.742	89.429	236.304	987.934	1.578.106	3.025.979	1.921.553	756.662	8.827.710
	F/C	533.166	463.406	1.508.700	6.724.879	15.161.071	26.018.757	12.369.449	2.227.093	65.006.522
	Total	764.909	552.835	1.745.005	7.712.812	16.739.177	29.044.736	14.291.003	2.983.756	73.834.232
(TOTAL)	L/C	4.726.213	1.379.272	2.939.869	10.327.279	14.256.745	24.116.885	13.724.862	4.903.912	76.375.037
	F/C	5.036.761	3.343.752	8.868.242	33.539.744	65.982.715	100.859.428	43.380.973	7.154.039	268.165.654
	Total	9.762.974	4.723.024	11.808.111	43.867.024	80.239.460	124.976.313	57.105.835	12.057.951	344.540.691

Nota;(Los imprevistos economicos) del componente de moneda local estan modificados debido a la fluctuacion de la tasa de cambio en el futuro, la cual fue estimada en base a las tasas de cambio de los 10 anos anteriores (43.8% a 1.7%)

5.4 OPERATION AND MAINTENANCE

The objective facilities to be operated and maintained in the Project are the Piñán Dam, Cariyacu Head Works, Head Race, Main, Branch and Tertiary Canals, and related facilities. These facilities excluding the Branch and Tertiary Canals shall be operated and maintained by INERHI. On the other hand, the Branch and Tertiary Canals are to be operated and maintained by the water users' associations which will be organized by the beneficiaries. The general guide lines for operation and maintenance of respective facilities are described below:

5.4.1 Operation and Maintenance Method

(1) Dam

The operation and maintenance of the gate equipped with Piñán Dam shall be performed in accordance with the regulations which shall be prepared prior to the operation of the dam. The gate operation shall be performed by the operator staying at the dam site with the instruction from the O/M Office in Ibarra.

For the communication between O/M Office and the Site Office, the wireless telecommunication facilities shall be provided due to the long distance (50 km) and no telephone line between two sites. In addition to the gate operation, observation of the meteorological data such as discharge from the dam, water level of the reservoir, rainfall, river discharge, etc. is required for the proper management of the dam facilities.

(2) Head Works and Head Race

At the Head Works, the operation of both intake and diversion gates shall be made by the operator preferably staying at the site with the instruction from the O/M Office.

The installation of the wireless telecommunication facilities and observation of intake and diversion water volumes, river discharge, etc. are necessary similarly to the case of the dam operation. This operator shall also have the responsibility for the maintenance of the Head Race.

(3) Main Canal

The main work to be done at the Main Canal site is to operate the distribution gates

to the respective Branch Canals. The patrol and maintenance of the Main Canal are also necessary. These operation and maintenance works are to be performed by the person to be dispatched from the O/M Office in Ibarra from time to time in case of necessity.

(4) Branch and Tertiary Canals

The operation and maintenance of the Branch and Tertiary Canals are under the responsibility of the water users' associations to be organized for respective Branch Canals or irrigation blocks. The main works to be done are to operate the distribution gates and maintain the canals.

(5) Operation and Maintenance Road

The access roads to the sites of Dam, Head Works and Head Race, and the construction roads along the Head Race and Main Canal to be constructed before and during the construction of respective works are to be used as the operation and maintenance road after the completion of the construction works. The control and maintenance of these roads are under the direct responsibility of the O/M Office. The damages of the roads shall be repaired immediately when the damages are found out. For this purpose, the O/M equipment shall be procured in advance and maintained all the time.

5.4.2 Operation and Maintenance Agency

INERHI shall have the overall responsibility for the operation and maintenance of the main Project facilities. The O/M Office shall be prepared in the building of INERHI Imbabura Office.

The offices of the water users' associations which shall have the responsibility for the operation and maintenance of the Branch and Tertiary Canals shall be prepared at the respective irrigation blocks.

The main duties of the O/M Office are as follows:

- Operation and maintenance of the main Project facilities
- Maintenance of the O/M road
- Instruction to the water users' association on O/M of the facilities
- Collection of water charge

The required staff members of the O/M Office are as follows:

Table 5.4.1 Required Personnel for Operation and Maintenance

Personnel	Number
Officer in charge	1
Civil Engineer	2
Assistant Engineer	4
Secretary	2
Janitor	1
Driver	1
Operator	3
Assistant Operator	6
Total	20

5.4.3 Operation and Maintenance Costs

The annual operation and maintenance costs are 617 x 10^6 S/. (Table 5.4.2)

Table 5.4.2 Annual Operation and Maintenance Costs

(Unit: 1,000 S/.)

Item	Amount
1. Salary	144,000
2. Repayment of facilities	194,305
3. Cost of equipment and materials	222,581
4. Others	56,089
Total	616,976

Some of the mechanical items and heavy equipment shall be renewed due to their shorter durability than the Project life.

Table 5.4.3 Replacement Cost of Gate (20 years)

(Unit: 1,000 S/.)

Item	Amount
1. Head Race	264,932
2. Main Canal	223,106
3. Branch Canal	237,521
Total	725,559

CHAPTER 6

PROJECT EVALUATION

CHAPTER 6: PROJECT EVALUATION

6.1 EVALUATION BASIS

6.1.1 Evaluation Criteria

The evaluation criteria used for the estimation of financial and economic feasibilities of the Project are as follows:

a. The currency used for the Project evaluation is Sucre (S/.).

b. The life of the Project is set as 60 years from the commencement of the Project.

c. The official exchange rate used for the evaluation is US$1.00 = 1,883 Sucre as of July, 1993.

d. Financial cost of the farm labor is 4,000 Sucre per day determined based on the field survey. Economic cost of the same is 2,252 Sucre converted with a factor of 0.563 for rural unskilled labor force.

e. Water charge is 543,392 Sucre per hectare calculated with the method adopted by INERHI.

f. Economic prices and costs used for the economic calculation are set by using the following conversion factors established by the Ecuadorian government (Metodología y Estimación de los Parámetros Nacionales de Cuenta, Caso: Ecuador, abril de 1993, CONADE).

- Standard Conversion Factor	:	0.72633 for general
- Import Goods	:	1.37045 for chemicals
- Import–Export Goods	:	4.02824 for fruit
- Public Investment	:	0.7745 for public works
- Foreign Loan	:	1.000 for foreign loan
- Rural Unskilled Labor Force	:	0.563 for farm labor
- Total Labor Force	:	0.708 for total labor
- Transport	:	0.7461 for domestic transport
- Foreign Currency	:	1.377 for foreign currency

6.1.2 Prices of Farm Products and Inputs

Farmgate prices for farm products and inputs as of July, 1993 are adopted. The international market prices for the economic calculation are based on the document of World Bank (Price Prospects for Major Primary Commodities, 1990–2005 including Quarterly Review of Commodity Markets, First Quarter 1993).

(1) Farmgate Prices for Farm Products

a. Wheat

The international market price of wheat is US$129 per ton, FOB Gulf. Consequently, economic farmgate price of wheat is estimated at 467,000 Sucre per ton and its financial farmgate price 309,000 Sucre per ton.

b. Kidney bean

Almost all the production of kidney bean is shipped to Colombia and its currency for settling trade accounts is made by local currency under the agreement of Andean countries (Acuerdo de Cartagena). Main market for the products from the Project Area in Colombia is Ipiales market. The market price of kidney bean in Ipiales is 1,295,950 Sucre per ton. Therefore, economic farmgate price of kidney bean is estimated at 1,273,000 Sucre per ton and its financial farmgate price 683,000 Sucre per ton.

c. Fruit

Presently, small amount of peach and apple is imported from foreign countries. Fruit introduced by the Project, such as peach and apple, is expected as export farm products in the future. Accordingly, economic price of fruit (peach and apple) is converted by a factor of 4.02824 (for Import–Export Goods).

Fruit	Financial Price	Economic Price
Peach	S/.1,600,000/ton	S/.6,445,000/ton
Apple	S/.1,200,000/ton	S/.4,834,000/ton

For the farm products except for wheat, kidney bean and fruit, the following financial prices are also used for the economic calculation due to shipping of them to local markets:

–	Maize (seco)	:	S/.573,000/ton
–	Maize (choclo)	:	S/.331,000/ton
–	Potato	:	S/.220,000/ton
–	Tomato	:	S/.400,000/ton
–	Onion	:	S/.300,000/ton
–	Sugarcane	:	S/. 28,000/ton
–	Avocado	:	S/.333,000/ton
–	Alfalfa	:	S/.111,000/ton

(2) Farmgate Prices for Farm Inputs

Economic prices for farm inputs are converted using the conversion factor established by the Ecuadorian government. Since all of the main chemical fertilizers are imported from foreign countries, economic and financial prices of these fertilizers are calculated as follows:

Item	Financial Price (Sucre/ton)	Economic Price (Sucre/ton)
1. Urea	400,000	613,000
2. Fosfato de Amonio	440,000	558,000
3. Muriato de Potasio	368,000	554,000

The prices of agrochemicals (insecticide, fungicide, herbicide, etc.) are obtained from INIAP, BNF, MAG and UCAN (Union de Cooperativas Agropecuarias del Norte). Economic price of these chemicals is converted with a factor of 1.37045 (Import Goods).

6.2 BENEFIT OF THE PROJECT

Benefits of the Project generated by the Project implementation are consist of two categories of benefits; farm production and the operation/maintenance roads along the Main Canals.

The goal of full development of the crop benefit is set at three years after completion of the Project facilities, and in the case of fruit, it is set at respective production years.

Benefit from saving cost of transport is estimated in compliance with the amount of crop production.

6.2.1 Farm Production Benefit

The farm production benefit is constituted by incremental net farm production values brought by the provision of irrigation water and supporting services to the farmers. After completion of the Project facilities, the production plan based on the proposed cropping pattern is to be carried out, and the farm production benefit has been estimated with the confirmation by INERHI.

Farm production benefit based on the agricultural production plan is calculated as shown in Tables 6.2.1 and 6.2.2.

Table 6.2.1 Farm Production Benefit (economic)

(Unit: 1,000 Sucre)

Item	With Project	Without Project	Increased Value
Gross Production Value	222,711,707	11,214,987	211,496,720
Production Cost	17,060,701	3,098,769	13,961,932
Net Production Value	205,651,006	8,116,218	197,534,788

Table 6.2.2 Farm Production Benefit (financial)

(Unit: 1,000 Sucre)

Item	With Project	Without Project	Increased Value
Gross Production Value	104,754,964	10,260,479	94,494,485
Production Cost	18,599,757	3,651,662	14,948,095
Net Production Value	86,155,207	6,608,817	79,546,390

6.2.2 Other Benefits

Other benefits can be defined as the anticipated effect of the O/M roads along the Main Canals.

Table 6.2.3 Anticipated Effect of the O/M Roads

(Unit: Sucre/Year)

Economic Value	Financial Value
15,080,000	20,845,000

6.3 ECONOMIC AND FINANCIAL EVALUATIONS

The Project benefit adopted in the evaluation is the value calculated in Article 6.2. The Project cost is comprised of the costs for construction works, land acquisition, procurement of machinery and equipment for operation and maintenance, environmental preparation, project administration, advance survey, consulting services, and physical and price contingencies. However, price contingency is excluded from the Project evaluation. On-farm improvement works is basically constructed by farmers themselves. Accordingly, the cost required for these improvement works is not included in the Project cost.

6.3.1 Economic Evaluation

(1) Overall Project Cost

1) Project Cost

The Project construction cost is estimated on the basis of prices in July, 1993. Since the construction works are scheduled to be completed within some 8 years, change of prices in future is not considered. For the evaluation, all the construction cost are broken down into two components; foreign costs (foreign currency) and local costs (local currency). The conversion factor for the foreign costs is 1.000 (foreign loan conversion factor). On the other hand, the local financial costs are converted into the economic costs using public investment conversion factor of 0.7745. The economic costs of the Project is estimated as shown in Table 6.3.1.

Table 6.3.1 Project Cost (economic)

(Unit: 10^3 S/.)

Year	Project Cost	Local Currency (L/C)	Foreign Currency (F/C)
1st	7,984,562	3,480,968	4,503,594
2nd	3,879,329	998,983	2,880,346
3rd	9,453,453	2,093,991	7,359,542
4th	34,048,189	7,233,323	48,549,817
5th	60,641,249	9,819,606	76,034,187
6th	91,175,578	16,334,907	46,150,535
7th	40,153,187	9,141,663	12,754,165
8th	8,138,990	3,212,044	4,926,946
Total	255,474,537	52,315,405	203,159,132

2) Operation and Maintenance Costs

Operation and maintenance costs comprise the administrative and general expenditure including salary and wage, costs of equipment repair, maintenance and amortization, and costs of fuel and office maintenance. Economic costs of the operation and maintenance costs are estimated as follows:

Annual operation and maintenance costs: S/.445,488,000

3) Replacement Cost

For the purpose of maintaining the performance of the Project facilities, the replacement of the gates for Head Race, Main Canals and Branch Canals is required. The replacement cost is estimated as follows:

Replacement cost for gates: S/.526,995,000
(Terms of replacement: every 20 years)

(2) Project Justification

1) Economic Internal Rate of Return

The project justification is mainly appraised based on the calculation of economic internal rate of return (EIRR). Additionally, the net present value (NPV) and benefit/cost ratio (B/C) are also taken as economic indicators. The net present value and benefit/cost ratio are calculated using the discount rates of 20%, 22% and 24%.

The results of the evaluation are as follows:

EIRR = 22.9%

Item	Discount Rate		
	20%	22%	24%
N.P.V (1,000 Sucre)	30,892,729	7,807,548	-7,800,429
B/C ratio	1.31	1.08	0.91

The social discount rate of Ecuador is estimated at 14.25%. Consequently, the EIRR of 22.9% shows that the Project is economically feasible.

2) Sensitivity Analysis

Sensitivity analysis is made in the event of variations in prices of farm products, crop yields and escalation of construction costs. The results are shown in Table 6.3.2.

Table 6.3.2 Sensitivity Analysis

Case	EIRR (%)
1. Original	22.9
2. Price/Yield of Farm Products	
10% of decline/decrease	21.7
3. Production Costs	
10% of increases	22.7
4. Construction Costs	
10% of increase	21.9
5. Delay of Production Target	
1 year	20.8
2 years	19.2
6. Combination of 2 and 4	20.7

6.3.2 Financial Evaluation

(1) Overall Project Cost

1) Project Cost

Table 6.3.3 Project Cost (financial)

(Unit: 1,000 Sucre)

Year	Product Cost	Local Currency (L/C)	Foreign Currency (F/C)
1st	8,998,065	4,494,471	4,503,594
2nd	4,170,189	1,289,843	2,880,346
3rd	10,063,107	2,703,565	7,359,542
4th	36,154,211	9,339,345	26,814,866
5th	63,500,282	12,678,639	50,821,643
6th	95,931,577	21,090,906	74,840,671
7th	42,814,833	11,803,309	31,011,524
8th	9,074,195	4,147,249	4,926,946
Total	270,706,459	67,547,327	203,159,132

2) Operation and Maintenance Costs

Annual operation and maintenance costs: S/.616,976,000

3) Replacement Cost

Replacement cost for gates: S/.725,559,000
(Terms of replacement: every 20 years)

(2) Project Justification

1) Financial Internal Rate of Return

FIRR = 14.5%

Item	Discount Rate		
	12%	14%	16%
N.P.V (1,000 Sucre)	52,597,971	8,703,448	-18,110,453
B/C	1.35	1.06	0.86

2) Sensitivity Analysis

Table 6.3.4 Sensitivity Analysis

Case	EIRR (%)
1. Original	14.5
2. Price/Yield of Farm Products	
10% of decline/decrease	13.6
3. Production Costs	
10% of increases	14.3
4. Construction Costs	
10% of increase	13.7
5. Delay of Production Target	
1 year	13.4
2 years	12.5
6. Combination of 2 and 4	12.8

6.3.3 Cash Flow Analysis

The Project financing plan and cash flow analysis of the model farmers are made as follows:

(1) Project Financing Plan

The Project cost including physical contingency allowance is comprised of foreign and local currency components. The annual disbursement schedule of the Project Cost is as shown in Table 6.3.5.

Table 6.3.5 Disbursement Schedule

(Unit: 1,000 Sucre)

Year	Project Cost	L/C	F/C
1st (1996)	8,998,065	4,494,471	4,503,594
2nd (1997)	4,170,189	1,289,843	2,880,346
3rd (1998)	10,063,107	2,703,565	7,359,542
4th (1999)	36,154,211	9,339,345	26,814,866
5th (2000)	63,500,282	12,678,639	50,821,643
6th (2001)	95,931,577	21,090,906	74,840,671
7th (2002)	42,814,833	11,803,309	31,011,524
8th (2003)	9,074,195	4,147,249	4,926,946
Total	270,706,459	67,547,327	203,159,132

The foreign currency component of the Project cost is to be financed by the loan from an international financing institution, and the local currency component by the Ecuadorian government.

The repayment schedule of foreign currency loans is estimated based on the following conditions:

- Interest per annum : 3.0%
- Grace period : 10 years
- Loan period : 30 years
- Repayment period : 20 years (annual repayment in ad-on system)

The maximum annual repayment of foreign loans including related interest is 15,948 million Sucre.

The repayment schedule for foreign currency loans is shown in Table 6.3.6.

Table 6.3.6 Repayment Schedule

(Unit: 1,000 S/.)

Year	Foreign Loan	Accumulated Foreign Loan	Interest Payment	Capital Repayment	Total Repayment
1	4,503,594	4,503,594	135,108		135,108
2	2,880,346	7,383,940	221,518		221,518
3	7,359,542	14,743,482	442,304		474,677
4	26,814,866	41,558,348	1,246,750		1,952,754
5	50,821,643	92,379,991	2,771,400		4,233,780
6	74,840,671	167,220,662	5,016,620		5,618,296
7	31,011,524	198,232,186	5,946,966		5,991,837
8	4,926,946	203,159,132	6,094,774		6,130,562
9			6,076,607		6,130,562
10			6,076,607		6,130,562
11			5,790,035	10,157,957	15,947,992
12			5,485,297	10,157,957	15,643,254
13			5,180,558	10,157,957	15,338,515
14			4,875,819	10,157,957	15,033,776
15			4,266,342	10,157,957	14,424,299
16			4,266,342	10,157,957	14,424,299
17			3,961,603	10,157,957	14,119,560
18			3,656,864	10,157,957	13,814,821
19			3,352,126	10,157,957	13,510,083
20			3,047,387	10,157,957	13,205,344
21			2,742,648	10,157,957	12,900,605
22			2,437,909	10,157,957	12,595,866
23			2,133,171	10,157,956	12,291,127
24			1,828,432	10,157,956	11,986,388
25			1,523,694	10,157,956	11,681,650
26			1,218,955	10,157,956	11,376,911
27			914,216	10,157,956	11,072,172
28			609,478	10,157,956	10,767,434
29			304,739	10,157,956	10,462,695
30			0	10,157,956	10,157,956

(3) Water Charges and Share of the Project Cost

According to the law of Ecuador, the benefitted farmers in the Project Area are required to bear the Project cost and the cost for operation and maintenance of irrigation facilities as water charge.

The water charge comprises two components; basic component and volumetric component. Basic component is a fixed charge to recover 75% of the Project investment over a period of fifty years. Annual charge of the basic component is

estimated at 473,594 Sucre per hectare. Volumetric component is a charge necessary for the operation and maintenance of irrigation facilities, and it is estimated at 112.92 Sucre per cubic meter. It is equivalent to 545,553 Sucre/ha/year.

(4) Financial Analysis of Model Farmers

In order to justify the financial viability of the Project at a farm level, the model farmers of small and medium-scales in the Project Area have been selected and financial analysis of these farmers has been made. These model farmers are determined on the basis of the results of the farm survey conducted by the Study Team and the study by PROTECA of DPA-Imbabura, MAG.

The features of the model farmers are summarized in Table 6.3.7.

Table 6.3.7 Model Farming Pattern

Model Farmer	Area (ha)	Cultivated Crop	Actual Situation 1st S.	Actual Situation 2nd S.	With Project 1st S.	With Project 2nd S.
1	1.0	Maize	1.0		0.5	
		Potato			0.5	
		Vegetable				1.0
2	3.0	Maize	1.0		1.0	
		Potato	1.0		0.5	
		Kidney bean	1.0			1.5
		Vegetable			0.5	0.5
		Alfalfa			(1.0)	(1.0)
		Fruit			1.0	1.0
3	10.0	Maize	3.0		2.0	
		Potato	3.5		2.0	
		Wheat				2.5
		Kidney bean	3.5		2.5	4.0
		Vegetable			1.5	1.5
		Alfalfa			(2.0)	(2.0)
		Fruit			2.0	2.0

Note: 1st S. = 1st semester
2nd S. = 2nd semester

The calculation of the farm household economy of the model farmers is made on the basis of the following conditions: