3-4 Salinity Control

3-4-1 General management practices for salt accumulated soils

The major objective of management of practices for salt accumulated soils is to improve soil moisture availability to crops. General management practices include:

a) increased irrigation frequency to maintain a more adequate soil moisture supply to crops;

b) routine use of extra water to satisfy leaching requirements;

c) selection of irrigation methods which provide better salt control;

d) cultivation of salt tolerant crops;

e) implementation of cultivating practices such as presowing irrigation and adequate seed placement to ensure good germination;

f) improvement of soil drainability;

g) reducing concentration of accumulated salts by leaching;

h) improvement of drainage conditions; and

i) application of chemical amendments.

Of these, d) and e) are commonly practiced in the Project area. g), h) and i) are drastic practices to improve salt accumulated soils, and implementation of the same is proposed for the Project.

3-4-2 Countermeasures for improvement of salt accumulated areas

(1) Basic countermeasures

In the project area, two types of salt accumulated soils are distributed. Different countermeasures are proposed for the improvement of each type of salt accumulated soil as follows:

1) 1st type; salt accumulated soils in poorly drained ares

Improvement measures to be taken include; i) lowering of subsurface water level by drainage improvment, ii) desalinization by leaching, and iii) application of chemical amendments (in case of saline - alkali soil).

2) 2nd type; salt accumulated soils in areas with good drainage conditions

Measures to be taken for improvement consist of desalinization by leaching.

(2) Basic principles for desalinization

For the formulation of desalinization measures, the following issues should be taken into account.

a) Desalinization measures should not include any extended interruption in cropping.

b) The surface layer should be desalinized to a permissible level as soon as possible so as to make annual crop planting possible. Major root zones should be desalinized to a permissible level by the time growing roots reach the same.

c) Irrigation practices such as presow wetting and application of water satisfying leaching requirement should be practiced to supplement leaching operations and to ensure desalinization.

d) In orchards, desalinization should be achieved in a short period.

3-4-3 Proposed plan for desalinization

(1) Proposed areas for desalinization plan

The proposed areas for the desalinization plan are the salt accumulated areas distributed in the drainage improvement study areas delineated by PLANREHATIC and in Hattillo. It is proposed, however, that the salt accumulated areas of salinity class S1 (ECe of surface layer, 0-15cm, is 4-8ms/cm) should be desalinized by irrigation practices before sowing and/or after harvesting. For this reason, desalinization of these areas is not included in the present plan. The proposed areas for the desalinization plan are shown in Table 3-4-1.

Table 3-4-1 PROPOSED AREAS FOR DESALINIZATION PLAN

Areas	Salinity classes S2	S3	S3N1	Remarks
1. Drainage improvement study areas	ha	ha	ha	1st type 2/
Donoso/Quincha 1/	273	-	524	
Boza	15	61	69	
San Luis	168	-	82	
Lunavilca	50	-	-	
Palpa	30	-	-	
Total	536	61	675	
2. Hattillo	-	160	-	2nd type B 3/

1/ salt accumulated areas with good drainage conditions distributed on slightly sloping land are not included.

2/ 1st type: salt accumulated soils in poorly drained areas

3/ 2nd type B: salt accumoulated soils with good drainage conditions distributed in Hattillo

* The soil salinity maps of the major drainage improvement study areas are presented in Annex C.

(2) Proposed desalinization mesures

Desalinization measures for achievement of target ECe values in three years are proposed as follows:

1) 1st type: salt accumulated soils in poorly drained areas

1st year 1st step: removal of accumulated salts by initial furrow flooding

3rd year 2nd step: presow furrow irrigation
3rd step: continuous leaching by irrigation water

* The 2nd and 3rd step could be performed by ordinary irrigation practices.

** Drainage improvement should be implemented prior to commencement of desalinization.

The target ECe in the final year is;

soil depth 0 - 50cm < 4ms/cm
soil depth 50 - 100cm < 8ms/cm

2) 2nd typeB: salt accumulated soils in Hattillyo

1st year 1st step: removal of accumulated salts by initial ponding
2nd step: presow furrow irrigation
3rd step: continuous leaching with irrigation water

2nd, 3rd year 1st step: Presowing furrow irrigation
2nd step: continuous leaching by irrigation

Leaching on and after the 2nd step of the 1st year should be performed by ordinary irrigation practices.

The target ECe in the final year is;

soil depth 0 - 30cm < 4ms/cm
soil depth 30 - 100cm < 8ms/cm.

(3) Criteria of desalinization

1) Salt accumulation status of top soil in actual situation:

1st type (Depth of top soil: 0 -- 15cm)

S_2 : 10ms/cm
S_3 : 30 -- 40ms/cm
S_3N_1 : 30 -- 40ms/cm

2nd type (Depth of top soil: 0 -- 30cm)

S_3 : 30ms/cm

2) Required inundation depth for desalinization necessitating to desalinize as far as $4m^S/cm$ on the ECe level of top soil.

1st type

Salt accumulation status	Water requirement in depth - ponding - (cm)	Desalinization efficiency	Water requirement in depth - furrow - (cm)
S_2	30	60 --70%	45
S_3, S_3N_1	60	"	90

2nd type

50

water requirment in depth -ponding- 50 cm

(4) Leaching requirements

Total area of 1,432 ha. including salinity class S_2 (ECe 8-5m mhos/cm) and S_3 (ECe 15m mhos/cm) is necessary to remove salinity for crop cultivation. Leaching requirements of salinity class S_2 and S_3 are 30cm and 60cm, respectively. (Refer to Table 3-4-2)

Soil type	Area (ha.)	Concerned area
1st Type	1,272	Donoso, Quincha, Boxa, Luonavilca
2nd Type B	160	San Luis, Palpa and El Hatillo
Total	1,432	

When durations to be necessary for leaching are 3 years for 1st type and one year for 2nd t B, allocation of leaching requirements are shown in the following table.

Table 3-4-2 ALLOCATION OF LEACHING REQUIREMENTS

(Unit: thousand m^3)

	Leaching duration			
Soil Type	First year	Second year	Third year	Total
1st type	3,765	3,766	3,766	11,297
2nd type B	1,000	-	-	1,000
Total	4,765	3,766	3,766	12,297

(5) Available water amount for leaching

Available water amount for leaching is river discharge during wet season from February to June. Leaching should be commenced just before sowing of crop seed and it is considered to be appropriate that commencement of leaching for cotton is from May to June because taking into accouont the relation between river discharge and irrigation water demand as indicated below, available water amount for leaching will be around 15,621 thousand cubic meters per year.

(Unit: thousand m^3)

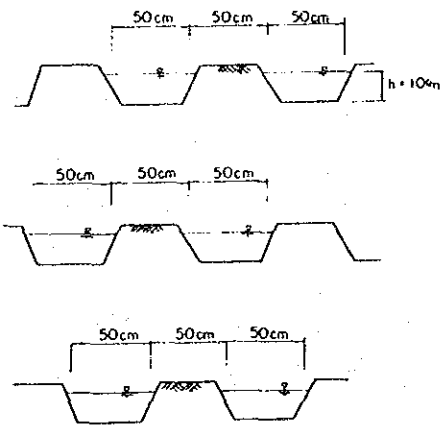
	May	June	July	Total
River discharge in 1/10 dry year	14,899	11,166	9,234	35,299
Irrigation water demand	9,656	5,479	4,545	19,680
Available water amount for leaching	5,243	5,687	4,689	15,621

Leaching requirements in El Hatillo can be supplied by surplus infiltrated water as El Hatillo area is irrigated by infiltrated water from upstream area.

(6) *Leaching method on farm*

Leaching by controlled flooding is the most effective method for leaching in each farm lot. However, leaching by controlled flooding seems to be difficult for undulated area or farm land cultivated by furrow. Therefore, leaching by controlled flooding between furrows is adopted for the project except El Hatillo area which is flat area. (Refer to Fig.3-4-1)

Fig.3-4-1 Leaching method



(Furrow)

Leaching water amount per year

S_2 ... 1,500m^3/ha.

S_3 ... 3,000m^3/ha.

Depth of leaching water

S_2 ... 30cm

S_3 ... 60cm

In case that depth of leaching water is 10cm for one time, leaching water amount =500m^3/ha.

In case that in-flow water amount to farm lot is 15 liter/second, leaching hour for one time = 500 ÷ (0.015 x 3,600) = 9.3hr/ha.

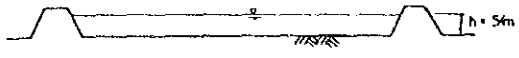
Accordingly, leaching water with depth of 10cm should be applied in the area of S_2 with three times during May to July, six times for area of S_3. This procedure should be repeated every year for three years.

When the furrow lay up in ridges, the alternation of shift its position every year should be considered.

It is necessary to mix by stirring mold and to carefully plow before furrowing.

In order to prevent outflow from the furrow to downstream, it must be made short furrow.

(Ponding method)



Leaching water amount per year

S_3 ... 5,000m^3/ha.

In case that depth of leaching water is 10cm for one time, leachingwater amount = 500m^3/ha.

When in-flow water amount to farm lot is 15 liter/second leaching hour for one time = 500 ÷ (0.015 x 3,600) = 9.3 hr/ha.

This procedure should be repeated 10 times a year.

(7) Chemical amendment requirement

Chemical amendments (gypsum) required for improving sodicity of saline-alkai soils (salinity calss S_3N_1) are estimated as follows:

1) Amount of gypsum required per ha

exchangeable-Na to be replaced by Ca ..... 1.0meq/100.soil gypsum requirement/ha to replace exchangeable-Na 1.0meq/100g.soil in the surface layer (0-15cm) 2.8t/ha.15cm

2) Total amount of gypsum required

2.8t/ha x 675ha (surface coverage of saline-alkali soils in the project area : S_3N_1 = 1,890 t

In total, about 1,900t of gypsum are required. It is recommended that the same be applied prior to the initial leaching operation of the first year. Applied gypsum should be thoroughly incorporated with surface soils.

3-4-4 Countermeasures to control salt accumulation

Salt accumulation is generally directly dependent on water management; irrigation, leaching and drainage as salts move with water. Therefore, primary measures to control future salt accumulation consist of the following irrigation and drainage practices:

a) satisfaction of leaching requirement;

b) irrigation before-sowing or after-harvesting to leach accumulated salts during cropping season;

c) improvement of drainage conditions; and

d) control of excess seepage loss by water management.

3-4-5 Recommendations

The desalinization plan proposed in the present study has been formulated based on the results of a limited number leaching tests. As field leaching tests are fundamental to desalinization plans, it is recommended that leaching tests be performed in the field and that desalinization measures and water requirement be studied in detail, similar field tests are required for estimation of the gypsum requirement.

Table 3-4-3 Leaching Water Requirements

Block	Salinity Class	Area (ha)	Net Leaching Water Requirement (cm)	Field Leaching Water Requirements in Depth (cm)	Field Leaching Water Requirements in Volume ($X10^3 m^3$)	Conveyance efficiency (%)	Gross Leaching Water Requirements ($X10^3 m^3$)	Leaching Method
DONOSO/QUINCHA	S_2	273	30	45	1,229			Furrow
	S_3	524	60	90	4,716			
	Sub-Total	797			5,945		7,431	
BOZA	S_2	15	30	45	68			"
	S_3	130	60	90	1,170			
	Sub-Total	145			1,238	80	1,548	
LUNAVILCA	S_2	50	30	45	225			"
	Sub-Total	50			225	80	281	
SANLUIS	S_2	168	30	45	756			"
	S_3	82	60	90	738			
	Sub-Total	250			1,494	80	1,868	
PALPA	S_2	30	30	45	135			"
	Sub-Total	30			135	80	169	
EL HATILLO	S_3	160	50	50	800			Flooding
	Sub-Total	160			800	80	1,000	
TOTAL	S_2	536			2,413			
	S_3	896			7,424			
	Total	1,432			9,837	80	12,297	

CHAPTER 4. AGRICULTURAL DEVELOPMENT PLAN

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4-1 Basic Conceptions

The Project aims at an increase in crop production, and its stability thereby improvement of the farmer's living standard in the project area by removing existing constaints in agriculture and farm management. The Project is also designed to contribute to the national economy. To this end, the basic conceptions for agricultural development plan of the Project are:

- To intensify land utilization to correspond with the improvement of irrigation and drainage facilities.

- To increase land productivity through the introduction of appropriate rotation systems.

- To increase crop yields.

- To establish rotation systems and scheduled cropping and increase cropping intensity.

- To increase maize production in order to contribute to the improvement of self-supply of agricultural products.

- To plan production increases of cotton.

- To plan production of vegetables and other food crops in order to help meet the demands of the Lima Metropolitan area.

- To restrict the area of fruit to the present level so as to place emphasis on production increase of other food crops.

- To plan production increase of beans to correspond with the government policy.

- To aim at the stability and improvement of production and farm management based on adequate crop rotation systems.

- To plan the intensification of farming in terms of farm scales, and ensure sufficient returns from farming even in the small scale farmers.

- To plan for stability and increases in crop yields by the improvement of farming practices.

4-2 Land Utilization Plan

Present patterns for perennial crop productions and annual crop productions in the project area will be maintained under the land utilization plan. However, small patches of swampy grass and fallow lands will be utilized for annual crop production parallel to the progress of the present rehabilitation project.

For annual crop production, intensive land utilization and improvoement of land productivity both based on rotation systems are planned in the proposed cropping plan. The utilization of the salt accumulated poorly drained area is also examined in the proposed cropping plan.

The proposed land utilization patterns at full develeopment are shown in Table 4-2-1.

Table 4-2-1 PROPOSED LAND UTILIZATION PATTERNS OF ARABLE LAND

Land utilization patterns	Area (ha)	Change in Area (ha)
Perennial crop production	6,530 (32.3%)	0
Annual crop production	13,670 (67.7%)	+620 (+4.8%)
Total	20,200 (100%)	

* Increase are from the present level.

4-3 Crop Production Plan

4-3-1 Selection of crops

The annual crops to be produced in the Project has been determined taking into account; i) the basic conception, ii) present cropping conditions, iii) intention of farmers, iv) cultivation technique of farmers, v) importance of crops, and vi) profitability.

a) The present major crops in the project area, namely, cotton, maize and vegetables have been selected as the principal crops in the proposed cropping pattern.

b) The cultivation of beans is envisaged to be incorporated in the crop rotation system with the principal crops.

c) In the proejct area, many kinds of vegetables are presently cultivated. In the proposed plan, however, only the cultivation of major begetables such as choclo, tomato, kidney bean, cabbage and carrot, which hold on important positions in the Lima market and have relatively stabilized market prices are planned.

d) The introduction of leguminuous green manure crops into the rotaiton system with the principal crops is planned in order to maintain and improve land productivity.

e) Cultivation of chala is less profitable while the same can be replaced by foliages of maize and choclo. Therefore, cultivation of chala is not included in the proposed plan.

4-3-2 Basic principles for cropping plan

The cropping plan is formulated according to the following basic principles:

a) The intensification of land utilization and the resultant increase in cropping intensity should be aimed at.

b) The Project will be designed to formulate cropping patterns in which the cultivation of economically important principal crops is the nucleus of the whole scheme. All crops except fruit would be cultivated under the rotation systems.

c) The cropped area of cotton should be maintained at the present level. A production increase in proportion to yield increase is aimed at the same.

d) The strengthening of maize cultivation is planned by allocating additional cropped area in order to increase maize production.

e) The present cropping conditions of fruit are maintained. A production increase and improvement of qualities are aimed at.

f) The annual cropped area of vegetables is planned to be kept at the present level and year-round cultivation is projected. Schedculed cropping and improvement of the marketing system are prerequiste for successful handling of increased production anticipated by the implementation of the Project.

g) The cropped area of potato is maintained at the present level. A production increase in proportion to yield increase is expected.

h) The introduction of beans into the rotation system of principal crops is proposed with a view to increase production of staple foods promoted by the government and to improve soil conditions.

i) In the poorly drained salt accumulated area, the rotation system of cotton-green manure crop-maize is adopted. The first crop after the commencement of desalinization should be cotton and salt torelant varieties of maize should be planted afterwards.

4-3-3 Proposed cropping patterns and cropping plan

Based on the land utilization plan and the basic principles, the cropping pattern has been formulated as shown in Fig.4-3-1. The following table outlines the proposed cropping pattern.

PROPOSED CROPPING PATTERN

Cropping pattern/rotation system	Area (ha)	%
Cotton - beans - maize	5,660	28
Cotton - green, manure crop - maize	5,660	28
Potato/vegetables - vegetables	900	5
Vegetables -vegetables	1,450	7
Fruit	6,530	32
Total	20,200	100

The proposed annual cropping plan corresponding to the proposed cropping pattern is tabulated at Table 4-3-1.

Substantial increase in cropping intensity is projected from the present 23,480ha to the future 28,935ha or an increase of 5,455ha (about 23% of the present cropped area), which are equivalent to the present 116% to 143% under the Project. The increase in cropping intensity and cropped area is mainly attributable to the intensification of land utilization.

4-3-4 Target yields and anticipated crop production

(1) Target yields

With the completion of the rehabilitation Project, crop yields will be increased and stabilized through improvement of irrigation and drainage facilities, renovation of farming practices and strengthening of agricultural supporting systems. The projected target yields at full development are assumed based on yield level of the successful farmers in the project area and the yield level of the existing similar project (Canete Project) as shown in Table 4-3-2.

In order to attain the projected target yields at a possible earlier stage, it is essential to improve the present farming practices and agricultural supporting systems. However, the farmers in the project area have; i) adequate experience in irrigation farming, and ii) chances to observe the farming practices of successful farmers. Therefore, it would not take long for the farmers to improve farming practices. The target yields are then assumed to be attained in 5 years. The crop yields during the build-up period are assumed as shown in Table 4-3-3.

(2) Anticipated crop production

The anticipated annual crop production is estimated in Table 4-3-4. The annual crop production at the full development are estimated at about; i) cotton 22,600 tons, ii) maize 39,600 tons, iii) fruit 108,700 tons, iv) vegetables 76,900 tons, v) beans 3,700 tons, and vi) potato 9,900 tons.

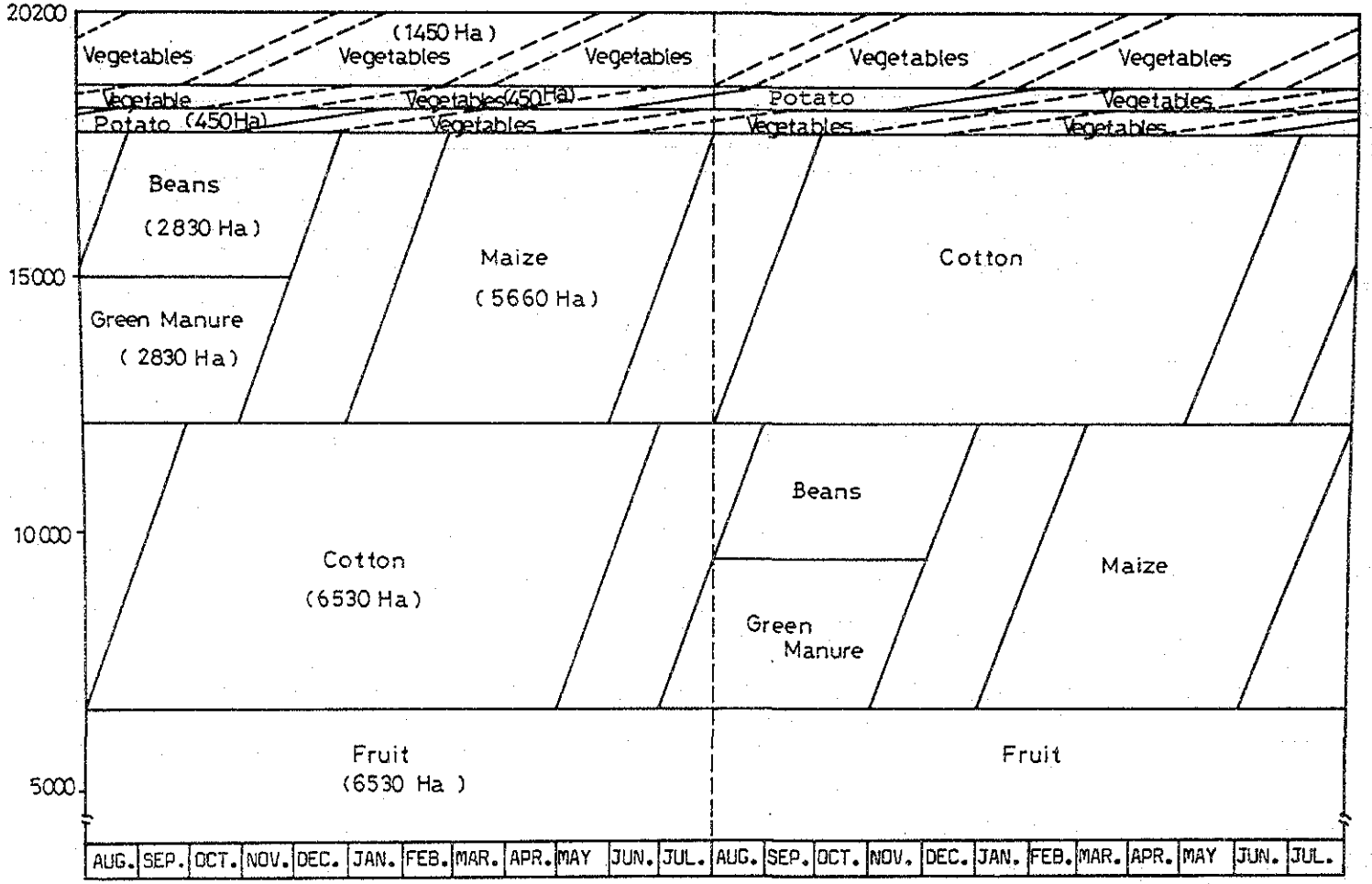


Fig. 4-3-1 Proposed Cropping Pattern (Whole Project Area)

Table 4-3-1 Proposed Cropping Plan by Irrigation Block

	Left Bank (Upper)		Left Bank (Lower)		Right Bank (Upper)		Right Bank (Central)		Right Bank (Lower)		Total	
	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Cotton	690	(20)	1,130	(21)	250	(5)	2,280	(26)	1,310	(21)	5,660	(19.5)
Maize	690	(20)	1,130	(21)	250	(5)	2,280	(26)	1,310	(21)	5,660	(19.5)
Potato	75	(2)	75	(2)	-		150	(2)	150	(2)	450	(1.5)
Beans (Frijol Seco)	460	(14)	450	(9)	125	(2.5)	1,140	(13)	655	(10)	2,830	(10.0)
Vegetables	600	(18)	1,225	(23)	-		1,200	(14)	1,950	(31)	4,975	(17.0)
Fruit	640	(19)	590	(11)	4,360	(85)	630	(7)	310	(5)	6,530	(22.5)
Green Manure	230	(7)	680	(13)	125	(2.5)	1,140	(13)	655	(10)	2,830	(10.0)
Total (ha)	3,385	(100)	5,280	(100)	5,110	(100)	8,820	(100)	6,340	(100)	28,935	(100)
Cultivable Area(ha)	2,320		3,400		4,860		5,790		3,830		20,200	
Cropping Intensity	146%		155%		105%		152%		167%		143%	

Table 4-3-2 Target Yields of Crops

Crop	With Project 1/ (kg/ha)	Present/without (kg/ha)	Rate of Increase (%)	successful Farmer 2/ (Huaral) (kg/ha)	Canete 3/ (kg/ha)
Cotton	4,000	2,700	148	5,500	3,680
Maize	7,000	4,500	156	8,000	5,000
Potato	22,000	15,000	147	30,000	20,000
Beans (Frijo/seco)	1,300	1,000	140	1,300	1,200
Tomato	25,000	17,000	147	33,000	25,000
Cabbage	25,000	17,000	147	30,000	-
Maize Choclo	13,000	9,000	144	15,000	10,000
Kidney bean(Vanita)	6,000	4,000	150	8,000	5,000
Cauliflower	25,000	17,000	147	28,000	-
Apple	14,000	10,500	133	16,000	-
Orange	23,000	18,000	128	30,000	15,000
Mandarin	26,000	20,000	130	35,000	-
Passion fruit	15,000	10,000	150	-	-
Grape	9,000	6,000	150	12,000	8,000

1/ target yield at full development

2/ average yield level obtained by successful farmers in the Project area

3/ average yield in Canete Project

Table 4-3-3 Crop Yields during the Build-up Period

Crop	Present/Without	With Project				
		1st Year	2nd Year	3rd Year	4th Year	5th Year
Cotton	2,700	2,900	3,200	3,400	3,700	4,000
Maize	4,500	4,900	5,400	5,900	6,500	7,000
Potato	15,000	16,200	17,500	18,900	20,400	22,000
Beans (Frijol Seco)	1,000	1,050	1,100	1,200	1,250	1,300
Tomato	17,000	18,000	20,000	21,500	23,000	25,000
Cabbage	17,000	18,000	20,000	21,500	23,000	25,000
Maize Choclo	9,000	9,700	10,400	11,200	12,000	13,000
Kidney bean (Vanita)	4,000	4,300	4,700	5,100	5,500	6,000
Cauliflower	17,000	18,000	20,000	21,500	23,000	25,000
Apple	10,500	11,100	11,800	12,500	13,200	14,000
Orange	18,000	18,900	19,800	21,100	22,000	23,000
Mandarin	20,000	21,100	22,200	23,400	24,700	26,000
Passion fruit	10,000	10,800	11,800	12,800	13,800	15,000
Grape	6,000	6,500	7,100	7,700	8,300	9,000

Table 4-3-4 Anticipated Crop Production

(unit: M.T.)

Crop	Present	With Project				
		1st Year	2nd Year	3rd Year	4th Year	5th Year
Cotton	14,310	16,414	18,112	19,244	20,942	22,640
Maize	17,325	27,734	30,564	33,394	36,790	39,620
Potato	13,500 3/	7,290	7,875	8,505	9,180	9,900
Beans (Frijol Seco)	900	2,972	3,113	3,396	3,538	3,679
Tomato	8,500	11,250	12,500	13,438	14,375	15,625
Cabbage	10,200	9,000	10,000	10,750	11,500	12,500
Maize Choclo	4,500	8,730	9,360	10,080	10,800	11,700
Kidney bean(Vanita)	2,800	3,010	3,290	3,570	3,850	4,200
Cauliflower	6,800	5,400	6,000	6,450	6,900	7,500
Other Vagetable 1/	18,900	18,915	20,280	21,840	23,400	25,350
Vegetables - Total	51,700	56,305	61,430	66,128	70,825	76,875
Apple	17,640	18,648	19,824	21,000	22,176	23,520
Orange	27,900	29,295	30,690	32,550	34,100	35,650
Mandarin	11,400	11,970	12,650	13,340	14,100	14,820
Passionfruit	5,500	5,940	6,490	7,040	7,590	8,250
Grape	2,100	2,275	2,485	2,695	2,905	3,150
Others	15,550	17,751	19,032	20,496	21,960	23,332
Fruit Total	80,095	85,879	91,171	97,121	102,831	108,722

1/ Calculated with caigua 2/ Calculated with avocado 3/ Production of Tuber Crops

4-4 Farm Management Plan

4-4-1 Proposed farming practices

To realize increased agricultural potential by the improvement of irrigation and drainage facilities, the improvement of farming practices should be achieved through the strengthening of agricultural supporting systems. The introduction of farming practices formulated on the basis of the present farming practices as well as the farming practices of successful farmers in the project area is proposed (Refer to Annex E-2-5 (1)).

4-4-2 Proposed farming operation systems

(1) Farming operation systems

The proposed farming operation systems correspondent to the proposed cropping pattern and farming practices are shown in Fig.4-4-1 and Fig.4-4-2. In the formulation of the farming operation systems, the following conditions of the project area have been taken into consideration and drastic changes in the farming operation systems are avoided:

a) There exist surplus labor in the urban areas;

b) Sufficient migrant laborers are employed every year during the harvesting period of cotton; and,

c) Rapid farming mechanization is difficult judging from availability of funds by farmers.

(2) Future farm labor balance

Study on the balance between available labor and labor requirement for the proposed cropping pattern and farming operation systems are shown in Table 4-4-1 and Fig.4-4-3. Available labor are estimated based

on the number of farm households in rural areas. The number of farm households in urban areas are excluded from the calculation because the actual figures are unknown. As the result of the study, labor deficits are indicated in the said Table in May and June during the harvesting season of cotton and maize. For the following reasons, however, the proposed cropping pattern is possible in terms of the future labor balance:

a) Farm households in urban areas are not considered in the study of the labor balance;

b) Considerable proportion of cotton harvesting are presently carried out by migrant laborers from the mountain areas; and,

c) Considerable surplus labor exists in the urban areas.

With the intensification of land utilization and agriculture under the Project, the annual labor requirement will increase from the present 2,250,000 man/days to 2,440,000 man/days in the future. The increase in labor opportunities of 195,000 man/days per year is expected under the Project.

(3) Future farm machinery balance

The number of farm tractors required in each month under the proposed cropping pattern and farming operation systems are presented in Table 4-4-2. According to the calculations therein, the peak period of tractor use occurs from July to August.

As the result of the studies on annual tractor balance, the following countermeasures are proposed in order to make the proposed cropping pattern practicable:

a) Maintenance systems of farm tractors should be strengthened so as to improve the rate of operation. In concrete terms, maintenance and repair of tractors should be done during the period of low

demand for tractor use, especially February to April, and the rate of operation should be increased to arouond 100% during the peak period of tractor use;

b) The system of tractor use should be formulated in order to ensure the intensified tractor use during the peak period;

c) The tractor hiring service systems in which most of the tractors possessed in the project area is involved should be formulated; and,

d) If tractors possessed by fruit producers are not used for services, a deficit of tractors will occur. In this case, the establishment of financial supporting services for the procurement of tractors by farmers' groups and/or the establishment of tractor hiring service center are proposed.

4-4-3 Proposed farming pattern

Based on the basic conceptions of farm management plan, the proposed cropping pattern and farming operation systems, the farming patterns corresponding to farming scales are proposed as set in below.

1) Farming scale less than 1.5ha

- proposed farming patterns

vegetables in rotation (2.5crops/year)
poteto-vegetables rotation system (4 crops/2 years)

2) Farming scale 1.5 to 3.0ha

- proposed farming patterns

cotton-beans or green manure crop-maize rotation system (2-year rotation) + vegetables in rotation

cotton-beans or green manure crop-maize rotation system + potato-vegetables rotation system

3) Farming scale 3.0 to 6.0ha

- proposed farming patterns

cotton-beans-maize rotation system + cotton-green manure crop-maize rotation system

cotton-beans or green manure crop-maize rotation system + vegetables or potato-vegetables rotation system

4) Farming scale over 6.0ha

Farm households with farming scale over 6.0ha enjoy relatively stable farm management at present. The farming patterns which combine 2 rotation systems; i) cotton-beans-maize; and ii) cotton-green, manure crop-maize, are proposed for farming scale over 6.0ha. The introduction of green manure crops is recommended to improve soil conditions.

5) Fruit producers

The farming scale of fruit producers in the project area is generally large and stable farm management is the norm. Therefore, the continuation of the present farming pattern is proposed. Increased production and improvement of quality of products will be achieved with the improvement of irrigation water supply and farming practices, and the establishment of stabilized profitable farm management is expected.

4-5 Anticipated Production Increase

4-5-1 Crop production under without-project conditions

Crop production in the area is primarily governed by the condition

of irrigation water supply and accordingly the increase of crop productivity will not be expected without the improvement of irrigation and drainage facilities. While the water management system and the O&M systems of irrigation facilities in the area are relatively well organized, further strengthening of the management systems of both irrigation water and facilities is required to ensure the present condition of irrigation water supply. In the poorly drained area, continued efforts in farm management is also imperative. It is projected that further countermeasures including O&M aspects will be adopted even if the present Project is not implemented and that the crop production of the present level will be maintained.

4-5-2 Anticipated production increase

The anticipated production increase under the Project are presented in Table 4-5-1. At the full development stage, the production increases of; i) cotton 8,330t, 58%, ii) maize 22,295t, 129%, iii) fruit 28,627t, 35%, iv) vegetables 25,175t, 49%, and, v) beans 2,779t, 309%, are expected.

4-6 Recommendation

In the implementation of the proposed cropping pattern, shortage of tractors is apprehended. Joint ownership and tractor hiring system are presently common in the project area, however, strengthening of supporting systems are recommended. To this end, the following activities should be considered:

a) establishment of a tractor hiring service center with repairing function of farm machinery; and,

b) financial supporting service for procurement of farm machinery by individual and farmers' groups.

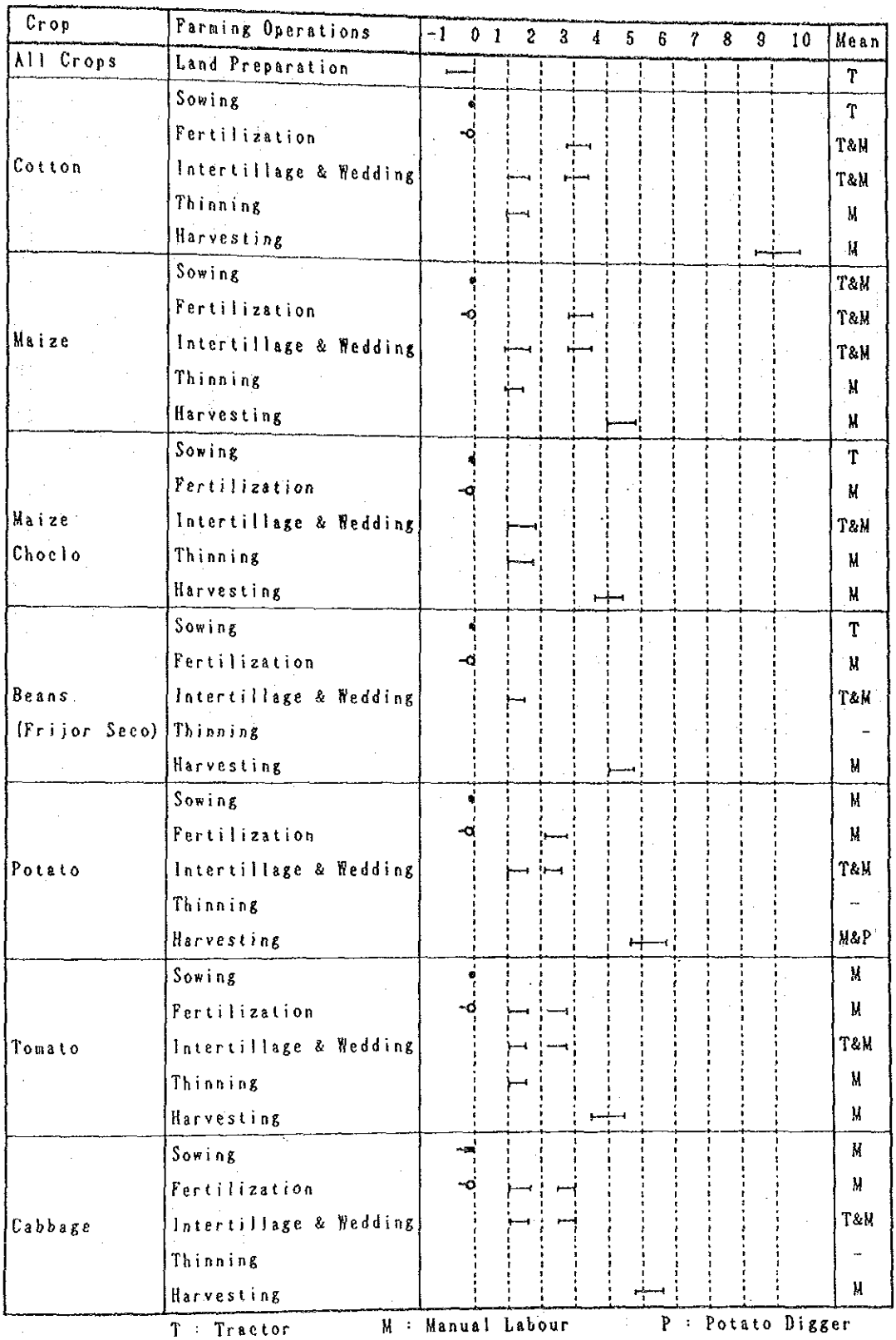
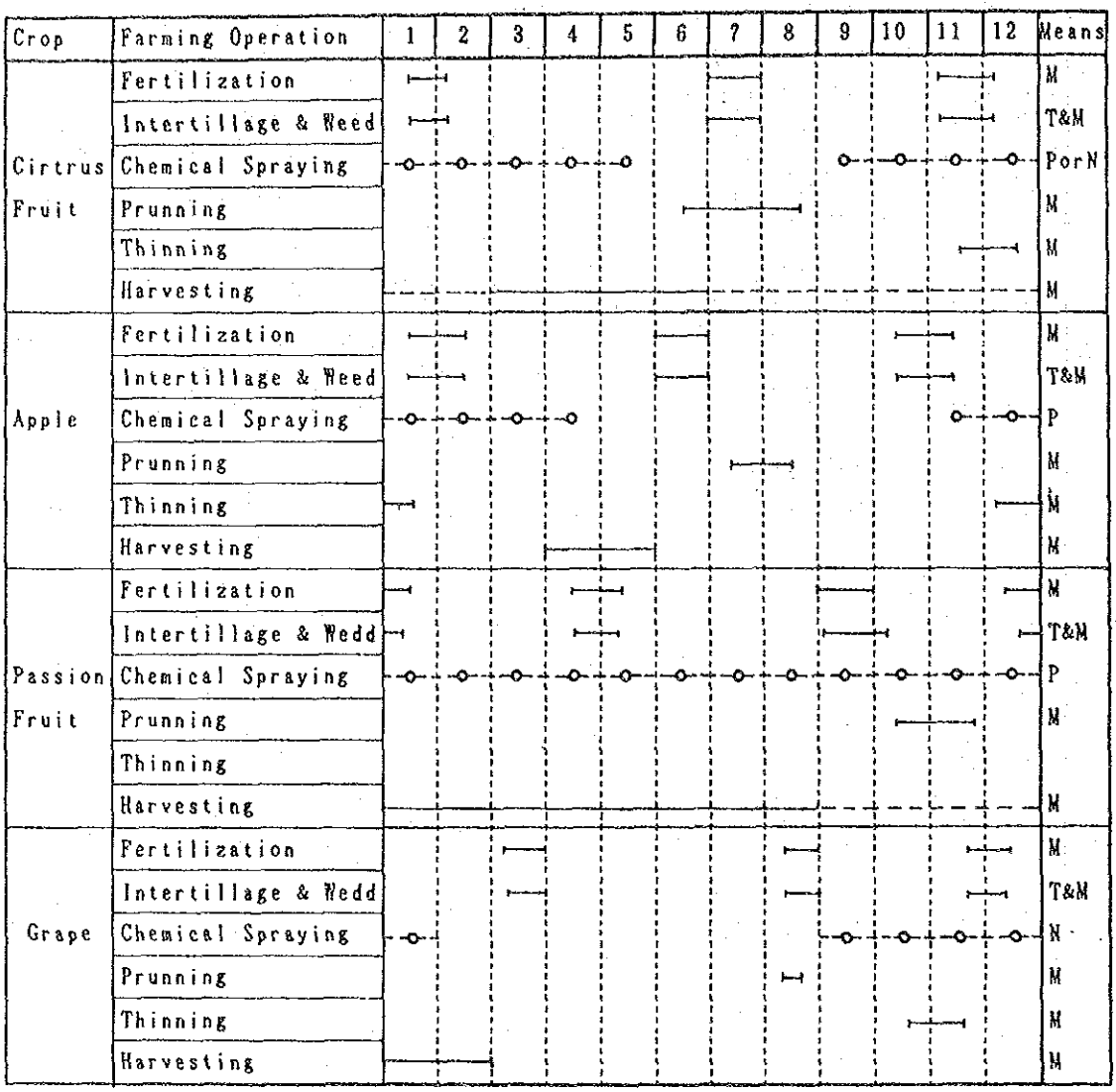


Fig. 4-4-1 Proposed Farming Operation System



M : Manual Labour

T : Tractor

P : Power Splayer

N : Napsack Type Splayer

Fig. 4-4-2 Proposed Farming Operation System

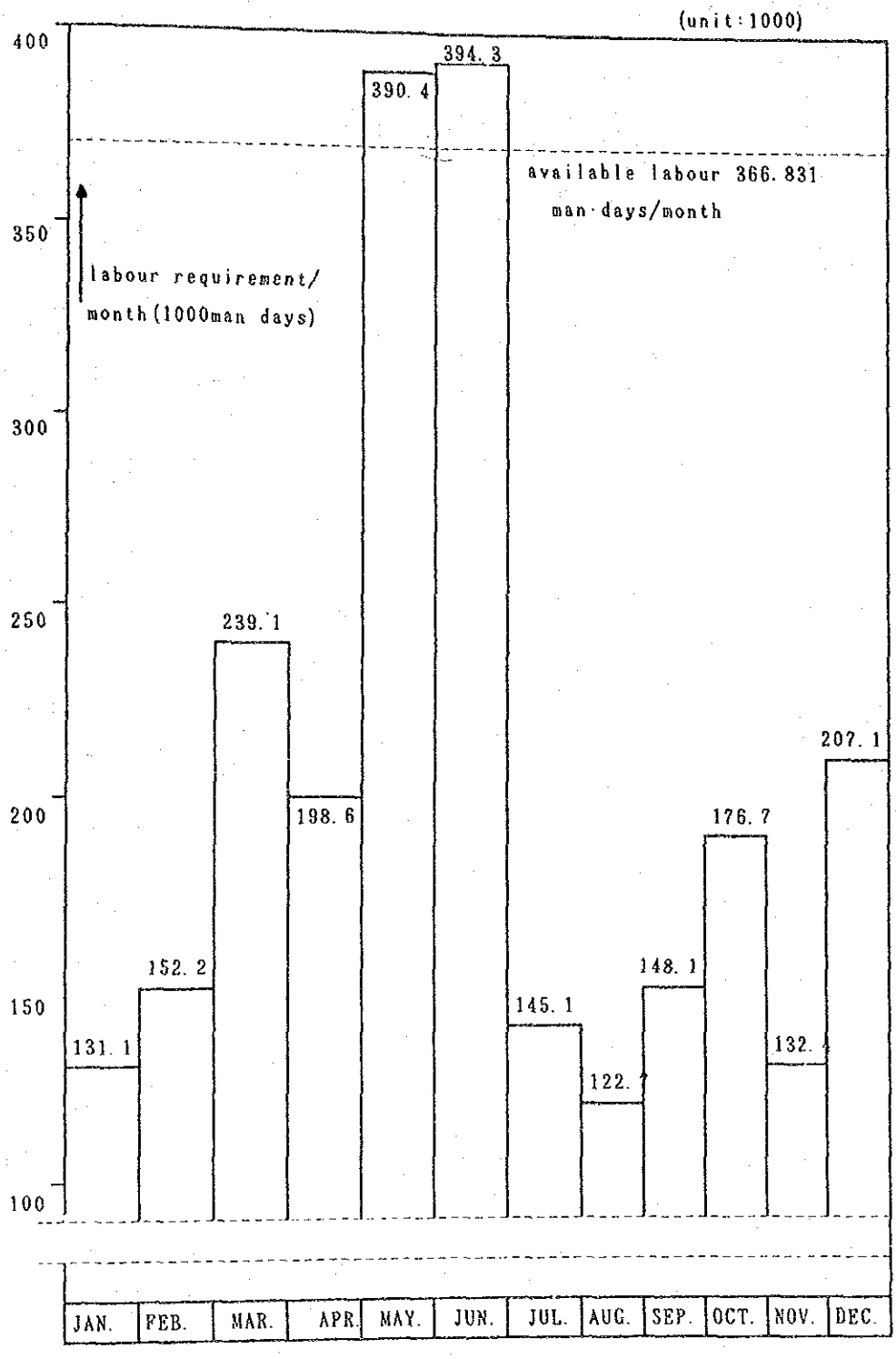


Fig. 4-4-3 Future Farm Labour Balance

Table 4-4-1 Future Farm Labor Balance

(Unit: Mon - Day)

	TERMS	AREA	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL
1.	Labor Requirement	per ha									(Unit man.days)				
	Cotton	1	4.8	2.8	2.8	2.8	28.8	28.8	1.8	3.0	6.0	9.8	8.8	5.8	106
	Maize	1	5.5	12.75	9.75	2.25	3.25	7.5	7.5				3.0	5.5	58
	Beans(Frijol Seco)	1							6.0	5.0	7.5	7.5	1.0	12.0	39
	/1 Potato & Vegetables	1	9.95	9.4	10.5	7.5	7.25	11.9	17.4	10.5	5.4	4.8	8.0	7.6	107
	/2 Vebetagles	1	16.15	10.8	23.84	31.68	34.51	16.1	11.57	26.38	30.73	36.35	10.51	20.18	268.8
	/3 Fruit	1	6.35	6.35	23.85	23.85	23.83	23.85	6.35	6.35	6.35	6.35	6.35	6.35	146
	Green Manure	1						1.0	1.0	1.0	1.0	1.0			
2.	Total Labor Requirement										(Unit 1000 man.days)				
	Cotton	5,560	26.7	15.6	15.6	15.6	160.1	160.1	10.0	16.7	33.4	54.5	49.0	32.2	589.5
	Maize	5,560	30.6	70.9	54.2	18.1	18.1	41.7	41.7				16.7	30.6	322.6
	Beans	2,780							16.7	13.9	20.9	20.9	2.7	66.7	141.8
	Potato + Vegetables	900	8.9	8.5	9.5	6.8	6.5	10.7	15.7	9.5	4.9	4.3	7.2	6.8	99.3
	Vegatables	1,450	23.4	15.7	4.1	2.4	50.0	23.3	16.8	38.3	44.6	52.7	15.2	29.3	315.8
	Fruit	6,530	41.5	41.5	155.7	155.7	155.7	155.7	41.5	41.5	41.5	41.5	41.5	41.5	954.8
	Green Manure	2,780						2.8	2.8	2.8	2.8	2.8			14.0
	Total Labor Requirement		131.1	152.2	239.1	198.6	390.4	394.3	145.2	122.7	148.1	176.7	132.3	207.1	2,437.8
3.	Available Labor		366.8	366.8	366.8	366.8	366.8	366.8	366.8	366.8	366.8	366.8	366.8	366.8	4,401.6
4.	Balance (3-2)		235.7	214.6	127.7	168.2	-23.6	-27.5	221.6	244.1	218.7	190.1	234.5	159.7	1,963.8
5.	Surplus Ratio(%)		64	59	35	46	-6	-7	60	67	60	52	64	44	45

Available Labor: 4,413 (Farm Household) x 3.5 (Average Available Labor Per Farm Household) x 25 days x 0.95 (estimated accident and sickness rate at 5%) = 366,831 man days (per month)

/1 : Calculated with potato and vegetables (Choclo) 2.0 croppings per year
/2 : Calculated with tomato and cabbage, 2.5 croppings per year
/3 : Calculated with orange

Table 4-4-2 Farm Tractors Required Under the Project

Crops	(2)	(3) Number of Tractors Required per Day in Each Month											
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
Cotton	8 hrs x 25 days							127	168	127	127	56	14
	9 hrs x 27 days							105	139	105	105	46	12
Maize	8 hrs x 25 days	84	21	28	7								84
	9 hrs x 27 days	69	17	23	6								69
Beans	8 hrs x 25 days						49	49	42				
	9 hrs x 27 days						40	40	35				
Potato	8 hrs x 25 days	7				18	18	36	18	15		9	7
	9 hrs x 27 days	6				15	15	30	15	12		8	6
Vegetables 1/	8 hrs x 25 days	18	21	12	41	41	41	14	27	27	29	35	47
	9 hrs x 27 days	15	17	10	34	34	34	12	22	22	24	29	39
Fruit 2/	8 hrs x 25 days	32	32	32	32	32	32	32	32	32	32	32	32
	9 hrs x 27 days	26	26	26	26	26	26	26	26	26	26	26	26
Green Manure	8 hrs x 25 days					49	49	29					
	9 hrs x 27 days					40	40	24					
Total	8 hrs x 25 days	141	74	72	80	140	189	287	287	201	188	132	184
	9 hrs x 27 days	116	70	59	66	115	155	237	237	165	155	109	152

1/ Calculated with tomato and cabbage, 2.5 croppings per year

2/ Calculated with orange

Basis for calculation:

(1) Tractor operation hours per ha (hrs/ha) x monthly operation area (cropped area, ha) = monthly operation hours required (hrs/month)

(2) Monthly operation hours/tractor (hrs/month tractors) = monthly working days (days/month) x working hours per day (hrs/day)

(3) Number of tractors required per day (units/day) = (1) ÷ (2)

Table 4-5-1 Anticipated Production Increase

	Without Project	With Project													
		1st Year			2nd Year			3rd Year			4th Year			5th Year		
	Production M.T	Production M.T	Increase M.T	1/ (%)	Production M.T	Increase M.T	1/ (%)	Production M.T	Increase M.T	1/ (%)	Production M.T	Increase M.T	1/ (%)	Production M.T	Increase M.T	1/ (%)
Cotton	14,310	16,414	2,104	(15)	18,112	3,802	(27)	19,244	4,934	(34)	20,942	6,632	(46)	22,640	8,330	(58)
Maize	17,325	27,734	10,409	(60)	30,564	13,239	(76)	33,394	16,069	(93)	36,790	19,465	(112)	39,620	22,295	(129)
Potato	13,500	7,290	-6,210	(-40)	7,875	-5,625	(-42)	8,505	-4,995	(-37)	9,180	-4,320	(-32)	9,900	-3,600	(-27)
Beans (Frijol Seco)	900	2,972	2,072	(230)	3,113	2,213	(246)	3,396	2,496	(277)	3,538	2,638	(293)	3,679	2,779	(309)
Tomato	8,500	11,250	2,750	(32)	12,500	4,000	(47)	13,438	4,938	(58)	14,375	5,875	(69)	15,625	7,125	(84)
Cabbage	10,200	9,000	-1,200	(-12)	10,000	-200	(-2)	10,750	550	(5)	11,500	1,300	(13)	12,500	2,300	(23)
Maize Choclo	4,500	8,730	4,230	(94)	9,360	4,860	(108)	10,080	5,580	(124)	10,800	6,300	(140)	11,700	7,200	(160)
Kidney bean (Vanita)	2,800	3,010	210	(7.5)	3,290	490	(18)	3,750	950	(34)	3,850	1,050	(38)	4,200	1,400	(50)
Cauliflower	6,800	5,400	-1,400	(-21)	6,000	-800	(-12)	6,450	-350	(-5)	6,900	100	(1.5)	7,500	700	(10)
Other Vegetables	18,900	18,915	15	(13)	20,280	1,380	(7)	21,840	2,940	(16)	23,400	4,500	(24)	25,350	6,450	(34)
Vegetables Total	51,700	56,305	4,605	(89)	61,430	9,730	(19)	66,128	14,428	(28)	70,825	19,125	(37)	76,875	25,175	(49)
Apple	17,640	18,648	1,008	(5.7)	19,824	2,184	(12)	21,000	3,360	(19)	22,176	4,536	(26)	23,520	5,880	(33)
Orange	27,900	29,295	1,395	(5)	30,690	2,790	(10)	32,550	4,650	(17)	34,100	6,200	(22)	35,650	7,750	(28)
Mandarin	11,400	11,970	570	(5)	12,650	1,250	(10)	13,340	1,940	(17)	14,100	2,700	(24)	14,820	3,420	(30)
Passion Fruit	5,500	5,940	440	(8)	6,490	990	(18)	7,040	1,540	(28)	7,590	2,090	(38)	8,250	2,750	(50)
Grape	2,100	2,275	175	(8)	2,485	385	(18)	2,695	595	(28)	2,905	805	(38)	3,150	1,050	(50)
Others	15,555	17,751	2,196	(14)	19,032	3,477	(22)	20,496	4,941	(32)	21,960	6,405	(41)	23,332	7,777	(50)
Fruits Total	80,095	85,879	5,784	(7)	91,171	11,076	(14)	97,121	17,026	(21)	102,831	22,736	(28)	108,722	28,627	(36)

1/ Increase in production compared with that of without project conditions

CHAPTER 5. INFRASTRUCTURE

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5-1 Outline of infrastructure

The majority of infrastructures planned for use in the project will be executed by rehabilitation of existing structures. The project area is already cultivated. Accordingly, infrastructures including irrigation facilities have been established. However, these facilities insufficient in number and the majority are superannuated to fulfill their function. Deterioration is particularly evident in intakes and certain portions of the canals. For effective use of water resources, reduced maintenance cost and to increase productivity of appropriate crops, therefore, rehabilitation of existing facilities is planned along with construction of new structures. Items of the rehabilitation and construction plan of this Project are tabulated below.

Table 5-1-1 INFRASTRUCTURE PLAN

Description	Facilities	Number
Intake facilities	With weir	2
	With partial weir	5
	Collecting conduit	1
Canal works	Rehabilitation of irrigation canals	162.4 km
	Newly construction of irrigation canals	12.6 km
	Rehabilitation of drainage canals	22.6 km
	Newly construction of drainage canals	47.4 km
Reservoirs	Rehabilitation of reservoirs	13
	Newly construction of reservoirs	5
Roads and bridges	Main roads	49 km
	Secondary roads	125 km
	Bridge rehabilitation on the Chancay river	2
	Small scale bridges over canals	253
Drainage improvement facilities	Pipe drainage system	2,180 ha
	Flood protection Levee	13.5 km

5-2 Intake Facilities

There are 17 intakes in total,8 intakes for the right bank and 9 intakes for the left bank of the project area. Of these, 4 intakes are concrete structures and others are natural open intakes (only excavated in the river). These intakes are damaged by scour, wash away or fill up with deposit during floods while necessitating repairs or excavation of training levees in the dry season to maintain intake level. Rationalization of the intake system by rehabilitation and combining of two or three intakes is therefore necessary to stabilize intake and reduce maintenance costs.

5-2-1 Rehabilitation and integration plan

In formulating an intake rehabilitation and combination plan, 5 alternatives were examined from technical and economical standpoint of view as follows:

- Unification at geologically and topographically stable place to intake water

- Unification for proper water management and operation and maintenance

- Unification for better use of recycle water resources, such as available collection return flow and groundwater of the river at lower zone of the project area

- Economical standpoint of view

Case 1 All existing intakes will be rehabilitated at their present locations.

Case 2 Theintake will be unified Cuyo (16km upstream from the Esperanza intake) due to its geological and topographically stability and feasibility for installation of a both side intake.

Case 3 4of large scale intakes (Q>1.0 m^3/sec.) in the upstream area will be rehabilitated in their present locations while small-scale intakes located in the downstream area will be combined into 5 intakes. A total of 9 intakes will be combined and rehabilitated.

Case 4 Three intakes, Esperanza, Huando and Chancay-Huaral, will be unified into one diversion at Palpa. In this case, a connecting canal is necessary for abolished intakes. Small-scale intakes located in the downstream area will also be integrated into one intake on the right bank and one intake on the left bank. A total of 3 diversions will thus be proposed.

Case 5 The Esperanza diversion will be unified with the Palpa intake, while the Chancay-Haural diversion will be combined with the Huando diversion. In this case, the connecting canal (L=5.6 km) will be necessary. In the downstream, small-scale intakes will be reconstructed or combined into 2 on the right bank and 3 on the left bank, amounting to a total of 7 diversions or intakes. Location of the diversions in this case are shown in Fig.5-2-1.

The study results of the above mentioned 5 alternatives are as follws;

Case 1 Although water rights complications are avoided by this alternative, the number of intakes is still so many, and the maintenace cost is higher than that of the other cases.

Case 2 The cost for construction of the connecting canal is excessive and this alternative is not considered to be economically viable.

Case 3 Same as in case 1, maintenance cost is too high and not economically viable.

Case 4 Construction cost of the connecting canal (including the tunnel, between Esperanza and Huando L=2.5km) is too high. Moreover, if 3 existing diversions are combined at Palpa, the total intake capacity of the canal should be 10.73m^3/sec. In this cace, intake width shall be required about 43 m and sediments in the canal would be increased due to the lack of balance between riverbed and canal bed. Therefore, this unification plan is not adequate. As for integration of 2 intakes in the lower stream, water management would also be difficult.

Case 5 Integration of the Esperanza diversion at Palpa and Chancay Huaral at Huando can allow to take stable water.

The small scale intakes downstreams (2 on the right bank and 3 on the left bank) are situated in the most effective location in terms of return flow. In addition, Case 5 is of the most economical construction cost.

Table 5-2-1 COMPARISON OF CONSTRUCTION COST

(unit price US$)

Description	Case 1	Case 2	Case 3	Case 4	Case 5
Rehabilitation cost of diversion weir	5,600,000	1,910,000	4,720,000	2,580,000	3,600,000
Construction cost for connecting canal	0	5,450,000	340,000	3,160,000	850,000
Total	5,600,000	7,360,000	5,060,000	5,740,000	4,450,000

Based on the evaluation, therefore, Case 5 is recommended for the Project. Moreover, in addition to the rehabilitation plan, collecting conduit will be set up in the Boza Alto area to collect the under flow water of the Chancay River, as run off water of the river during the dry season is low.

The location and intake water amount of integrated intakes and collecting conduit are shown in Table 5-2-2.

Table 5-2-2 LOCATION AND INTAKE WATER AMOUNT FOR INTEGRATED INTAKE

Integrated intake	Location	Intake water amount (m^3/sec)
Palpa & Experanza	Palpa	2.56 (Palpa)
		3.51 (Esperanza)
Huando & Chancay-Huaral	Huando	7.22
Slinas Alto	Salinas Alto	0.26
Salinas Bajo	Salinas Bajo	0.16
Boza Alto	Boza Alto	0.54
Boza Bajo	Boza Bajo	0.46
Pasamayo Bajo	Pasamayo Bajo	0.44
Boza collecting conduist	Boza Alto	0.1

5-2-2 Weir structure plan

(1) Design flood discharge

A design flood discharge of 450 m^3/sec with an estimated probability of 50 years will be applied for the diversion wier design, while past maximum flood discharge is 480 m^3/sec.

(2) Geological Condition

Seismic survey was conducted at Palpa and Huando diversion sites where new diversion weirs will be proposed. The stratum is divided into three classes, namely, soil stratum where Vp=0.43-0.73km/sec, alluvium stratum where Vp=2.21-2.51 km/sec and bedrock stratum where Vp=4.29-5.24 km/sec.

Depth of soil stratum ranges from 2-4 m , alluvium stratum from 20-60 m and bedrock from 20-100 m. A diorite outcrop occurs at the

diversion intake and the dense alluvium stratum underlying the riverbed is expected to provide adequate structural support.

(3) Structure

a) Type of intake

Although the slope of the Chancay River is comparatively steep, between 1/60 and 1/80, considerablly meandering in the river course due to the shallow riverbed. Moreover, the amount of suspended substance with diameters ranging from 0.5m to fine silt is large. Generally, the normal diversion method under such conditions is the mountain torrent type (Example; Tirol type, Scoope type etc.); however, the same which is not suitable in consideration of flow conditions in the Chancay River, as the following reasons.

- Although riverbed slope is comparatively steep, there is no platform in the area for the mountain torrent type.

- Riverbed of the Chancay River is shallow, and the river channel is frequently meandering in the river course.

- Flow with a large amount of suspended substance debris flow occurs over along period resulting in sedimentation at the intake mouth.

- During the dry season, the entire river flow must occasionally be diverted to obtain sufficient water for irrigation.

For the above reasons, the intake at Palpa and Huando will consist of permanent weir which will raise the intake water level. A sand sluiceway will also be installed on the intake gate side to maintain the river course and reduce sediment deposit in the intake mouth. As for the Palpa diversion wier, intake structure will be installed on both the Palpa and Esperanza side. Construction of partial weir is necessary for other small-scale intakes as the design intake water amount is less than 0.7 m^3/sec.

These intake structures comprising a partial weir, sand sluiceway and intake gate are shown in Fig.5-2-1.

b) Design

i) Permanent weir

The permanent weir will made of concrete. As the foundation rock lies at 50 to 100m below the riverbed, a floating type permanent weir will be designed. After study of the most effective hydrodynamic section, apron length and piping, the weir section will be designed according to the Bligh's formula. The downstream apron will be the water cushion type to reduce the impact of stones and water energy flow.

PROFILE OF PERMANENT WEIRS

Diversion weir	Height of Back water (m)	Length of Fixed weir (m)	Overflow head (m)	Depth of overflow (m)
Palpa - Esperanza	1.70	100	1.75	1.30
Huando - Chancat	2.00	140	1.50	1.20
Small-scale Intake	1.00	30	-	-

ii) Sand sluiceway

The width of the sand sluiceway gate is designed at 3m to flush away deposits of 0.1m diameter in normal discharge (7.8 m^3/sec.) and deposits of 0.3m diameter during floods (16.8 m^3/sec). This width also permits manual operation. Two or three gates will be installed, the number being related to the intake width.

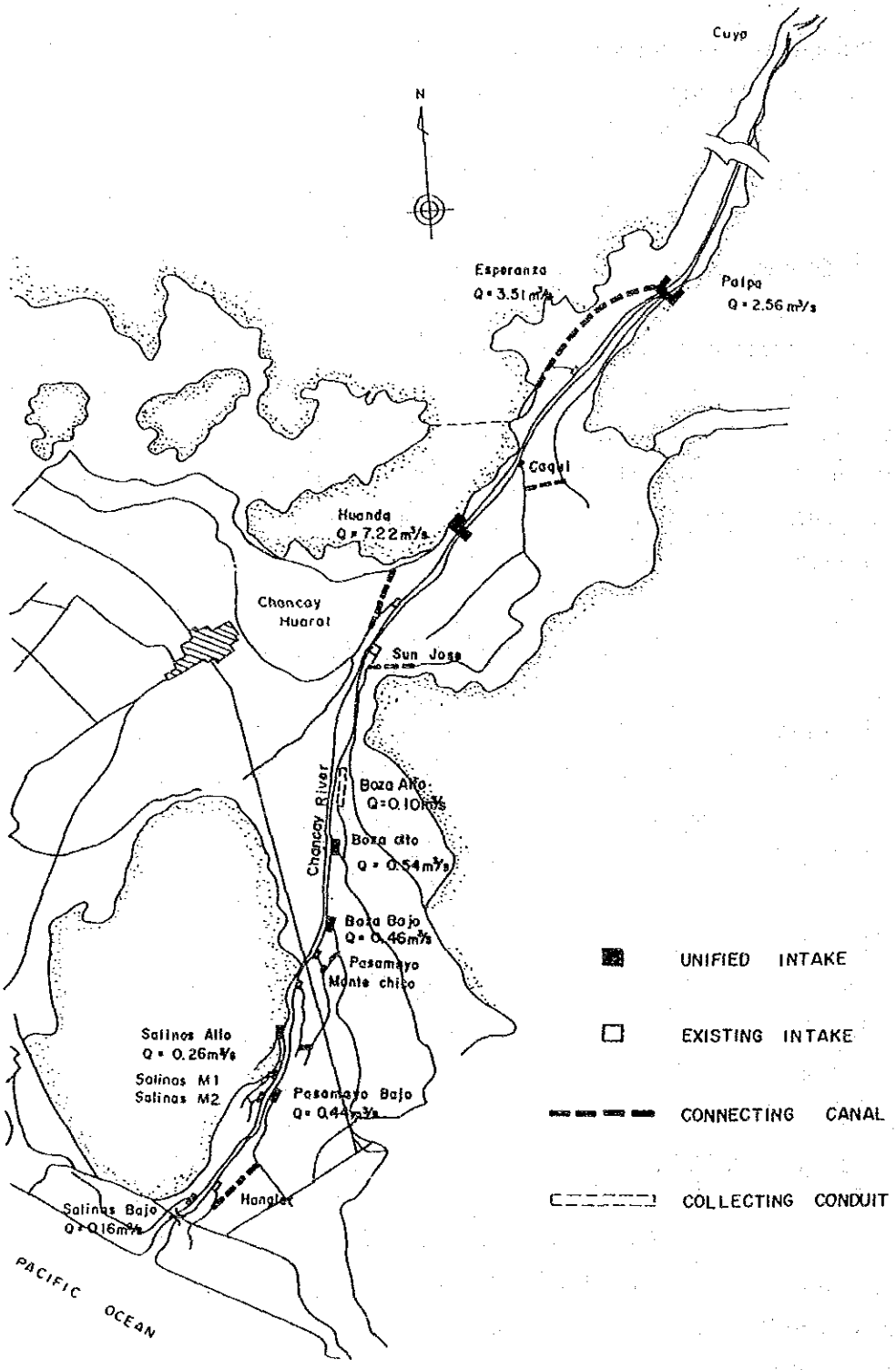

Fig. 5-2-1 Proposed Intake Facilities

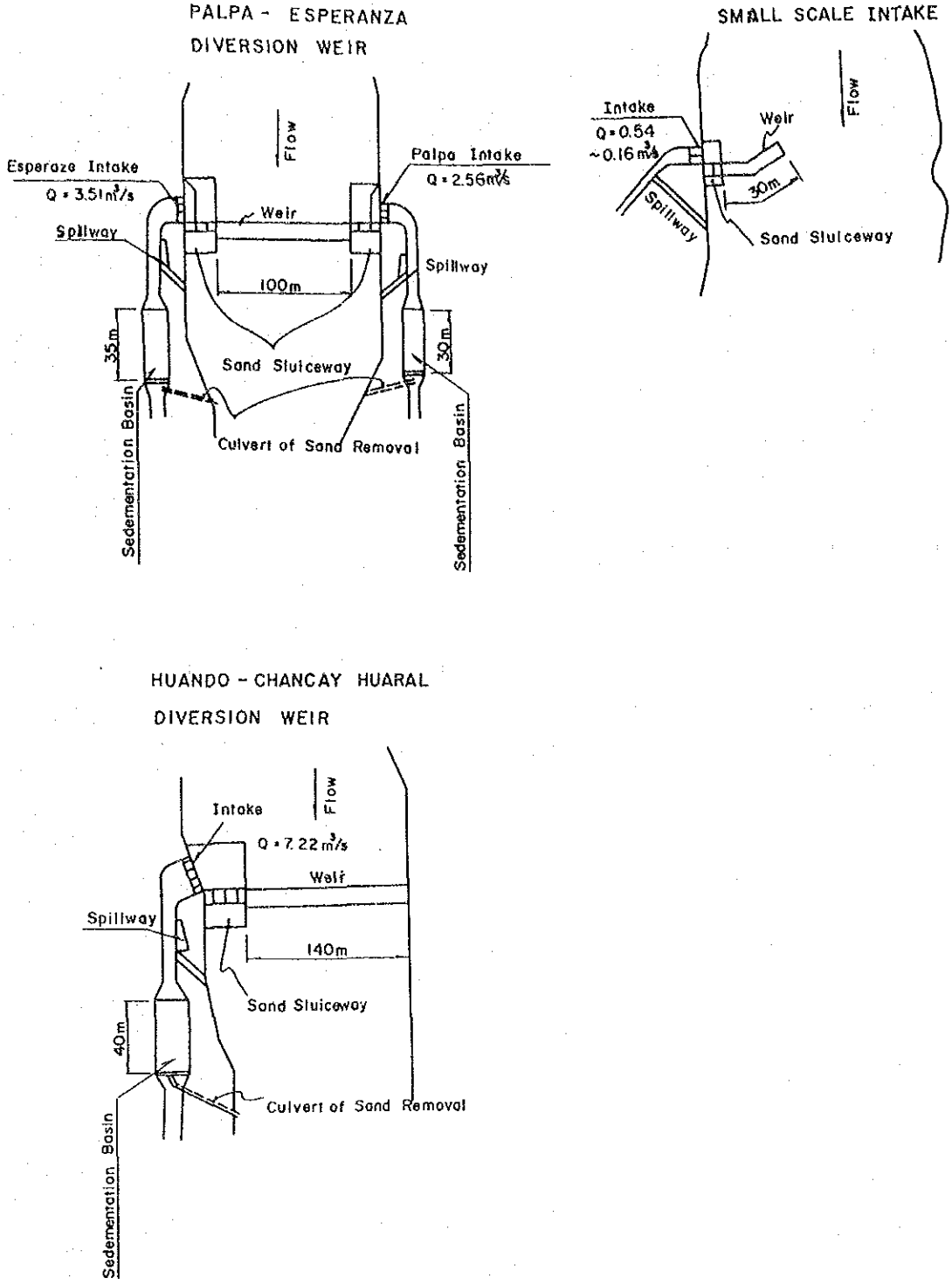

Fig. 5-2-2 Proposed Diversion Weir

DIMENSION OF SANDSLUICEWAY

Diversion weir	Gate width (m)	Number of gates	Gate height (m)	Diameter of Deposit (m)
Palpa - Esperanza	3.0	4	1.7	0.1 - 0.3
	2.0	2	1.7	0.1 - 0.3
Huando - Chacay	3.0	3	2.0	0.1 - 0.3
	2.0	1	2.0	0.1 - 0.3
Small-scale Intakes	2.0	2	1.0	0.1 - 0.3

iii) Intake structure

A large sediment deposits occur at the mouth of the intake as the riverbed and canal bed are at alomst the same level as the existing intake. For removing sedimentation effectively, the elevation of the canal bed at Palpa and Huando will be designed more than 1.0m above the level of the riverbed, and 0.5m for small-scale intakes. Intake velocity is designed between 0.5 to 1.0 m/sec. A screen should be set up in front of the gate to check the driftwood in the flow, etc.

INTAKE FEATURES

Intake	Amount intake water (m3/sec)	Width of gate (m)	No. of gate	Height (m)	Velocity (m/sec)
Palpa	2.56	2.50	3	1.0	0.70
Esperanza	3.51	2.50	4	1.0	0.70
Huand-Chancay-Huarol	7.22	2.50	5	1.0	0.70
Small-scale Intake-I (2)	0.26	1.20	1	0.8	0.60
Small-scale Intake-II (3)	0.46	1.20	2	0.8	0.60

iv) Sedimentation basin

Sedimentation basins will be installed in headrace in case of a large scale intake; namely, Palpa, Esperanza and Huando. The minimum diameter of deposit is 0.03cm and the gravity drainage method will be used.

DIMENSION OF SEDIMENTATION BASIN

Intake	Sedimentation basin width (m)	length (m)	Depth (m)	Box culvert (m)
Palpa	6.0	30	3.0	50
Esperanza	10.0	35	3.0	40
Huando-Chancay-Hural	18.0	40	3.0	60

5-2-3 Collecting conduit

A collecting conduit will be constructed at Boza Alto area where surface runoff from the Chancay River becomes groundwater during the dry season. The collecting conduit will be of a pipe with 1.0 m in diameter and 300m in length in order to collect total water amount of about 0.1 m^3/sec which is water demand. The collecing conduit will be installed 4 - 5m depth below ground surface and a filter will be installed around the pipe to prevent obstruction.

Standard section of collecting conduit is shown in Fig.5-2-3.

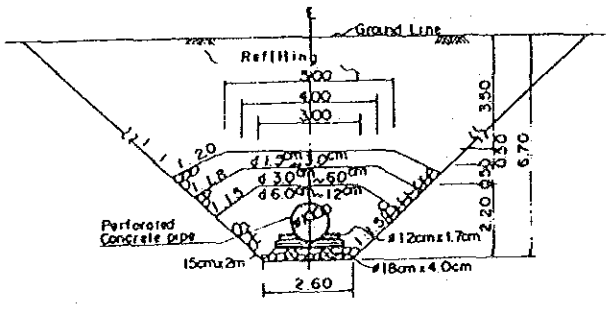

Fig.5-2-3 Collecting Conduit

5-3 Irrigation Canal Plan

Rehabilitation of a total length 162.4 km Class I irrigation canal as mentioned in 2-3-4 and construction of additional 12.6 km connecting canal for the unification of the existing intakes modification of a part of irrigatin system are planned in this Project.

The upper parts of San Jose, Boza Alto, and Boza Bajo canals will be used for collecting filtration water, and unlined canals of about 8.5km in total length out of 162.4 km will be used in the said areas.

Canals and related structures are comparatively small-scale structures and accordingly, there will be no problem in the foundation of the same.

(1) Plane plan of canal network

The Project is located in cultivated area with existing irrigation canal networks and in upland field. Moreover, drainage canals are aligned for collecting filtration water which is used to supply water to irrigation canals in the lower area. Accordingly, the most part of existing canal alignment will be maintained as it is when canals are rehabilitated.

(2) Profile and typical cross section of canal

The existing canal slope is steep following the topographical slope (1/30 - 1/1500) and consequently, flow velocity is high causing erosion and scour of the canal bed and sides. A considerable number of drops is required to adjust the irrigation and drainage canals to a reasonable slope.

The canals should be lined with concrete or cobble stones, which are easily procured at the site and are used for back filling of the canals. Each drop should have a maximum head of less than two meters (one drop each for 200m to 500m long of canal).

According to the design discharge, design velocity and canal bed slopes are designed as follows:

discharge (m^3/sec)	Designed velocity (m/sec)	Canal Bed slop	Material
Q = 1.0	v = 1.0	1/400 - 1/900	Masonry
1.0 - 2.0	v = 1.2	1/700 - 1/1100	do
2.0 = Q	v = 1.5	1/800	Concrete lining (t = 10cm)

Based on the Design Standards No.3 of USBR, 10cm thickness is designed for concrete lining considering construction mode prevailing in Peru and actural example implemented in similar projects of PE-REHATIC.

Typical canal Section is shown in Fig.5-3-1.

(3) Distribution devices

The main canal diversion will be longitudinal division, and irrigation water will be distributed and regulated by sluice gates. Moreover, a parshall flume will be installed in the comparatively large scale diversions for efficient water management. As for small diversions or tunouts, irrigation water will be distributed by sluice gates and check gates will be installed.

Type	Required Facilities	Numbers	Remarks
Distribution divices -I	2 Nos sluice gate & Parshll flume	59	m^3/sec $0.5 < Q$
Distribution divices -II	Check gate and intake gate	60	$0.1 < Q < 0.5$
Turnout	Intake gate	*	$Q < 0.1$

* Turnouts will be installed 3 - 5 places per one kilometer on the average.

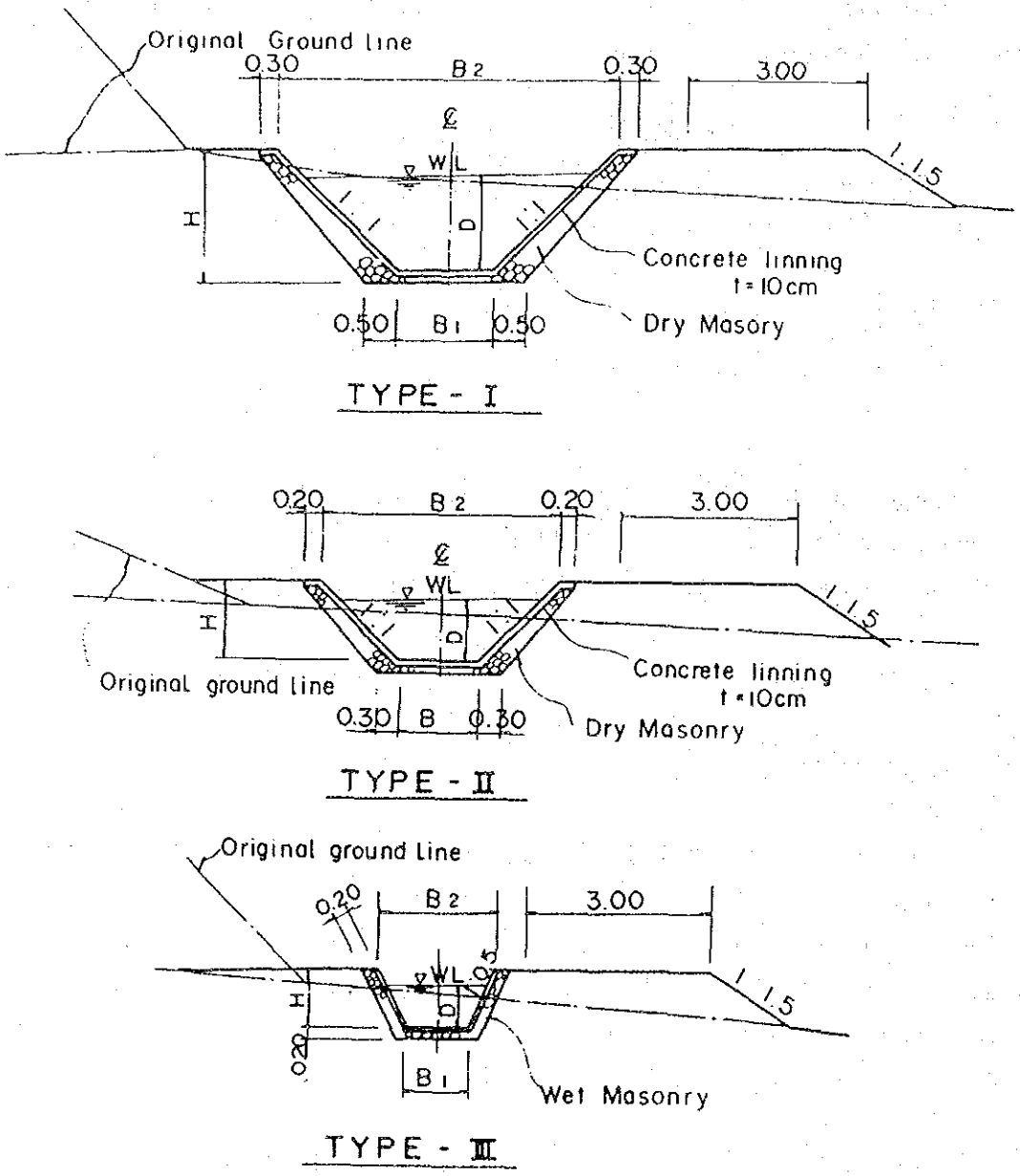

Fig. 5-3-1 Typical Canal Section

(4) Connecting canal

In case of unification of the intake facilities, the following connecting canals are required.

a) Palpa - Esperanza 4.0km
b) Huando - Chancay Huaral 1.6km

There is 13 meter difference in level along Huando-Chancay-Huaral connecting canal. Therefore, it is considered that the small scale hydro-power station will be able to install at this canal.

c) The small connecting canals, Palpa-Caqui, Caqui-San Jose, Boza Bajo-Pasamayo Alto, Pasamayo Bajo-Hangler are included in canals which will be rehabilitated.

5-4 Reservoir Plan

5-4-1 Improvement of existing reservoirs

All of 6 reservoirs will be dredged to increase the storage capacity of reservoirs up to the irrigation water requirement. Total storage capacity will be 233,200 m^3 with the capacity of each reservoir is shown in Table 5-4-1. In addition, as intake and outlet gates have been deteriorated , the same will be improved, while the location of upstream canal to the Palpa reservoir will be partially changed to supply water to the reservoir due to raised water level.

5-4-2 New reservoirs

Five more new reservoirs will be constructed in irrigation water shortage areas, namely, Esparanza Baja, Aucallama, Chancay and Los Laureles. Total storage capacity will be 92,000m^3, details of which are presented in Table 5-4-2. As the reservoirs will be constructed on a permeable foundation, concrete lining of the inside slope and bottom (t = 5cm in thickness) is recommended.

TABLE 5-4-1 Rehabilitated Reservoirs

Reservoir	Actual Storage Capacity (m^3)	Design Storage Capacity (m^2)	Shortage Capacity (m^3)	Remarks
Jesus Ded Valle	24,600	34,100	9,500	Enlargement 60m to south side
Cerrito	12,000	17,700	5,700	Enlargement 40m to west side
Quepe Pampa	10,800	13,800	3,000	Enlargement 20m to west side
Chancay Bajo	7,300	9,300	2,000	Enlargement 20m to south side
San Joan	5,000	7,300	2,300	Enlargement 15m to south side
Palpa	33,800	40,200	6,400	50cm height increasing west side bank

TABLE 5-4-2 New Reservoirs

Reservoir	Design Storage Capacity	Storage Capacity	Remarks
Granados 1	13,850 m^3	16,900 m^3	100^m x 100^m x 2.5^m, 2 Sluice Gates
Granados 2	18,800	21,700	140^m x 100^m x 2.5^m, 2 Sluice Gates
Aucallama	16,420	19,200	130^m x 100^m x 2.5^m 2 Sluice Gates
Las Laureles	12,700	14,700	100^m x 100^m x 2.5^m 2 Sluice Gates
Boza Bajo	14,510	19,200	130^m x 100^m x 2.5^m 2 Sluice Gates
Total	76,280	91,700	

5-4-3 Geological condition

As the reservoir foundations are laid upon river terrace,sufficient bearing capacity for structural suport is expected. However soil deposits in the reservoir and local soils which will be used for bank materials have a high silt content. Therefore material tests and careful sellection of construction method will be required.

5-5 Road Improvement Plan

5-5-1 Roads

Under the road improvement plan, 6 main roads and 25 secondary roads which connect the main roads to villages will be improved.

Rehabilitation will mainly include the expansion of width and pavement with gravel. Datails are tabulated in Table 5-5-1.

Table 5-5-1 ROAD IMPROVEMENT

Roads	Effective width (m)	Shoulder (m)	Width (m)	Type of payment (m)	Length (km)
Trunk roads	6.0	1.5x2=3.0	9.0m	Gravel 15	49
Secondary roads	3.0	1.5x2=3.0	6.0m	Gravel 10	125

5-5-2 Bridges

As mentioned in 2-3-6, the Palpa and San Jose bridges are paved by timbers for passing traffic, and due to the poor condition of the same, rehabilitation works is urgently required. Therefore, floorboard will be changed to steel for smooth passing.

Small scale bridges crossing over canals made of wood or concrete which have been deteriorated will be rehabilitated by concrete slab. Table 5-5-2 presents the details of the bridge rehabilitation plan.

Table 5-5-2 BRIDGE REHABILITATION

Bridge	Length (m	Width (m)	Rehabilitation works
Palpa Bridge	109.0	2.7	Wooden boards will be replaced by steel floorboard
San Jose Bridge	129.0	2.3	do
Main Road Bridges	8.5-2.7	7.0	Concrete slab type
Secondary road Bridge	8.5-2.7	4.0	do
Farm road Bridge	8.5-2.7	2.5	do

5-6 Drainage Facilities

(1) Flood protection

Flood protection embankments will be constructed at Palpa and Huaral as these areas are frequently damaged by floods and portions of canals have been washed away.

Embankments protected by rocks (about 1 m in diameter),gabion and concrete will be constructed using locally available material. Some materials may also be obtained from road improvement work in the Esperanza area. Planned protection levee types are presented below.

TYPE OF FLOOD PROTECTION LEVEE

Type	Length	Location
Levee by concrete	1.5 km	Palpa
Levee by rock	3.0	Palpa, San Jose, Huando
Levee by gabion	9.0	Chancay-Huaral
TOTAL	13.5 km	

(2) Drainage canals and improvement of poor drainage areas

a) Drainage canals

Among the existing drainage canals, the Esperanza-Jecuan drainage canal has been damaged by excessive erosion, and accordingly a concrete panel fence with gabion will be installed.

In poor drainage areas, several drainage canals will be constructed with designed depth of more than 2.50m for collecting water from pipe drains.

Drainage canal features are briefly outlined below.

DRAINAGE CANAL FEATURES

Drainage canal	Remarks	Length (km)
Existing drainage canal	Concrete panel fence with gabion	4.2
do	Canal section improvement	18.4*
New drainage canal	Unlined canal	47.4
Total		70.0

(* Include 16.1 km of group II)

b) Pipe drainage

A pipe drainage system will be adopted for land improvement in the approximately 2,180ha of poor drainage area where the groundwater table is less than 1.5 m from top of ground surface.

Perforated pipe will be adopted as the drainage method. The pipe discharges collected water into the drainage canal. Each pipe will be installed at a depth of 1.8m from ground surface and spacing will be at 40 or 60m depending on soil texture.

PIPE DRAINAGE SYSTEM FEATURES

Pipe	Soil texture	Interval (m)	Area (ha)	Length (m/ha)	Total length (km)
Perforated Vinyl chloride Currgate pipe ϕ100	Coarse Mudium Fine	60 40	1,720 460	170 250	292 115
Total			2,180		407

CHAPTER 6. PROJECT IMPLEMENTATION AND COST ESTIMATION

CHAPTER 6. PROJECT IMPLEMENTATION AND COST ESTIMATION

6-1 Project Implementation

6-1-1 Organization for project implementation

Ministerio de Agricultura (MAG) is the executing agency for the project. Instituto Nacional de Ampliacion de la Frontera Agricola (INAF), which is one of the institute of MAG and is established for the land reclamation and rehabilitation, would have primary responsibility for the project implementation. Direccion Ejecutiva del Proyecto Especial de Rehabilitacion de Tierras Costeras (DEPE-REHATIC) has been established and would be responsible for the construction works.

The role and limits of the agency related to the project implementation will be considered as follows:

1. Administracion Tecnica de Distrito de Riego (ATDR)

ATDR Chancay-Huaral, which depends upon Oficina Agraria Huacho of Region Agraria VI, MAG, will be in charge of operation and maintenance for the facilities after completion of the construction works, and supervises the Junta de Usuarios.

2. Banco Agrario del Peru (BAP)

BAP would act as banking agency to provide the farm credit to individual farmers and cooperatives.

3. Junta de Usuarios (Water users' organization)

Water users' organization under control of ATDR will be in charge of operation and maintenance for agricultural infrastructures.They collect part of water charge and partial charges from water users in order to carry out their concern activities.

4. Centro de Investigacion y Promocion Agropecuaria (CIPA)

CIPA Chancay-Huaral will be responsible for the guidance and spread of cultivation method, and be also in charge of management of agricultural experimental station at Donoso.

5. Administracion Tecnica de Distrito Agropecuario de Chancay-Huaral, and other organizations.

Empresa Nacional de Comercializaion de Insumos (ENCI) Huaral, Comite de Productores de Algodon de Chancay-Huaral-Aucallama and Cooperatives would give indirect aid when necessary.

6-1-2 Implementation of civil work

The civil works consisting of diversion weir, irrigation and drainage system, road and flood protection work will be carried out under the control of DEPE-REHATIC.

The detailed design and construction supervision of the civil works would be carried out by Consultant employed by DEPE-REHATIC. The construction of the civil works will be executed on a Contract Basis not on Force Account Basis, since the construction of the civil works required large scale construction equipments.

(1) Project offices

To smoothly execute the works, project office would be established in DEPE-REHATIC.

The project office will carry out all the field works, such as additional survey and investigation, land acquisition and supervision of the consultant. It is proposed to construct the head office in DEPE-REHATIC, the branch office in the service area in keeping place with the progress of construction works.

(2) Consultant services

Consultant would be in charge of detailed design and construction supervision of the civil works. Detailed design extent to the preparation of tender documents would be carried out being as adaptation of additional survey.

(3) Project implementation schedule

The implementation schedule for the project is shown in Fig.6-1-1.

6-2 Construction Plan

6-2-1 Civil works

The construction of civil works consisting diversion weirs, irrigation and drainage facilities, roads and protection levees will be carried out by the Contractor under the supervision of Consultant who assists DEPE-REHATIC.

(1) Available construction materials

- Concrete aggregate, metalling material for road and filter material for pipe drain are produced at the site, and sand is purchased.

- Excavated material is available for its backfill.

- Cement, reinforced steel bar and steel material, etc. can be transported from the manufacturing factory located in the vicinity of the project site.

- Gate to be installed at the diversion weirs and irrigation canal is purchased from the foreign or local manufacturers.

- PVC pipe for pipe drain is purchased from the foreign manufacturers.

(2) Construction method

- Major works for diversion weir and flood protection levee will be carried out from May to November in dry season.

- Main irrigation canal will be rehabilitated to provide temporary canal, however, lateral canal will be improved under the condition that irrigation water is keeping stop for a constant period, in principle. In the place where by-pass canal can be used, it is the best way to utilize that as possible.

- Roads are paved by the gravel from the proposed crushing plant.

- Pipe drain will be installed by a trencher.

- Concrete is mixed at each site by mixing plant and placed by a truck crane in case of diversion weir, by man-power in canal.

Note: Construction equipments will be provided by the Contractor themselves.

6-2-2 Construction plan

(1) Diversion weir and flood protection levee

Seven diversion weirs are proposed, each of which must be completed during the dry season from May to November. There no particular attention will be paid to carry out the construction works due to low height the weir

(2) Irrigation facility

Irrigation facilities are consisted of irrigation canal (L=175km) and regulating reservoir (improved; 13, newly constructed; 5). It is desired to construct the main canals when consumptive use is comparative small. The construction of irrigation canal will be carried out taking into consideration the adequate construction blocks.

(3) Drainage facility

Open drainage canals (L=64km) are constructed in the first half of the construction stage. And then, pipe drain (L=407km) would be installed two to three years thereafter, taking into account the variation of groundwater level.

(4) Road

Road will be constructed in the first half of the construction stage for the convenience of traffic for the construction equipment.

6-3 Cost Estimation

6-3-1 Basic rate

The basic rate for labor, material and construction equipment is estimated on the basis of the prevailing rate, as of 1984. The foreign and local currency portions for the basic rate are estimated, taking into consideration the shadow price.

6-3-2 Unit rate

The unit rate for the civil works is estimated, based on the basic rate and the output of construction equipment, etc., shown in Table 6-3-1.

6-3-3 Project cost

The project cost, shown in Table 6-3-2 and 6-3-3, including the construction cost of the civil works and other cost for survey & investigation works, land acquisition, consulting services and administration. Assumed that the construction period including detailed design will be four years as alternative, the project cost will be increased as follows:

Original	US$41,474,000
Alternative	US$44,802,000

(1) Construction cost

The construction cost of the civil works is estimated, based on the quantities calculated by preliminary design and the unit rate as described on Table 6-3-1. 25% of the unit rate is considered as overhead for the works to be carried out on a Contract Basis.

(2) Other cost

The other cost for survey & investigation, land acquisition, consulting services and administration is estimated.

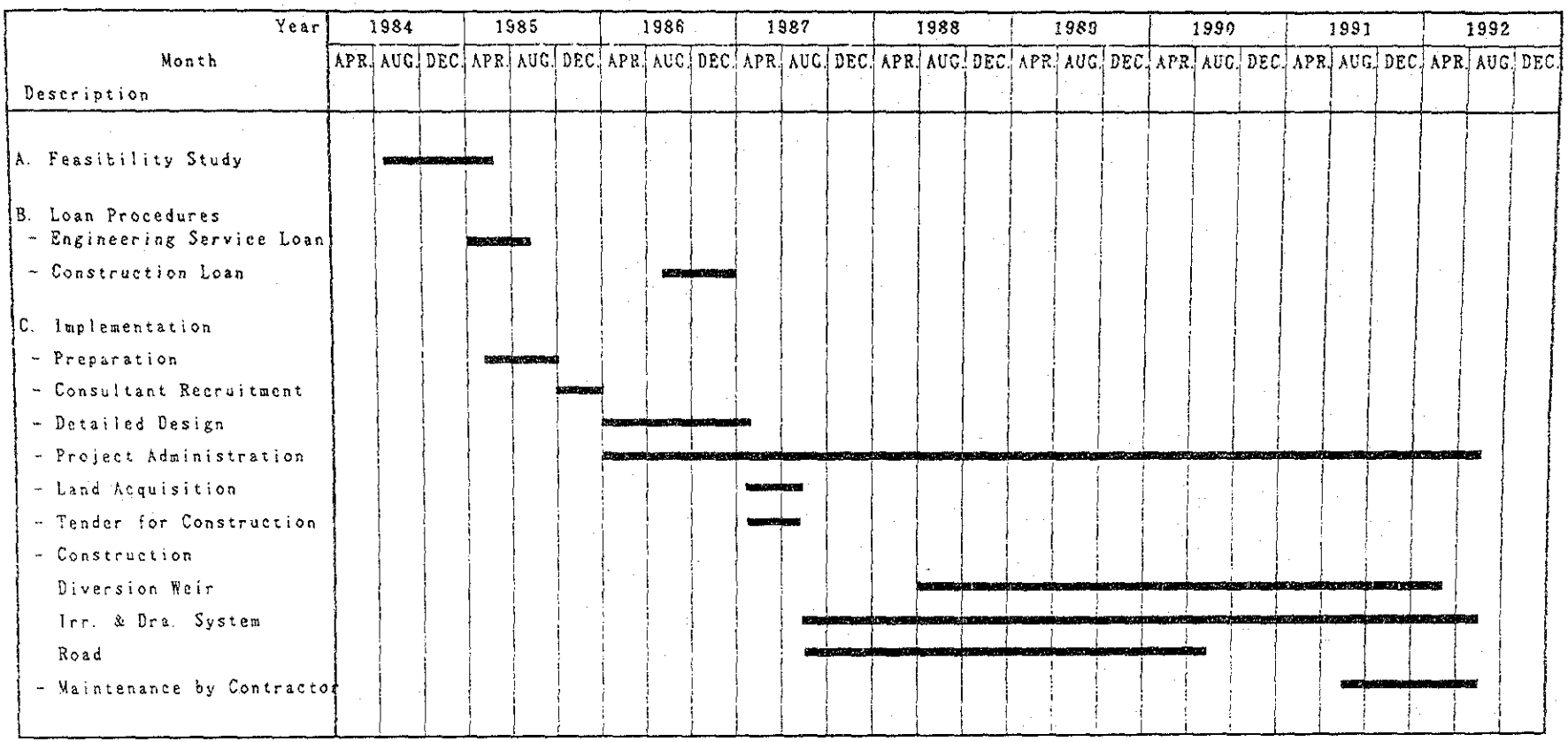

Fig. 6-1-1 Implementation Schedule for Project (Original)

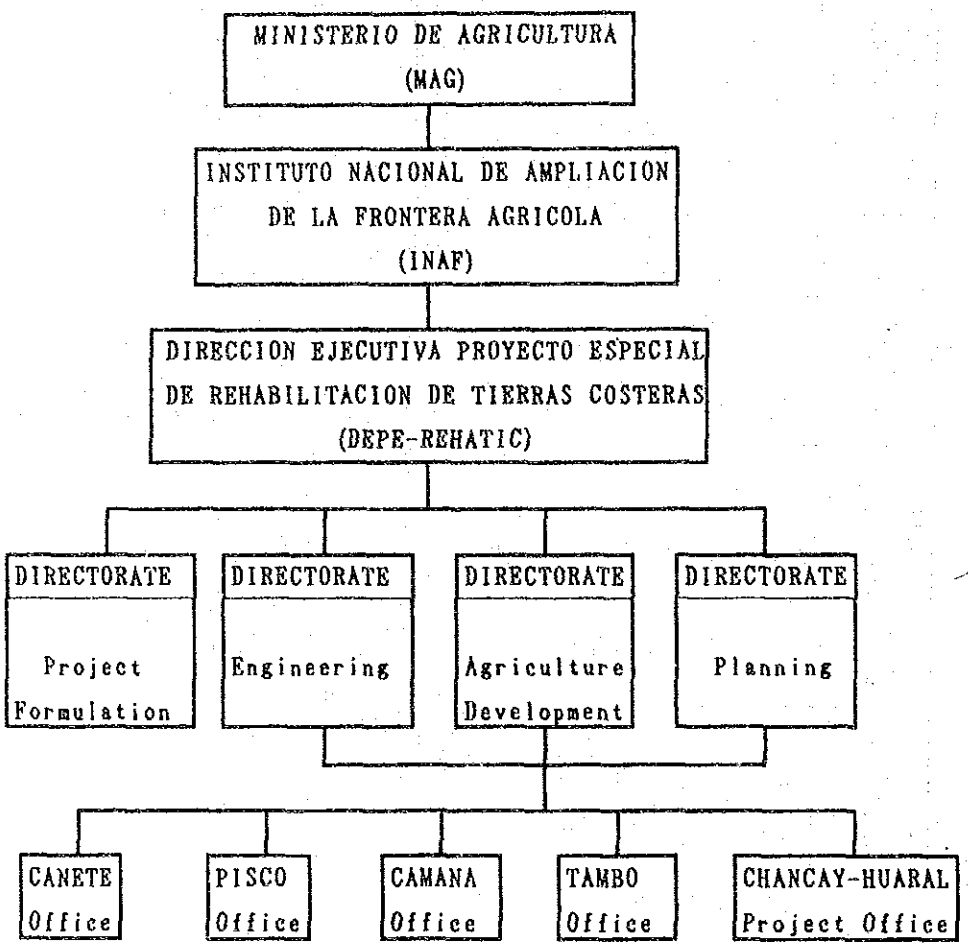

Fig. 6-1-2 Project Organization Chart for Implementation

Table 6-3-1 Unit Rate

Description	Unit	Unit Rate (S/.) F/C	L/C	Total
A. Diversion Weir & Protection Work				
- Common Excavation	cu.m	2,102	1,078	3,180
- Trench Excavation	cu.m	6,938	3,961	10,899
- Fill & Backfill	cu.m	2,976	1,646	4,622
- Reinforced Concrete	cu.m	215,507	174,001	389,508
- Plain Concrete	cu.m	106,277	86,801	193,078
- Stone Pitching	cu.m	24,112	31,046	55,158
- Protection Levee, Type I	m	184,064	257,562	441,626
- - do - Type II	m	118,453	152,306	270,759
- - do - Type III	m	16,852	30,307	47,159
B. Irrigation System				
- Common Excavation	cu.m	1,331	671	2,002
- Fill & Backfill	cu.m	161	3,476	3,637
- Dredging	cu.m	3,682	1,854	5,536
- Reinforced Concrete	cu.m	199,900	167,247	367,147
- Plain Concrete	cu.m	95,813	90,225	186,038
- Linning Concrete	cu.m	123,061	91,202	214,263
- Dry Masonry	cu.m	7,979	14,034	22,013
- Wet Masonry	cu.m	34,098	31,604	65,702
C. Drainage System				
- Common Excavation	cu.m	763	3,433	4,196
- Pipe Drain	m	13,058	7,715	20,773
D. Road Net Work				
- Grading & Compaction	cu.m	1,081	569	1,650
- Rock Excavation	cu.m	7,802	15,739	23,541
- Rock Embank	cu.m	5,329	2,950	8,279
- Metalling	cu.m	17,026	11,618	28,644

Table 6-3-2 Project Cost (Original)

(unit: $)

Description	F/C	L/C	Total
A. Civil Work			
1. Preparatory Work	411,000	373,000	784,000
2. Diversion Weir	3,602,000	1,919,000	5,521,000
3. Irrigation System	5,917,000	4,672,000	10,589,000
4. Drainage System	2,315,000	2,026,000	4,341,000
5. Road Network	1,385,000	1,191,000	2,576,000
6. Flood Protection Work	352,000	501,000	853,000
Total	13,982,000	10,682,000	24,664,000
B. Survey & Investigation	82,000	326,000	408,000
C. Land Acquisition	-	10,000	10,000
D. Consulting services	1,843,000	697,000	2,540,000
E. Administration	-	1,657,000	1,657,000
Base Cost	15,907,000	13,372,000	29,279,000
F. Physical Contingencies	1,591,000	1,337,000	2,928,000
G. Price Contingencies	5,086,000	4,181,000	9,267,000
Grand - Total	22,584,000	18,890,000	41,474,000

Table 6-3-3 Project Cost (Alternative)

(unit: $)

Description	F/C	L/C	Total
A. Civil Work			
1. Preparatory Work	411,000	373,000	784,000
2. Diversion Weir	3,602,000	1,919,000	5,521,000
3. Irrigation System	8,706,000	5,977,000	14,466,000
4. Drainage System	2,315,000	2,026,000	4,558,000
5. Road Net Work	1,385,000	1,191,000	2,576,000
6. Flood Protection Work	352,000	501,000	853,000
Total	16,771,000	11,987,000	28,758,000
B. Survey & Investigation	82,000	326,000	408,000
C. Land Acquisition	-	10,000	10,000
D. Consulting Services	1,843,000	697,000	2,540,000
E. Administration	-	1,903,000	1,903,000
Base Cost	18,696,000	14,423,000	33,619,000
F. Physical Contingencies	1,870,000	1,492,000	3,362,000
G. Price Contingencies	4,395,000	3,426,000	7,821,000
Grand - Total	24,961,000	19,841,000	44,802,000

CHAPTER 7. OPERATION AND MAINTENANCE

CHAPTER 7. OPERATION AND MAINTENANCE

7-1 Organization for Operation and Maintenance

Administracion Tecnica de Distrito de Riego (ATDR) Chancay-Huaral, which depends upon the Oficina Agraria Huacho of Region Agraria VI-Lima , MAG, is in charge of operation and maintenance of irrigation district and has a responsibility in accordance with operation and maintenance of irrigation facilities. Junta de Usuarios (water users' organization), supporting organization of ATDR, consists of water users representative organization and is actually in charge of operation and maintenance of irrigation facilities in his district.

ATDR is managing all of water including the upstream lagoons and its roles are:

- to authorize the distribution of irrigation water,
- formulating the programs of operation and maintenance of the infrastructures,
- to audit the account of water charge collected by the water users' organization (Junta de Usuarios)
- participate in the formulation of budget of water users' organization (Junta de Usuarios) and Comisiones de Regantes.

At present, operation and maintenance of irrigation facilities and levying of water charge, etc. are performed by water users' organization, which has 15 Comisiones de Regantes (irrigation district commission) and Comicion de Regantes is formed of the representative of Comite de Regantes that is a farmer's organization by each canal.

After completion of construction works by DEPE-REHATIC which depends upon INAF, operation and maintenance of irrigation and drainage facilities will be transferred to ATDR being in charge of operation and maintenance.

Consequently, operation and maintenance services of the project will be mainly carried out by ATDR and Junta de Usuarios. The basic role, viz, of ATDR and Junta de Usuarios will not be changed, since it is considered to get a satisfactory target assuming that the role of these organization would be the same as present condition.

Since existing division for operation and maintenance of ATDR, however, is responsible for not only irrigation and drainage systems but water supply for municipal purpose, it is necessary to increase the personnel as to strengthen the operation and maintenace after completion of construction works. Therefore, a division which is in charge of operation and maintenance only for this project would be established and required to organize and train personnel among the Junta de Usuarios, to give adequate advice in the field.

It is proposed that the division, which manages the equipments for operation and maintenance and personnels, and carries out the adequate operation and maintenance whole the service area, would be newly installed in the water users' group for the purpose of overall conservation and management for project facilities being newly constructed in this project, since the supply of the equipments and materials for operation and maintenance, the correspondence for repair, etc. are different for each canal and/or each district in the present condition.

The operation and maintenance office will be placed at Huaral, and office and motor pool, etc. provided during the construction period will be utilized. The operation and maintenance equipment will be newly purchased.

Organization chart for operation and maintenance is shown in Fig.7-1-1.

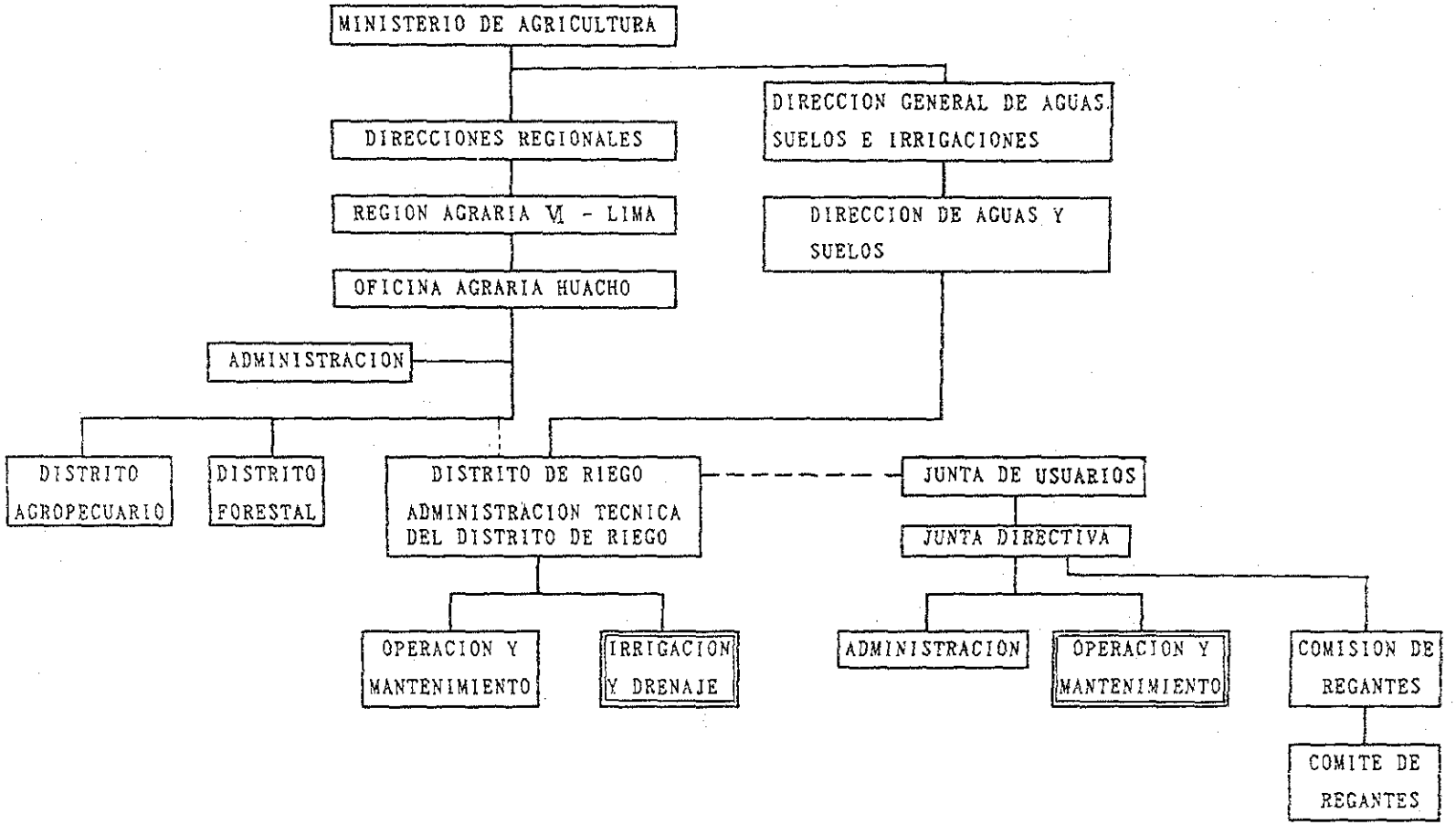

Fig. 7-1-1 Organization Chart for Operation and Maintenance

7-2 Cost for Operation and Maintenance

Cost for present operation and maintenance has been met by a part of water charge that is levied, based on the law of water charge, and the charge to be levied for other purposes. The labor force , operation and maintenance cost for the irrigation and drainage facilities including pumping plants and etc. have been borne by the farmers themselves besides the expence mentioned above. Taking into account the factors, thereto, calculated cost for operation and maintenance is US$ 53 /ha in present condition, US$ 48 /ha in case of the proposed new organization.

7-3 Basic Procedure of Water Management

(1) Water management

It is necessary to regulate the water management so as to function rationally, since the irrigation water is utilized the water from Chancay river including upstream lagoons, re-using water from upstream parts and groundwater, and/or these combination in the project area.

The basic rules for the water management will be as follows:

- Discharge gauging station, equipped at Santo Domingo, will be newly provided at the point where Palpa - Esperanza diversion weir is proposed, for the daily observation.

- Water shortage occurs, in generally, from end of August up to end of January. In this piriod, water release of upstream lagoons will be commenced when river discharge at Palpa is less than the value mentioned below, however, the accumulated volume to be discharged by end of each month will not be permitted to exceed the value described in table.

Month	River discharge (m^3/sec)	Accumulated volume (m^3)
September	3.6	4,500,000
October	5.8	11,500,000
November	6.7	22,500,000
December	8.0	30,000,000

- In the case that river discharge including the upstream lagoons is low, it is considered the operation of pumps for taking groundwater (26 places in the area). Maximum discharge set up to 1.0 m^3/sec in total, moreover, it is limited ten million m^3 in a year due to the conservative use of groundwater.

- When water shortage still takes place by means of above mentioned countermeasures, distribution corresponding with diversion ratio of each intakes will be made.

- Regulated discharge must be intaked at each diversion weir, using the H-Q curve presented the relationship between opening of gate (H) and discharge (Q).

- Regulating reservoir (18 places), to be rehabilitated and/or constructed at main diverging point of canal, is proposed giving 12 hours capacity. Adequate operation will make the water management rational and reduct of labor force.

Operation mentioned above and distribution to on-farm will be administrated by both ATDR and Junta de Usuarios, especially, the intaked discharge from each diversion weir should be regulated strictly.

(2) Infrastructure

To keep the function and smoothly manage the project infrastructures, basic items to be carried out are shown as follows:

- Maintaining the river channel at the intake structures with partial weir.

- Adequate removal of sand and gravel in the settling basin of intake facility.

- Continuous dredging of the sediments in the canal and regulating reservoir.

- Operation and maintenance of the gate installed at intake, waste way and diversion.

- Maintenance of the canal, road and dams of upstream lagoon.

- Operation and Maintenance of the wells and pumps.

7-4 Organization for Agricultural Development

CIPA V-Lima which depends upon INIPA (Instituto Nacional de Investigacion y Promocion Agropecuaria), will carry out the extention services in agricultural improvement and the training of farmers for introducing new agricultural technology in the project area.

Nevertheless there is a agricultural experimental station at Donoso, the roles to be carried out by CIPA in the station are confined within narrow limits such as supply of seeds to the farmers, nor the guidance of farming technology, from the reasons of lack of sufficient personnel and fund in the present condition. CIPA will be defined as the core of organization which execute not only the extension and training of agricultural technology by using the existing facility but the guidance for the farmer in this project.

The project area has 26 agricultural cooperatives and Central de Cooperativas del Valle Chancay-Huaral-Aucallama organized by the cooperatives.

The details of these cooperatives is given as that 4 cooperatives holds their land (CAP), the others carry out the agricultural services (CAS) such as the material supply for agricultural production to the members of cooperative, and the commercialization of agricultural products. After completion of construction works, it will be necessary for each cooperative to improve the farming organically, guided from CIPA.

On the other hand, farm credit to the farmers have been financed by BAP, although, it will be desired to insure the fund so as to response to the credit for equipment and facility.

It will be keenly desired to function comprehensively in mutual cooperation with each organization and to obtain a full success of the project, not only combination directly between the organization for operation and maintenance mentioned herein and each farmhold.

The cost estimated below are required to accelerate the promotion of agriculture in the Project area.

Investiment :

Housing	US$	60,000
Equipment		45,000
Total		105,000

Running Cost :

Wages	US$	69,360
O&MCost etc.		19,640
Total		89,000 per annum

Cost of Demonstration Farm :

Anual Cost	US$	15,000 / 50 ha

The extension services (Promotion & demonstratin) are taken to be continued for seven years.

CHAPTER 8. ECONOMIC ANALYSIS

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8-1 Economic Evaluation

8-1-1 Benefit

The expected benefit of the Project consists of mainly incease of crop production, saving cost of operation and maintenance and of road improvement. While the benefit on municipal water service will be estimated as an alternative construction cost, but it is insignificant compare with terms of the internal rate of returns.

(1) The agricultural benefit is considered to be an increase in the net value of output. Benefit in target year assuming the fifth year after completion of the Project is tabulated below.

	Without project	With project	Incrrease
Gross value of production	$48,405,000	$72,571,000	$24,166,000
Production costs	$21,013,000	$26,579,000	-$5,366,000
Net value of production	$27,392,000	$45,992,000	$18,600,000

(2) Annual saving cost for operation and maintenance as described in Chapter 7 will be expected equivalent to an amount of US$94,000 in the year as follows;

	Without project	With project	Net benefit of saving cost
O & M cost	$1,065,000	$964,000	$101,000

(3) Reduced transportation cost by road improvement is calculated an amount of $284,000 in the year.

Accordingly, annual benefit is estimated at $18,985,000 ($940/ha) in total.

(4) Indirect benefits

If the project is implemented, it will give an impact on the regional economy as described below.

- Employment opportunity increased by construction 400,000 man-days
- Procurement of construction materials and it works $11,200,000
- Increase in an amount of dealings with commercial enterprises following production increase of crop 41,500 M.T. in crops
- Increase of crop supply for agroindustry
  MAIZE: 22,000 M.T. TOMATO: 7,000 M.T. MARACUYA: 27,000 M.T.
- Increase of working days on farm 190,000 man-days per year
- Procurement increase for crop production materials 3,900 M.T.
- Increase of the purchasing power of farmer's with grade-up and stabilization of farm household economy.

8-1-2 Project costs

The project costs consists of construction costs, land acquisition cost, survey and design cost, etc. And the required expenditure of operation and maintenance cost will be eventually more profitable than that without the project. The project is assumed to have a life of fifty years for civil works and 25 years for gate. If the construction is carried out as scheduled, annual construction cost will be as follows;

x 10^3 US$

1986:	2,284	1990:	8,348
1987:	4,210	1991:	7,231
1988:	7,352	1992:	3,357
1989:	8,692	Total:	41,474

8-1-3 Economic internal rate of return

Economic internal rate of return is calculated based on the cost and benefit as forementioned, the conditions are; Target yield will be reached at fifth year after completion of the project, and the production cost is paid in advance six months of, farmer's income. Result of this calculation: EIRR = 17.8%

8-1-4 Sensitivity analysis

Sensitivity analysis is carried out on the basis of seven years construction period by escalation of project cost, gradual decrease of the benefit and delay, also in case of four years period in construction period.

	Analysed item	EIRR
(1)	Original/ Basic EIRR	17.8%
(2)	4 year construction period	20.5
(3)	Cost is 10% higher than expected.	16.9
(4)	Production is 5% less than expected.	15.6
(5)	Combination of (3) and (4)	14.8
(6)	Benefit is delayed by 2 year than expected.	14.1
(7)	Combination of (3) and (6)	13.5
(8)	Combination of (4) and (6)	12.4
(9)	Combination of (5) and (6)	11.8
(10)	2 years delay of the commencement of construction work	16.7

8-2 Financial Analysis

Total project cost is US$41,474,000 including US$22,624,000 of local currency, as to 6-3. The reimbursable cost is calculated by way of completed purchase by the following conditions corresponding proposed construction schedule in 6-2, but contribution (investor) of foreign loan is undecided yet. The results are shown in Table 8-2-1.

The premise

1) An amount of loan annually

(Unit: US$1,000)

		Case A		Case B	
Year	Construction cost	F.C.	L.C.	F.C.	L.C.
1986	2,284,000	1,105	1,179	1,599	685
1987	4,210,000	2,154	2,056	2,947	1,263
1988	7,352,000	4,027	3,325	5,146	2,206
1989	8,692,000	4,802	3,890	6,084	2,608
1990	8,348,000	4,586	3,762	5,844	2,504
1991	7,231,000	4,070	3,161	5,062	2,169
1992	3,357,000	1,840	1,517	2,350	1,007
Total	41,474,000	22,584	18,890	29,032	12,442
		(54.4%)	(45.6%)	(70.0%)	(30.0%)

2) The loan conditions

Case 1
- Amount of loan : US$22,584,000
- Annual interest : 7%
- Grace period : 5 years
- Amortization : 20 years (uniform annual payment)

Case 2
- Amount of loan : US$22,584,000
- Annual interest : 15%
- Grace period : 3.5 years
- Amortization : 15 years (uniform annual payment)

Case 3
- Amount of loan : US$29,032,000

Other conditions are the same to Case 1.

Case 4 Amount of loan : US$29,032,000
Other conditions are the same to Case 2.

Note; As the construction period for 4 years, a result of its calculation under the same condition is described in Annex K.

8-3 Financial Analysis of Farm Household

8-3-1 Profit and loss

In consideration of existing farming pattern, farm scale and local condition, the farm management of model farmers at target year will be calculated in case of farm management under proposed farming pattern. However,

- The agricultural products to be put into the comercial base is assumed at 90% of the yield, 10% for self consumption of farmer.

- Family labor is excluded from production cost.

- Annual interest cost of the credit for farm production cost is established at 62% including banker's commission, and credit term is decided in consideration of cultivation period.

Result of these calculation is shown in Table 8-3-1 -- 3, as farming condition of model farmers will make rapid improvement.

8-3-2 Possibility of a burden for water charge

Through the project implementation, the farmers in the project area would have gain lot of profit from the project, accordingly if the project cost may be assumed the shape of water charge, the profit to be received from the project after completed the project is calculated as follows;

1) Operation and maintenance cost

As mentioned in the Chapter 7, total cost of operation and maintenance after completion of the project is estimated at US$964,000 in annual average which is equivalent to US$48 per hectare.

2) Depreciation cost

To as same as another similar project in Peru,

Interest:	Zero
Grace period:	5 years
Depreciation period:	40 years

In case of the above mentioned condition, depreciation cost of US$41,474,000 equivalent to the project cost comes to US$51.33 per hectare, while net increase of benefit with the project is estimated at about US$ 940/ha (Refer to 8-1-1)

From the above, it appears to be adequate as the water charge equivalent to US$99.03 (= US$100) per hectare, including the both of operation and maintenance and depreciation costs.

Based on the result in financial analysis of the model farmers,currently, the farmers have been paying annualy s/.5,100 per hectare in cash as water charge. Compared wuth this amount of s/.5,000, US$ 48 per hectare seems to be quite big amount for the farmers. However in addition to the above mentioned amount of s/.5,000 the farmers are levied by special charge occasionally for O & M cost of pumping facilities and extra cost for restoring disasters caused by flood and others. Also they offer their own labor forces. Therefore, total O & M cost under present condition which is estimated at US$ 53 (Refer to 7-2) is almost same as the proposed cost of US$ 48.

As the paying manners of operation and maintenance cost following the project implementation, it should be examined to get farmer's understanding on the project, installment of its burden, etc.

Table 8-2-1 Repayment Schedule (Trial)

unit: US$1,000

	Year	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97	
Case A	Loan (22,624)	1105	2154	4027	4802	4586	4070	1840						
	Repayment Fund (Alternative 1)	77.4	228.2	510.1	813.5	1134.4	1433.9	1660.4	1758.6	1875.6	1987.1	2086.4	2131.4	(Since then same value)
	Repayment Fund (Alternative 2)	165.8	488.9	1093	1824.9	2546.8	3122.1	3591.3	3689.7	3780.7	3842.8	3862.1		(")
Case B	Loan (29,032)	1599	2947	5146	6084	5844	5062	2350						
	Repayment Fund (Alternative 3)	111.9	318.2	678.4	1104.3	1513.4	1906.6	2142.7	2267.8	2415.6	2557.6	2680.6	2737.7	(Since then same value)
	Repayment Fund (Alternative 4)	239.9	682	1453.9	2383.2	3307.6	4151.8	4622.2	4747.5	4862	4939.8	4964.5		(")

	Year	'03	'04	'05	'06	'07	'08	'09	'10	-	'20	'21	'22	'23	'24	'25	'26
Case A	Repayment Fund (Alternative 1)										2131.4	2027.1	1823.8	1443.7	890.9	558.2	174.0
	Repayment Fund (Alternative 2)	3862.1	3767.6	3439	2960.5	2205.7	1403.1	663.2	157.6								
Case B	Repayment Fund (Alternative 3)										2737.7	2586.9	2309	1823.7	1250	698.9	221.6
	Repayment Fund (Alternative 4)	4964.6	4827.8	4439.2	3747.2	2787	1767.2	834.5	200.9								

Table 8-3-1(1) Estimation of Profit and Loss in Model Farmer
(at Target Year)

unit: US$

	Model A	Model B	Model C
Farmming area	15.0 Ha	6.0 Ha	4.5 Ha
Main Cropping	Fruits	Cotton, Maize	Cotton, Maize
Income			
Turnover of Crops	111,780	16,427	12,928
Sub-Total (A)	111,780	16,427	12,928
Expenditure			
Production Cost	28,577	7,079	5,273
O&M Cost	720	288	216
Repayment Amount for Construction Cost	770	308	231
Interest of Credit	-	1,248(-)	2,016
Household Expense	7,986	2,142	2,667
Sub-Total (B)	37,283	11,065(987)	10,403
(A) - (B)	74,497	5,362(6610)	2,525
Depreciation Cost	56,602	5,886	1,356
Profit after Depreciation	17,895	(-)524(724)	1,169

Note: Target year is set up fifth year after completion of the project. Figures in the parentheisis of the model B show of sixth year after completion of the project.

Table 8-3-1(2) Estimation of Profit and Loss in Model Farmer (at Target Year)

unit: US$

	Model D	Model E	Model F
Farmming Area	6.0 Ha	4.5 Ha	1.0Ha
Main Cropping	Maize	Maize	Vegetables
Income			
Turnover of Crops	18,180	20,823	5,825
Sub-Total (A)	18,180	20,823	5,825
Expenditure			
Production Cost	4,793	7,547	1,517
O&M Cost	288	216	48
Repayment Amount for Construction Cost	308	231	51
Interest of Credit	-	-	-
Household Expense	2,828	2,977	925
Sub-Total (B)	8,217	10,971	2,541
(A) - (B)	9,963	9,852	3,284
Depreciation Cost	4,696	2,712	813
Profit after Depreciation	5,267	7,140	2,471

Note: Target year is set up fifth year after completion of the project.

Table 8-3-1(3) Estimation of Profit and Loss in Model Farmer (at Target Year)

unit: US$

	Model G	Model H
Farmming Area	2.0 Ha	6.0 Ha
Main Cropping	Maize,Cotton	Vegetable,Fruits
Income		
Turnover of Crops	6,271	16,824
Sub-Total (A)	6,271	16,824
Expenditure		
Production Cost	1,959	5,451
O&M Cost	96	288
Repayment Amount for Construction Cost	102	308
Interest of Credit	-	3,534
Household Expense	1,531	2,829
Sub-Total (B)	3,688	12,410
(A) - (B)	2,583	4,414
Depreciation Cost	1,356	2,984
Profit after Depreciation	1,227	1,430

Note: Target year is set up fifth year after completion of the project.

APPENDIX

1 PERSONNEL ENGAGED IN THE FEASIBILITY STUDY

(1) Advisory Committee

1. Chairman

Mr. Yoji TAKANO	Director, Construction Dept., Tokai Agricultural Administration Bureau, Ministry of Agriculture, Forestry & Fisheries. (MAFF)

2. Soil/Agriculture Expert

Mr. Yasuichi SUZUKI	Advisor, Office of Planning and Coordination, Tokai Agricultural Administration Bureau, Ministry of Agriculture, Forestry & Fisheries. (MAFF)

3. Irrigation/Drainage Expert

Mr. Hitoshi SATO	Assistant Cheif, Project Planning Section, Planning Dept., Agricultural Structure Improvement Bureau, Ministry of Agriculture, Forestry & Fisheries. (MAFF)

4. Agro-economist

Mr. Yukio SHIMIZU	Assistant Chief, Regional Planning Section, Planning Dept., Tokai Agricultural Administration Bureau, Ministry of Agriculture, Forestry & Fisheries. (MAFF)

(2) Supervisory Team of the Field Study

Leader

Mr. Yasumi YAMAGUCHI	Chief, Technical Affairs Div., Agricultural, Forestry & Fisheries Planning and Survey Dept., Japan International Cooperation Agency.
Mr. Yasuichi SUZUKI	same as preceding
Mr. Yukio SIMIZU	same as preceding

(3) Feasibility Study Members

1.	Team Leader	Mr. Narao TAKEMURA
2.	Meteorology/Hydrology	Mr. Yoshitaka INOUE
3.	Soil & Land Use	Mr. Takeshi SHIRAKI
4.	Geology & Groundwater	Mr. Tetsuo SHIBATA
5.	Agronomy	Dr. Mitsuo YOSHIMEKI
6.	Agronomy	Mr. Izumi IIKAWA
7.	Irrigation/Drainage	Mr. Masanobu SAKURAI
8.	Structure Planning	Mr. Sumio SHINDO
9.	Survey/Structure Design	Mr. Junichi USAMI
10.	Administration/Organization	Mr. Yasuo MAEDA
11.	Civil Work/Cost Estimate	Mr. Tsugio KOISHI
12.	Agro-economy	Mr. Yoshihiro UCHIDA

(4) Officials (Counterparts) of the Government of Peru

1.	Executive Director	Mr. Amilcare Gaita Z.
2.	Formulating Projects Acting Director	Mr. Jorge Honores R.
3.	Coordinator Peruvian Counterpart	Mr. Carlos Nonone M.
4.	Chief of Regional Office (Huacho)	Mr. Plinio Gutierrez
5.	Resident Engineer (Chancay-Huaral)	Mr. Jorge Salas S.
6.	Soil/Land Use	Mr. Lorenzo Carbajal
7.	Soil/Land Use	Mr. J. Zegarra
8.	Agro-economy	Miss. Haydee Pino N.
9.	Economist	Mr. Ladislao Zafra
10.	Economist	Mr. Ricardo Leon
11.	Irrigation/Drainage	Mr. Juan C. Montalvo
12.	Water Management/Organization	Mr. Felix Hatta S.

2. MAJOR ITEMS OF MEETINGS BETWEEN STUDY TEAM AND THE PERUVIAN GOVERNMENT

Date	Major items
February 18, 1984	Preliminary meeting on the study execution and the problem in the project area
February 23 and 24	Meeting on hydrological study
March 14	Interim meeting
March 24	Meeting on the field study (Huaral)
March 26 and 27	Meeting on the point of issue in the field study (1st stage) and discuss on the 2nd stage field study
June 20 and 25	Meeting by each parts on 2nd stage field study and the point of issue on the planning based on the 1st stage field study
August 6 and 10	Meeting on basic scheme of the Project and result of 2nd stage field study
August 7	Joint meeting
August 23	Explanation of Field Report