FINAL REPORT

VOLUME III SUPPORTING REPORT

D. IRRIGATION AND AGRICULTURE

STUDY
ON
INTEGRATED WATER RESOURCES DEVELOPMENT
IN THE CAÑETE RIVER BASIN
IN
THE REPUBLIC OF PERU

FINAL REPORT
VOLUME III
SUPPORTING REPORT

D: Irrigation and Agriculture

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Chapter 1 Present Agricultural Conditions

1.1 Peruvian Agriculture and Its Market

It should be noted that the agricultural balance of trade of Peru in the year 1998 was a deficit of US$ 668 million, i.e. the importation of US$ 1,271 million and the exportation of US$ 603 million. The success of agriculture, agro-industry and agro-exportation would contribute the alleviation of rural poverty and the deficit of balance of trade.

The Peruvian agriculture has a large potential to reduce the imports and increase the exports. At present, however, the agro-export of Peru is concentrated in few products and few markets. In the year 1997, the exported agricultural products had a value of US$ 860.7 million (FOB price), coffee and asparagus shared 63% (US$ 397.2 and US$137.9 million, respectively). They were followed by sugar, cochineal, cotton, marigold flour, cocoa and dying lacquer. The United States and Germany imported 50% of the total value (US$ 289.0 and US$ 142.3 million, respectively), particularly, the former imported coffee, sugar and asparagus, and the latter did coffee and asparagus. Other important destinations were Spain (asparagus), Japan (coffee) and Netherlands.

The strategies to develop the agro-export should be aimed to achieve several changes that rebound to a better and larger competitiveness in this sector. They are pointed out to be as follows:

- To increase the access of the population to an education of quality that develops the human values and the permanent self-learning capacity,
- To adequate the structure of institutional mechanisms to achieve the necessary coordinated participation that ensures the success in the export operation,
- To encourage the organization of producers and the cooperation between farmers and exporters,
- To promote the establishment of national "trading" and national and international strategic alliances,
- To direct and encourage the investments so as to achieve larger scale economies, productivity per worker, added value of the export products and diversification both of the exportable offering and of the market per products,
- To promote the decentralization of the agricultural development, encouraging the agro-industry, and
- To plan the development and to establish priorities in the investments of the public sector.

1.2 Land Tenure and Holdings

The Cañete Valley has 24,462 ha of agricultural land, which is distributed to 5,158 families (or business units). The small properties prevail in relation with the number of units and the agricultural area. The average landholding size of the irrigated area is 4.74 ha. The property stratum of which area varies between 0.5 and less than 10 ha covers 66% of the total agricultural area of the valley. Agrarian structure of in terms of landholding in the Cañete Valley is shown in Table 1.1.

According to the census information in 1994, about 94% of the agricultural units were directly managed by their owners and 6% were rented. In the last five years, the leasing or renting areas have been increased. In general, the tenant farmers maintain certain level of efficiency, and they intend to widen their agricultural area as economical resources.

1.3 Agricultural Activities

1.3.1 Family Structure

In an agricultural unit, number of people varies between 4 and 13, including parents and children, in some cases grandparents, relatives(uncles and/or nephews) and others. Regarding the decision making on farming issues, it was revealed that in the 53% of cases this is the task for the farther, in the 31% the decision is shared with the wife and the 11% this is a sole decision of one woman, in other cases some of the sons take part of it. In these years, the sons are establishing independent familiar units and demand or expect that a part of the parcel would be given to them.

1.3.2 Generation Problem

Certain percentage of the youth reject the agricultural activities consciously or unconsciously. Perhaps, the television shows a reality that attracts the youth and induces to emigrate or to get involved in an activity different from the agriculture: in many cases the pressure to the family so as to receive higher income favors this situation. In the management of farm, the chief of the family adult or older (between 30 and 81 years old on average) transfer gradually delegation of the farming responsibility to the son or relative.

1.3.3 Family Manpower

It is understood that 51.5% of the members of the family participate in the farming tasks of their unit and 14.5% in other units:most of them carry out general works such as grubbing agrochemical application, irrigation and others. It is common that the woman has a hew-hour working day because of her role in the preparation of food. The working schedule is determined by the proprietor, area, crop and labor; but in general the people work in the morning and they are involved in other activities in the afternoon.

1.3.4 Access to Farming

There is an excess of manpower, even when in Some months of the year though it is scarce. The daily working hour is 5 or 6, and wages are US$ 3.5. There are sufficient farming machinery services, and all the cultivated lands are mechanized to a large or less extent. In the area, there are many agricultural shops that supply necessary raw materials for the activity, in many cases they offer open farm credit and technical assistance services. All the units have direct access to any thoroughfare.

1.4 Water Users' Association

At present, there are 63 Technical Administrations of Irrigation Districts implemented in the country. The Boards of Users (BU) are made up of water users solely for agricultural purposes, whereas small-scale agencies are formed by Irrigators' Commissions and Irrigators' Committees. There is usually a Board of Users per Valley, and since a Technical Administration may cover more than one valley, it may exist more than one Board of Users in a Technical Administration of Irrigation District (ATDR). In the case of the Mala-Omas-Cañete ATDR, there are two Boards of Users:the Mala Valley BU and the Cañete BU.

In the Valle de Cañete, there are seven Irrigators' Commissions, organized according to the same number of the following main canals:

- Nuevo Imperial Canal
- Viejo Imperial Canal
- Huanca Canal
- Palo Herbay Canal
- Maria Angola Canal
- San Miguel Canal
- Pachacamilla Canal

1.5 Land Use

The Cañete river basin covering an area of approx. 618,900 ha is divided into five (5) categories in terms of present condition of land, namely (i) irrigated agricultural lands with an area of approx. 33,400 ha (5.4%), (ii) non-irrigated agricultural lands of 2,100 ha (0.3%), (iii) grass lands for shepherding of 113,700 ha (18.4%), (iv) desert/dune of 116,500 ha (18.8%), (v) exposed rock of 353,200 ha (57.1%), and in addition, some forests with an area of 200 ha exist (Source: Inventario, Evaluacion y Uso Racional de los Recursos Naturales de la

Costa Cuenca del Rio Cañete prepared by ONERN in June 1970). (see Figure 1.1)

In view of agricultural land use of (i) and (ii) above, the basin is divided into three (3) areas, namely, the sector el valle, the sector Caltopa-Zuniga and the sector Andino based on the topography soil, climate, etc. as discussed in the following paragraphs.

The sector el valle is located downstream the Nuevo Imperial intake covering a total area of 35,800 ha. Irrigation is practiced for an area of 24,100 ha or 67% of the area, which is divided into small pieces for private farms of large and middle extension. It is observed that the extensive cultivation of cotton, maize and potato occupies an area of 17,200 ha or 71% of the net agricultural land.

The sector Caltopa-Zuniga embraces the agricultural land located upstream the Nuevo Imperial intake up to Zuniga locality with a total area of 1,600 ha. The cultivation distribution in this area is not so different from that of the sector el valle. However, there is a predominance of orchard as it occupies an area of 670 ha, while cotton does 280 ha and pasture, 260 ha, It should be noted that forests with an area of approx. 200 ha are situated in this area.

The sector Andino pertains to the upper and middle reaches of the Cañete river basin. Most of the agricultural lands are scattered along the Cañete river and its tributaries. The agricultural activity is limited to the wet season lasting from October to March. Total agricultural lands are estimated at approx. 9,800 ha, out of which 2,100 ha are non-irrigated and 7,700 ha are supplementarily irrigated. The crops which prevail in the area are alfalfa, maize, potato and other kinds of forage (Source: Inventario y Evaluacion de los Recursos Naturales de la Microrregion de Yauyos prepared by ONERN in 1989).

Chapter 2 Soils

2.1 General

The characteristics of soils in the Cañete Valley are detailed in the Report "Inventario, Evaluacion y Uso Racional de los Recursos Naturales" prepared by ONERN in June 1970 (See Pages from 80 to 198). This paper briefs (a) Classification of soils and (b) Salinity and drainage condition.

2.2 Classifications of Soils

2.2.1 General Aspects

The difference among the kinds of lands for the purpose of irrigation is based on three main physical factors: soil, topography and drainage.

(1) Soil factor

This factor is related to the characteristics of the edaphic profile, such as an effective depth, prevailing texture, water retention capacity, porosity and friability of the layers, proportion of coarse element and presence of salts in amounts that are harmful for plant growth.

The characteristics that influence directly on the soil management under irrigation are the moisture retention capacity, infiltration rate, effective depth, coarse element content and the physical conditions of the surface and of ground water layers.

Other important characteristics are fertility, presence of different kinds of harmful salts and of ground water within the root zone. To some extent, it is possible to modify and correct the influence of these characteristics by means of leveling of slope, selection of crops, drainage, spacing of furrows and frequency of irrigation.

(2) Topography factor

To analyze this factor, three main aspects shall be considered: leveling of slope, nature of surface and location.

The leveling of slope influences adjusting the distribution of runoff, that is, surface drainage. Therefore, the most convenient levels are determined taking into account especially the tendency of soils to erosion.

As for the location, three specific cases are considered:

- Isolated; requires excessive costs for water supply,
- High: requires special engineering work to lift water, and
- Low: requires drainage by means of gravity and/or pumping

(3) Drainage factor

Drainage is related to the soil permeability, the nature of the substrata, topography and depth of ground water. Inner drainage is very important, which influences on the fertility, production costs, crop adaptability, etc.

2.2.2 Classification of Lands

The present classification system has different categories of soil groups based on their suitability for irrigation. The highest category divides lands into three groups:

(a) Lands that are suitable for irrigation

(b) Lands that have a limited suitability; and

(c) Lands that are not suitable for irrigation.

These general groups are subdivided into classes of suitability, which are the basic units according to the adaptability to irrigation agriculture. The first group is subdivided into three classes of suitability: 1 to 3, wherein limitations, needs and production costs increase progressively. The second group has only one class of suitability, Class 4, that is limited aptitude. Finally, the third one is subdivided into two classes of suitability, 5 and 6, which are considered unsuitable for irrigation.

Generally, Class 5 is considered as a temporary grouping. Soils that are included in this class should be eliminated temporarily from irrigation projects until economic and engineering measures are available in order to define its definitive category.

Classes, in turn, are divided into subclasses, which state the limitation factor according to soils, topography or drainage.

In the study area, six classes of suitability for irrigation described previously were defined. In relation to subclasses, the limitation factor is identified as follows:

s - soil

t - topography

ℓ - salt

w - drainage

Although the excess of salts (l) is usually considered as the unsuitable soil, it is independent here because it constitutes a specific characteristics within the factor in soil, besides being one of the interpretative objectives of this study. In turn, strictly physical deficiencies remain within the soil limitation(s).

In the oases wherein two or three prevailing limitation factors or interactions have been identified, these have been ordered in the following sequences: s, t, ℓ, and w.

In this respect, the following factors have also been identified; soil and topography (st); soil and salinity (sl); soil, topography and salinity (stl); soil, salinity and drainage (slw) and topography, salinity and drainage (tlw).

General Table No. 2.1 indicates the approximate extension and scope of the classes and subclasses of irrigation aptitude of the lands in the Cañete Valley.

The following paragraphs describe the kinds of lands according to their suitability for irrigation.

a) Class 1: Suitable

This class of land covers an area of about 2,703 ha, that is 9.7% of the total study area. Soils included in this class of aptitude are the following: Chilcal (CH), Ungara (UG), Polo (P), Montalvan (MV) and Ihuanco (CH).

This class includes lands considered as those that have the highest agricultural quality within the irrigated area. They are flat and even lands, with gentle slopes between 1 and 2%, very deep more than 120 cm of mean to moderately heavy texture, with excellent porosity and permeability, which provides an adequate balance in their hydraulic properties (infiltration rate and water movement through the soil). They are soils that have excellent drainage and are free of accumulation of soluble salts in amounts harmful for the plant growth and development. Because of their optimal conditions of soil, topography and drainage and because they are not exposed to hydraulic erosion, these lands do not require special works, except the normal engineering works for irrigation supply. Its agricultural exploitation is carried out within relatively wide economic margins.

b) Class 2: Suitable

This class of lands include an area of about 8,286 ha, that is 29.6% of the total study area. Soils included in this aptitude are the following: Hualcara (HL), San Isidro (SI), Pasamayo (PM), Casa Blanca (GB), Cañete (CN), drained Cantagollo (CG-d), slightly sloped Pasamayo and undulated Hualcara (HL-BB).

Soils included in this class of suitability have slight or moderate deficiencies that make them somewhat inferior to those included in Class 1. Therefore, the productive capacity is normally lower and requires more intensive agricultural actions and higher costs than the lands of the previous class. The main limitations of these soils are found especially in effective depths lower than the optimal one, more or less moisture retention (soils that are somewhat humid, or on the contrary, dry or absorbent), textures that usually are likely to a slight accumulation of coarse material on the surface or problems in the drainage system, presence of salts and somewhat heterogeneous topographic conditions.

In Class 2, it is recognized that the subclasses of aptitude are as follows: 2s (soil); 2t (topographic); 2ℓ (salinity); 2st (soil and topographic); 2sl (soil and salinity); 2stl (soil, topography and salinity) and 2slw (soil, salinity and drainage).

c) Class 3: Suitable

This class of lands includes an area of about 10,600 ha, that is 37.9% of the total cultivated area. Soils included in this class are the following: Pedrones (PE), Arenal (AR), San Jeronimo (SJ), Quilimana. (QU), slightly inclined Pedrones (PE-B), Chacramar (CHM), Imperial (IP), Ribereno Seco (RS), Palo Negro (PN), San Francisco (SF), Santa Rosa (SR), imperfectly drained San Pedro (SP-h) and Cantagallo (CG).

Soils of this class have moderate conditions for irrigation, but their agricultural quality is much more restricted than that of Class 1 and 2 soils because one or more limitation factors are stressed. They require much more intensive management and corrective practices than Class 2 soil do in order to locate them in a productive and economically favorable framework. Limitations are related to the soil factor (effective shallow depth, low moisture retention, or vice versa, excess of coarse fragments or elements on the surface; accumulation of harmful amounts of salts related normally to deficient drainage conditions; adverse topographic characteristics, such as variable gradients and unevenness of the surface.

In Class 3 of aptitude for irrigation, the following subclasses have been identified: 3s (soil), 3st (soil and topography); 3sl (soil and salinity), 3slw (soil, salinity and drainage) and 3tlw (topography, salinity and drainage).

d) Class 4: Marginal

This class of lands includes an extension of about 3,528 ha, that is 12.6% of the total study area. Soils included in this aptitude are the following: Contapiedras (CP), Herbay (HB), Piedras (P1), Lindero (LD), saline Arenal (AR-s), Ribereno Humedo (RH) and Agua Dulce (AD).

This class includes lands whose development is much more limited than in the classes mentioned due to a severe limitation of the soil, topography or drainage factors or excessive accumulation of salts. These lands are generally cultivated under irrigation, but their strong limitations prevent them from reaching the productivity levels of the previously mentioned good quality lands. They need very intensive corrective actions at high costs in order to locate them within an economically favorable production framework. Limitations include the presence of very shallow lands (Piedras, Contapiedras, salt Arenal, for example) which have very low retention capacity, light texture and high accumulation of coarse fragments both on the surface and subsurface, as well as adverse slope conditions, or vice versa, excessively heavy soils, low permeability and hard work conditions (Agua Dulce, for example), soils that have serious limitation in the drainage system (too high water table) related to convex or depressed topographic conditions, generally including an excessive accumulation of salts.

In this class, the following subclasses have been identified: 4st (soil and topography), 4sl (soil and salinity), 4stl (soil, topography and salinity) and 4slw (soil, salinity and drainage).

e) Class 5: Unsuitable (temporary grouping)

This class includes an area of about 1,256 ha (4.5% of the total study area). Soils included in this class are the following: poorly drained San Francisco (SF-w), Puquio (PU), poorly drained Santa Rosa (SR-w) and Cerro Awl (CA).

This class includes lands that do not have a real but potential agricultural value; that is, lands that could be included in the preceding classes, upon economic and engineering intervention for their improvement.

In this class, only one subclass has been recognized: 5siw (soil, salinity and drainage).

f) Class 6: Unsuitable

This class includes an area of about 1,582 ha, equivalent to 5.7% of the total study area. Soils included in this class are two: Carcavas (CV) and Cauce del Rio (RW).

Lands included in this class are considered unsuitable for irrigation purposes, because they do not have the minimum requirements for suitability. Class 6 lands of the study area are characterized because they basically have very severe limitations of the soil and topography factors. These are very shallow soils, with skeleton of fragmentary morphology because of high rocky-gravel accumulation, excessive filtration and serious deficiencies of the topographic factor.

Other series excluded from this classification, which includes lands unsuitable for irrigation, are the following: Play a series (PY) and Cerros series (M).

2.3 Salinity and Drainage Conditions

2.3.1 Classification of Soils end Drainage Conditions

As far as salt content is concerned, two classes of soil have been determined in the study area; normal and saline ones

Analyses prove that soils in certain areas contain a high content of exchangeable sodium. Nevertheless, these are very restricted areas and soils whose physical characteristics do not have evident adverse influence from sodium. For this reason, its cartographic separation and corresponding identification have been considered unnecessary. Table 2.2 shows the classification and level of adverse influence due to salinity and drainage of the different categorized soils.

a) Normal Soils

These soils include 10,657 ha, that is, 38.2% of the study area. They are soils that are usually free from salinity and deficient drainage problems. They embrace half of the series of soils identified in the agricultural recognition, as seen in Table 2.2.

b) Saline soils

About 15,716 ha or 56.1% of the total recognized lands in the valley are considered in this classification. These soils have been recognized in two groups: (1) incipient salinity soils and (2) evident salinity soils.

(1) Incipient Salinity Soils

They cover an area of about 10,261 ha, that is 36.7% of the study area. They are represented by six series of soils and two stages: Casa Blanca, Cañete, undelated Hualcala, Chacramar, Imperial, Ribereno Seco, Contapiedras and Arenal Salino.

(2) Evident Salinity Soils

This term is used for all the soils classified as saline and whose influence is proven both in the laboratory and in the field. Taking into account the extent of the influence, soils have been classified into four groups;

- low to moderate salinity, with moderate drainage
- moderate to high salinity, with imperfect drainage
- moderate to high salinity, with poor drainage
- high to very high salinity, with very poor drainage

a) Low to moderate salinity, with moderate drainage

This group includes four series that cover about 2,993 ha in total, which represent 10.6% of the study area.

They are soils wherein salt content ranges between 4 and 15 milimhos x cm approximately, but different from the previous group, drainability conditions exert a drastic influence on salt accumulation. Therefore, the policy that should be applied with these soils varies regarding those of the first group.

Representative series of this grouping are the following: San Pedro, Cantagallo, San Francisco and Santa Rosa. In all of them, the level of groundwater table is between 1 and 2 m deep. The presence of flecks on the profiles is evident, and the aeration conditions are not good.

b) Moderate to high salinity, with imperfect drainage

This group covers an area of about 1,206 ha, that is 4.3% of the total study area. This group includes the following series and stages; imperfectly drained San Pedro, Ribereno Humedo, Herbay and Agua Duke.

The level of the water table was detected between 75 and 125 cm. They are soils that have poor physical conditions, evidenced by the presence of glazed horizons and abundant specks. Salinity is variable, being its most frequent accumulation ranging between S and 15 milimhos x cm.

c) Moderate to high salinity soils, with poor drainage

They cover an area of about 528 ha,, that is 2.1% of the study area. These characteristics involve soils included in one series and two stags: Puquio, poorly drained San Francisco and poorly drained Santa Rosa.

In general terms, salinity ranges from 8 to more than 15 milimhos x cm. The level of the water-bearing stratum is between 25 and 75 cm.

d) High to very high salinity, with very poor drainage

They cover an area of about 674 ha that is 2.4% of the total study area. Cerro Azul series is only one member of this group.

It is an area located at sea level or about sea level, wherein salinity has reached the maximum value in Cañete Valley. Saline concentration ranged from surface to 1 m deep, between 125 and 38 milimhos x cm.

Chapter 3 Expected Yield and Production

3.1 Expected Yield arid Price Prospect

In estimating yields of the crops proposed for the project, the available yield data from the following sources were taken into consideration:

- Existing irrigated area in the Valle de Cañete; and
- Potential crop yields from experimental data (Cementos Lima).

The price prospects for the agricultural products are assessed based on the current market prices, The present yields, expected yields and the anticipated prices are shown in the following table:

Crop	Present yield (ton/ha)	Anticipated yield (ton/ha)	Anticipated price (US$/Kg)
Cotton	2.7	3.7	0.73
Starchy maize	10.0	12.0	0.15
Potato	20.0	35.0	0.10
Yellow maize for feed	5.0	9.0	0.26
Horticulture	30.0	40.0	0.15
Citrus	7.5	16.0	0.25
Fruits	7.5	15.0	0.24
Asparagus	5.0	8.0	0.90
Pasture	20.0	30.0	0.30

3.2 Crop Budgets and Production Value

Crop budgets for "without project condition", and for the proposed crops "with project condition" which are based on the estimated production costs and gross income are summarized as follows:

(Without project condition, Unit: US$/ha)

Crop	Gross income	Production cost	Net income
Cotton	1,970	790	1,180
Starchy maize	1,500	600	900
Potato	2,000	660	1,340
Yellow maize for feed	1,300	520	780
Horticulture	4,500	2,140	2,360
Citrus	1,870	240	1,630
Fruits	1,800	350	1,450
Asparagus	4,500	2,140	2,360
Pasture	1,800	580	1,240

(With project condition, Unit: US$/ha)

Crop	Gross income	Production cost	Net income
Cotton	2,700	1,440	1,260
Starchy maize	1,800	1,130	670
Potato	3,500	1,990	1,510
Yellow maize for feed	2,340	1,130	1,210
Horticulture	6,000	1,900	4,100
Citrus	4,000	1,500	2,500
Fruits	3,600	1,500	2,100
Asparagus	7,200	2,900	4,300
Pasture	2,400	1,110	1,290

The production values for the Valle de Cañete under "without project condition" are summarized as shown in Tables 3.1. The Valle de Cañete with project condition in Table 3.2. The Pampas de Concon - Topara y Chincha with project condition in Table 3.3. The Pampas de Altas de Imperial with project condition in Table 3.4. The Coastal Areas (Rio Omas, Rio Mala and Quebrada Chilca) with Project Condition in Table 3.5.

Chapter 4 Present and Future Water Demand Projection

4.1 Agricultural Water

4.1.1 General

It should be noted first of all that large scale development of irrigated agriculture is not expected in the upper basin higher than Nuevo Imperial because the land development has already been maximized wherever topography permits. Rather, population in this area has been decreasing, and part of the terraces developed in high and very steep lands has been abandoned. The fact indicates that the Study on water demand can be made without considering further water use for agriculture in the area. Therefore, the Study will be carried out for the areas located downstream the Nuevo Imperial intake.

The existing condition of the Cañete river basin is complicated in view of topography and climate. Especially, altitude ranges from seashore (0 m msl) to origin of the river (more or less 5,000 m msl). The basin is divided into three zones, i.e. upper, middle and lower basins for the Study on river discharge and rainfall. The distribution chart of yearly rainfall indicates that there are considerable rainfall in the high mountain ranges and little in the coastal areas. Temperature also depends on the altitude. Likewise, any other climatic conditions differ from place to place. It should be noted that dense cloud (mist) prevails in the coastal area during the months of May to September.

Most of the existing agricultural lands and virgin lands which are proposed for agricultural development with water are situated in the lower basin of the river, of which climatic conditions seem to be represented by the records at the Cañete meteorological station. In this regard, the climatic information at this station is used for the period of 30 years from 1969 to 1998 for the Study on agriculture.

4.1.2 Present condition of agriculture and irrigation

(1) Present condition of agriculture

The present agricultural land in the Study area is located in and around the San Vicente de Cañete within the range of approx. 15 km from the coast extending towards northeast and approx. 18 km from northwest to southeast, mostly on the right bank of the Cañete river.

The local Government offices concerned have conducted inventory surveys for the areas being irrigated for six times since 1970. The result is shown in the table below. It is understood from the table that the total net area of the agricultural land ranged between 22,193 ha and 23,614 ha.

Name of Agencies	Year	Cultivated Area
Oficina Nacional de Evaluacion de Recursos Naturales – ONERN	1970	23,200.00
Administracion Tecnica de Agua del Rio Cañete – ATAC	1970	23,415.66
Padron de Usuario del Distrito de Riego Cañete – PUDRC	1972	22,193.31
Direccion Generai de Aguas – DGA	1993	22,583.05
Junta de Uruarios, Cañete – JUC	1990	22,214.51
Proyecto Especial Sur Medio – INADE	1990	23,614.26

INADE summarized the land use in the Valle de Cañete. It indicates that out of the total land area of 28,983 ha, agricultural lands can be extended to 24,052 ha or 83.0%, which consist of 43.3% of extensive cultivation of cotton, 16.3% of maize and potato, 3.0% of horticulture, 8.6% of orchard of apple, grape, citrus, etc. and 11.8% of fodder. Remaining lands with an area of 4,931 ha or 17.0% consist of urban areas and/or public and private properties, and unsuitable areas for agriculture due to ill soil and salinity.

(2) Present condition of irrigation

In order to grasp the water demand in the existing condition (See Fig. 4.1), estimate of consumptive use was based on the potential evapotranspiration worked out by the methods of Hargreaves, Radiation and Blanney-Criddle (Source: Hidrologia Valle Del Cañete, INADE, June 1990). However, according to the guideline prepared by FAO (1977), it is suggested that modified Penman method be used since it offers the best results with minimum error of plus or minus 10% in summer, and up to 20% under low evaporative conditions, whereas the Radiation method, in extreme conditions, involves a possible error up to 20% in summer, and the Blaney-Criddle method should only be applied for a period of one month or longer; in humid, windy, mid-latitude winter conditions. Table 4.1 compares the potential evapotranspiration calculated by the three methods of Hargreaves, Radiation and Blanney-Criddle with the modified Penman method (calculated by the JICA Study team). It is understood that the potential evapotranspiration calculated by the modified Penman method gives the lowest values. It is important to note that dense cloud (mist) prevails during the months from May to September in this area, and hence sunshine hour is eventually short. Since the Blanny-Criddle method neglects sunshine hour in its formula, it should not be used in such area in predicting evapotrnspiration as presented in the said study report. In this regard, the modified Penman method will be used for the Study on the water demands for agriculture hereinafter.

A higher level of dependable rainfall (say 9 out of 10 years) needs to be selected during the periods that crops are germinating or are most sensitive to water stress, and yields are severely affected. Only a portion of heavy and intensive rains can enter and be stored in the root zone and the effectiveness is consequently low. It is recommended that the daily rainfall less than 5 mm/day is to be regarded as non-effective (FAO Irrigation and Drainage Paper No. 25, Effective Rainfall, 1975).

Probability analysis of daily rainfall is conducted by Gumbel method using the records at Cañete Meteorological Station covering a period of 30 years from the years 1969 to 1998. It is understood from the analysis that the dependability of once two years is 4 mm/day and that of 9 out of 10 years is only 0.9 mm/day, which is far below the recommended magnitude of 5 mm/day. Moreover, rainfalls which were more than 5 mm/day occurred only eight times in the last 30 years. Considering these situations, it is not practical to anticipate effective rainfall of dependable 9 out of 10 years. Therefore, in estimating water demand for agriculture, rainfalls are regarded as non-effective.

PRONADRET and PE-SUR MEDIO jointly conducted measurement of irrigation canal discharge for the major six (6) canals located downstream the Aforos Socsi Station namely, Canals Nuevo Imperial, Viejo Imperial, Palo Herbay, Ramadilla, Meria Angola and San Miguel from August 1990 to July 1991 in order to estimate the conveyance efficiency of respective irrigation canals. The results are shown in the following table:

Irrigation Canal	Conveyance Efficiency (%)
Canal Nuevo Imperial	81
Canal Viejo Imperial	70
Canal Palo Herbay	78
Canal Remadilla	85
Canal Meria Angola	75
Canal San Miguel	79

It is seen from the above that the conveyance efficiency ranges between 70% and 85% (average: 75%).

(3) Estimate of present water demand

Estimate of the present water demand is based on the potential evapotranspiration (ET_0) worked out by the modified Penman method, of which calculation result is shown in Table 3.2.1. The effect of the crop characteristics on crop water requirement is given by the crop co-efficient (kc) which represents the relationship between potential (ET_0) and crop evapotranspiration (ETcrop) or $ETcrop = kc \cdot ET_0$. On the assumption that the overall irrigation efficiency is 45% (conveyance efficiency: 75%, application efficiency: 60%), and that the cropping pattern being applied is as shown in Fig. 4.2, the total water demand for agriculture for an area of 24,052 is estimated as shown in Table 4.2. It is understood from the table that the annual demand is 378.82 MCM, while the peak demand is 59.86 MCM, which occur in February.

4.1.3 Evaluation of present irrigation water use and problems

There are several problems in the presently irrigated land, the Valle de Cañete, which can be solved by improving and rehabilitating the present conditions in order to economize on the use of water and to raise the agricultural productivity of the land.

(1) Seasonal inconsistency of river discharge and water demand

One of the important problems is the seasonal lack of water for irrigation due to the irregularity of the river flow. The water balance study conducted for the Valle de Cañete indicates that at present there is an annual deficit of approx. 46 MCM, which are equivalent to 12% of the annual demands (Source: Evaluacion de Racional de los Recursos Naturales del Rio Cañete prepared by ONERN in 1970).

(2) Deterioration of the water intake and conveyance facilities

A significant loss of water is observed in the deteriorated intake structures and canals, and temporary structures constructed with gravel and wood, though part of them has been already improved using concrete.

(3) Improper water management

It does not seem that water management is always conducted properly. Many of the gates on the intake structures are deteriorated, and measuring devices have not been fully installed (Installation of measuring flumes and gages have commenced from this year as will be discussed in Chapter 6). Diversion of water in the canals seem to depend on intuition of the local people so far. Since there is no regulating pond (reservoir and/or farm pond), it is hardly possible to manage irrigation water properly. The fact implies that there is a significant loss of water at night.

(4) Low irrigation efficiency

Furrow irrigation is practiced in the area. Its irrigation efficiency is eventually low. In undulating and sloping lands, because of mal-improvement of lands, its efficiency is worse. No water saving irrigation, such as sprinkler and drip methods, etc. is practiced.

(5) Inundated and saline areas

It is important to note that the consecutive loss of land is progressing due to inundation and/or salinization, which have been caused by over irrigation and lack of drainage. The studies made by CENDRET and ONERN indicate that approx. 3,140 ha or 13% of the total cultivated area of the Valle de Cañete are under this situation.

4.1.4 Review of agriculture and irrigation development plans

(1) Valle de Cañete

Although the total area to be irrigated in future is limited to 24,052 ha due to the topographic and soil conditions, it is possible to increase irrigation efficiency by improving conveyance facilities, furnishing regulating ponds and applying water saving irrigation methods. According to the study made by INADE, irrigation efficiency could be raised as high as 55%. However, it does not seem to be practical to raise it more than 50% (conveyance efficiency: 78% and application efficiency: 65%) as indicated by the guideline of FAO (1977), even after the improvement and rehabilitation of the present conditions, as far as the existing canals remain unlined and furrow irrigation is practiced.

(2) Pampas de Concon – Topara y Chincha Alta

Pampas de Concon Topara is located at left bank of the Cañete river. It extends approx. 14 km from the coast towards northeast, and 18 km from northwest to southeast with an area of approx. 27,000 ha. The land is not used at present due to devastated dune. It is proposed to be developed as an irrigated agricultural land by constructing a barrage on the Rio Cañete near Lunahuana, which is located at about 28 km from the estuary, and a main canal from the barrage with a length of 25 km.

The proposed land use (cropping pattern) consists of extensive cultivation of cotton, potato, maize, horticulture (vegetables and flowers), orchard of citrus and mango, and perennial crops (alfalfa, etc.). Nevertheless, recent experience on new irrigation projects shows a trend high yield export oriented cropping patterns. This could be the case of Concon – Topare y Chincha Altas, even though this analysis is beyond the scope of this Study.

For the newly proposed agricultural land, the irrigation efficiency was estimated to be as high as 67% by applying water saving irrigation methods and water conveyance facilities (Source: Hidrologia Valle Del Cañete, INADE, June 1990). However, according to the guideline of FAO, the conveyance efficiency will be, in normal case, 85% for the concrete canals in such a large area and application efficiency, 75% for the sprinkler and drip irrigation methods. As a result, overall irrigation efficiency will be 60%.

(3) Pampas de Altas de Imperial

This project consists of the incorporation of the Pampas de Altas de Imperial and the Pampas de Quilmana (840 ha), Bandurria (1,040 ha), Conta (400 ha) and

Chivato (195ha). The total area for development is estimated at 2,475 ha, of which 1,110 ha are proposed for agricultural development, whilst 1,365 ha for forest exploitation. Considering that the conveyance facilities are proposed to be lined with concrete, irrigation efficiency is estimated at 52% (conveyance efficiency: 80% and application efficiency: 65%).

4.1.5 Potential Agricultural Land Located at the Coastal Area

The area located between the proposed water transmission line and the coast is generally hilly. There exist three non-perennial small rivers in the area, i.e., the Rio Omas, the Rio Mala and the Quebrada Chilca from the east. The estuaries of these rivers are flat, and soils are suitable for agriculture. In this regard, it is proposed to develop these lands for agriculture using the water of the transmission line. In order to minimize the water demand, it is suggested that the conveyance facilities be either concrete flume or pipeline, and water saving irrigation such as sprinkler and/or drip methods be practiced.

Net irrigable area located along the Rio Omas is estimated at 2,720 ha. Irrigation water for the area will be obtained from the transmission line at the station 76+850. Annual water demand is 35.40 MCM on the condition stated above, and peak water demand, 4.74 MCM which occur in February. Thus, the peak discharge of 1.96 m^3/sec is to be released from the transmission line.

The land suitable for the development of irrigated agriculture extends both banks of the Rio Mala with a net area of 1,960 ha. Water is to be issued for the proposed land from the transmission line at the station 112+640. Water demand throughout a year is estimated at 25.51 MCM, whereas that of the peak month of February, 3.42 MCM, which is equivalent to 1.41 m^3/sec.

Likewise, a land potential for agricultural development with an area of approx. 2,270 ha exists along the Quebrada Chilca. Water for the are is to be obtained from the same transmission line at the station 132+650. Annual water demand is estimated at 29.54 MCM, and peak water demand, at 3.96 MCM in also February. Thus the peak discharge to be released will be 1.64 m^3/sec.

4.1.6 Water Demand for Agriculture

The discussions made above for water demands for the respective areas are summarized as follows (see Tables 4.3 (1) to (3)):

1. Independent Projects

Projects	Net Area (ha)	Peak Demand (MCM)	Peak Demand (m^3/s)	Annual Demand (MCM)
Valle de Cañete	24,052	53.89	22.28	340.20
Pampas de Concon – Topara	27,000	47.06	19.45	351.41
Sub-total	**51,052**	**100.95**	**41.73**	**691.61**

2. Projects on the Water Transmission Line

Projects	Net Area (ha)	Peak Demand (MCM)	Peak Demand (m^3/s)	Annual Demand (MCM)
Pampas de Altas de Imperial	2,475	4.06	1.68	30.17
Rio Omas	2,720	4.74	1.96	35.40
Rio Mala	1,960	3.42	1.41	25.51
Quebrada Chilca	2,270	3.96	1.64	29.53
Sub-total	**9,425**	**16.18**	**6.69**	**120.62**

3. Total Water Demand

	60,477	**117.13**	**48.42**	**812.23**

(in February)

Chapter 5 Water Resources Development Plan

5.1 Agricultural Development Sectoral Plan

5.1.1 Agricultural development plan

The study on agricultural development plan was conducted by INADE. In the process of crop selection and formulation of cropping patterns, the physical conditions of the Study area, the general crop selection criteria and the current policies are carefully considered under the following concepts and conditions (Source: Hidrología Valle del Cañete, INADE, June 1990).

- Adaptability of the crop to soil and agro-climatic conditions of the area and its ability to perform optimally under irrigation.
- Expected level of technology and the experience of the farmers.
- Practically in terms of the available labor force.
- Market potential and price prospect for the agricultural products.
- Optimization of the use of the supplied water resource.
- Generation of the maximum benefits to the farmers, to the region and country as a whole.

The propose cropping pattern, developed after due consideration of the matters stated above, is summarized below and presented in Tables 5.1 (1) to (3).

Cropping Pattern in the Valle de Cañete

(Unit: ha)

Crops	Base crops	Rotation crops	Total
Cotton	10,726	-	10.726
Starchy maize and potato	2,745	1,373	4,118
Yellow maize (feed) and starchy maize	1,965	1,965	3,930
Yellow maize (feed)	1,965	1,965	1,965
Cotton (in the submerged area)	1,811	-	1,811
Horticulture	868	868	868
Citrus	819	819	819
Orchard (apple, grape, etc.)	1,710	1,710	1,710
Pasture (alfalfa, etc.)	667	667	667
Starchy maize	776	-	776
Total	**24,052**	**9,367**	**27,390**

Cropping Pattern in the Pampas de Concon - Topara y Chincha Alta

(Unit: ha)

Crops	Base crops	Rotation crops	Total
Cotton	5,400	-	5,400
Starchy maize and potato	3,510	3,510	7,020
Yellow maize (feed) and starchy maize	2,700	2,700	5,400
Horticulture and potato	2,700	2,700	5,400
Citrus	540	540	540
Horticulture	2,700	2,700	2,700
Orchard (apple, grape, etc.)	2,700	2,700	2,700
Asparagus	3,000	-	3,000
Pasture (alfalfa, etc.)	3,750	3,750	3,750
Total	**27,000**	**17,600**	**35,910**

Cropping Pattern in the Pampas de Altas de Imperial

(Unit: ha)

Crops	Base crops	Rotation crops	Total
Cotton	300	-	300
Starchy maize and sweet potato	280	280	560
Horticulture and sweet potato	320	320	640
Orchard (apple, grape, etc.)	210	210	210
Forest	1,365	1,365	1,365
Total	**2,475**	**2,175**	**3,075**

5.1.2 Irrigation development plan

(1) Valle de Cañete (see location in Figure 5.1)

As discussed in the preceding paragraphs, a considerable loss of water is observed due to the deteriorated intake structures and canals. To cope with this situation, the Overseas Economic Cooperation Fund (OECF) of Japan financed for the four sub-projects of (i) Nuevo Imperial, (ii) Viejo Imperial. (iii) Palo Herbay, (iv) Maria Angola y San Miguel, which consist of construction/improvement of intake structures, main and lateral canals, water distribution structures as well as installation of water measuring devices.

In order to control fluctuating river discharge to meet the seasonal agricultural water demand and to maximize irrigation efficiency (furrow irrigation should be practiced only daytime), it is indispensable to regulate water by impounding it in reservoirs and/or in farm ponds. In the Valle de Cañete, there are several natural lagoons. At least, it is possible to store water with a volume of 42.6 MCM by creating reservoirs by means of damming up water in the three lagoons of Paucarcocha, Piscococha and Pariachata.

Development of drainage system is essential in the Valle de Cañete, because it is observed that consecutive loss of land is progressing due to inundation and/or salinization, which have been caused by over-irrigation with saline water and little rainfalls. The depth of drains for desalinization should be more than 2 m with an interval of less than 100 m. The total length of the drains to be constructed is estimated at 78.9 km. It is a common practice to use pumps to drain such water thus collected.

(2) Pampas de Concon – Topara y Chincha Alta (see location in Figure 5.1)

It is possible to develop the lower basins at the left bank of the Rio Cañete and at the right bank of the Quebrada Topara as an irrigated agricultural land using the river water of the Rio Cañete. The intake structure may be located at about 10 km upstream of Luahuana. For the maximum conveyance efficiency, the main canal with a length of 58.38 km will consist of reinforced concrete channel and tunnel, aqueduct, box culvert, etc. The secondary and tertiary distribution networks may require another approx. 360 km of either concrete lined channels or pressure vessels (pipelines).

Mechanical water saving irrigation is proposed to be practiced from the main and the secondary canals. In this regard, electric pumping stations will be installed at the canals so as to boost water to the pipelines, which will be connected to irrigation equipment such as sprinkler and drip. Furthermore, in order to raise application efficiency, land grading will be performed where the topography is undulating.

In view of the existing poor soil condition and little vegetation in the area, it is proposed to improve the soil and to plant trees for protection against the wind under the project. Farm roads will be constructed for the transportation of farming inputs and outputs. For the proper management of the irrigation system, some offices will be build in the area. Any transportation and office equipment necessary for the operation and maintenance of the facilities will be purchased under the project.

However, it should be noted that the preparation of the drainage system will be postponed to the next stage.

(3) Pampas de Altas de Imperial

According to the alternative study on the water transmission line to Lima metropolitan area between the mountain side and the sea side, the former alternative has been selected. In this case, it is possible to irrigate 2,475 ha of lands by means of gravity from the said conveyance facilities at the point at 48 km from the intake (Zuniga), where outlet facilities are to be installed. A concrete regulating pond with a capacity of approx. 200 m^3 will be constructed to receive the water released from the outlet of the conveyance facilities. The total length of the main and lateral canals lined with concrete will be approx. 56 km, and the length of irrigation ditches will be 150 km. In order to cope with the seasonal agricultural water demand and to maximize efficiency of furrow irrigation, which is practiced only daytime, it is proposed to construct a regulating reservoir with a capacity of 8.3 MCM by means of damming up water in Mollococha lagoon. It is noted, however, no development of drainage system is proposed at this stage.

Chapter 6 Water Use Management

The Ministry of Agriculture (MAG) has the primal responsibility for water sector planning and regulatory tasks. In the MAG, the General Directorate for Water and Soils (Direccion General de Agua y Suelos, DIGAS) is the principle agency responsible for water sector. Technical Administration for Irrigation District (ATDR) under DGAS is responsible for planning and regulatory tasks at local level.

At present, there are 63 ATDRs implemented in the country. The Boards of Users (Juntas de Usuarios, JU) are made up of water users solely for agricultural purposes, whereas small-scale agencies are formed by Irrigators' Commissions. There is usually one JU per valley, and since a ATDR may cover more than one valley, it may exist more than one JU in a ATDR (see Fig. 6.1).

In the Valle de Cañete, there are seven Irrigators' Commissions under the respective Irrigation Sub-sectors, organized according to the same number of the following main canals:

Nuevo Imperial Canal

Viejo Imperial Canal

Huanca Canal

Palo Herbay Canal

Maria Angola Canal

San Miguel Canal

Pachacamilla Canal

According to the recent information given by the National Institute for Natural Resources (Instituto Nacional de Recursos Naturales, INRENA) of the Ministry of Agriculture, the DGAS and the ATDR have installed 105 measuring flumes and gauges in the Nuevo Imperial irrigation system this year. In addition, the projects are being executed for the implementation of 200 water measuring devices in the Huanca, Palo Herbay, Maria Angola and San Miguel irrigation systems. Moreover, the Irrigation Sub-Sector Project (SPI) has planned to carry out irrigation system improvement works.

After establishing the distribution systems as well as the operation and management of such systems, monitoring should be executed on a permanent basis for both of the existing and new irrigation projects (such as Pampas de Concon-Topara y Chincha Alta). It includes evaluation of method of supply and scheduling of irrigation water as well as water use efficiencies studies by direct measurements of the respective components. Water use studies in the farmer's field are also required. Particular attention should be given to irrigation methods and practices for traditional and new cropping patterns.

Scheme management including institutional aspects, personnel, communication facilities, and improvement and maintenance schedules should be periodically reviewed.

It is important to establish the demand system with advance scheduling through the above procedures. In other words, requests for water are to be made 2 or 3 days in advance and the distribution of water is to be programmed accordingly. The well-trained staff should be available to operate the system that requires full control of water level and discharge at the intake and at each part of the distribution system.

TABLES

Table 1.1 Agrarian Structure of Cañete Valley

	Size of Agricultural Unit						
	Total	From 0.0 to 0.5 ha	From 0.5 to 4.9 ha	From 5.0 to 9.9 ha	From 10.0 to 19.9 ha	From 20.0 to 49.9 ha	From 50.0 to more ha
Agricultural Units	5,158	229	3,485	1,156	182	75	31
A. Number (%)	100.00	4.43	67.56	22.41	3.52	1.45	0.60
Agricultural Area (ha)	24,462.44	53.05	9,057.27	7,066.66	2,195.98	2,079.11	4,010.29
B. Area (%)	100.00	0.21	37.02	28.88	8.97	8.49	16.39
C. Properties							
with title deed	3,895	151	2,602	889	151	71	31
without title deed	787	71	493	122	101		

Source : III CENAGRO 1994.

Table 2.1 List of Soil Classes and Sub-classes

Class	Ha.	%	Soils included	Sub-class	Ha.	%
			Chilcal			
			Ungara			
1	2,703	9.7	Palo		2,703	9.7
			Montalvan			
			Ihuanco			
			Hualcara			
			San Isidro	2s	3,470	12.4
			Pasamayo		1,712	6.1
			Casa Blanca	21	182	0.7
2	8,286	29.6	drained Cantagallo	2t	2,012	7.2
			Cañete	2sl	32	0.1
			slightly sloped Pasamayo	2st	702	2.5
			San Pedro	2slw	176	0.6
			undulated Hualcar	2stl		
			Palo Negro			
			Pedrones	3s	3,169	11.3
			Arenal			
			San Jeronimo			
			Quilmana			
			slightly sloped Pedrones	3st	134	0.5
3	10,600	37.9	Chacramar			
			Imperial	2sl	4,862	17.5
			Ribreno Seco			
			San Francisco			
			Santa Rosa	3slw	1,973	7.0
			imperfectly drained San Pedro			
			Cantagallo	3tlw	1,062	3.8
			Contapiedras	4sl	1,040	3.7
			Piedras			
			Lindero	4st	967	3.5
4	3,528	12.6	saline Arenal	4stl	459	1.6
			Rivereno Humedo			
			Agua Dulce	4slw	1,062	3.8
			Herbay			
			poorly drained San Francisco			
5	1,256	4.5	Puquio	5slw	1,256	4.5
			poorly drained Santa Rosa			
			Cerro Azul			
6	1,582	5.7	Curcavas (Gullies)			
			Cauce del Rio (Riverbed)			
Total						

Note: In Cantagallo series, corresponding figures shall be 462 ha and 1.6% and not the ones stated in this table.

Table 2.2 Classification, Extension and Approximate Percentage of Soils in Cañete Valley Regarding Salinity and Sodium Content

Classification	Sub-groups	Rate of Affectation	Soils included	Extension			
				Partial		Total	
				Ha	%	Ha	%
Normal	-	-	Chilcal; Ungara; Palo; Montalvan-lhuanco; Hualcara; San Isidro; Pasamayo sligthly sloping; Pedrones; Arenal; San Jeronimo; Quilmana; Palo Negro; Pedrones slightly sloping; Stones; Border.	10.657	38.2	10.657	38.2
Saline	Early Salinity	Slight Salinity without drainage problems	Casa Blanca; Cañete ; Hualcara wavy; Chacramar; Imperial; Dry Riparian Soil, Contrapiedras, Saline sand dune.	10.261	36.7	15.716	56.1
	Evident Salinity	From slight to moderate salinity, moderate drainge.	San Pedro; Cantagallo; San Francisco; Santa Rosa	2.993	10.6		
		From moderate to strong salinity, imperfect drainage	San Pedro imperfectly drained; Humid Riparian one; Herbay; Fresh Water;	1.206	-4.3		
		From moderage to strong salinity, poor drainage	San Francisco poorly drained; Santa Rosa poorly drained; Puquio.	582	2.1		
		Strong to fairly strong salinity, very poor drainage	Cerro Azul	674	2.4		
Series not included in this classification	-	-	River bed; Gullies	1.582	5.7	1.582	5.7
Total				27.955	100.0	27.955	100.0

Table 3.1 The Valle de Canete without Project Condition

Anticipated Annual Production

Crop	Extent (ha)	Anticipated Yield (ton/ha)	Anticipated Annual Production (ton)
Cotton	12,537	2.7	33,850
Starchy maize	5,486	10.0	54,860
Potato	1,373	20.0	27,460
Yellow maize for feed	3,930	5.0	19,650
Horticulture	868	30.0	26,040
Citrus	819	7.5	6,143
Fruits	1,710	7.5	12,825
Pasture	667	20.0	13,340

Anticipated Unit Price

Crop	Unit	Anticipated Price
Cotton	US$/kg	0.73
Starchy maize	US$/kg	0.15
Potato	US$/kg	0.10
Yellow maize for feed	US$/kg	0.26
Horticulture	US$/kg	0.15
Citrus	US$/kg	0.25
Fruits	US$/kg	0.24
Pasture	US$/kg	0.09

Crop Budget

(US$/ha)

Crop	Gross Income	Production Cost	Net Income
Cotton	1,970	790	1,180
Starchy maize	1,500	600	900
Potato	2,000	660	1,340
Yellow maize for feed	1,300	520	780
Horticulture	4,500	2,140	2,360
Citrus	1,870	240	1,630
Fruits	1,800	350	1,450
Pasture	1,800	560	1,240

Production Value

Crop	Production (ton)	Production Value (US$ 1,000)
Cotton	33,850	14,794
Starchy maize	54,860	4,937
Potato	27,460	1,840
Yellow maize for feed	19,650	3,065
Horticulture	26,040	2,048
Citrus	6,143	1,335
Fruits	12,825	2,480
Pasture	13,340	827
Total	194,168	31,326

Table 3.2 The Valle de Canete with Project Condition

Anticipated Annual Production

Crop	Extent (ha)	Anticipated Yield (ton/ha)	Anticipated Annual Production (ton)
Cotton	12,537	3.7	46,380
Starchy maize	5,486	12.0	65,830
Potato	1,373	35.0	48,050
Yellow maize for feed	3,930	9.0	35,370
Horticulture	868	40.0	34,720
Citrus	819	16.0	13,100
Fruits	1,710	15.0	25,650
Pasture	667	30.0	20,010

Anticipated Unit Price

Crop	Unit	Anticipated Price
Cotton	US$/kg	0.73
Starchy maize	US$/kg	0.15
Potato	US$/kg	0.10
Yellow maize for feed	US$/kg	0.26
Horticulture	US$/kg	0.15
Citrus	US$/kg	0.25
Fruits	US$/kg	0.24
Pasture	US$/kg	0.08

Crop Budget

(US$/ha)

Crop	Gross Income	Production Cost	Net Income
Cotton	2,700	1,440	1,260
Starchy maize	1,800	1,130	670
Potato	3,500	1,990	1,510
Yellow maize for feed	2,340	1,130	1,210
Horticulture	6,000	1,900	4,100
Citrus	4,000	1,500	2,500
Fruits	3,600	1,500	2,100
Pasture	2,400	1,110	1,290

Production Value

Crop	Production (ton)	Production Value (US$ 1,000)
Cotton	46,380	15,797
Starchy maize	65,830	3,676
Potato	48,050	2,073
Yellow maize for feed	35,370	4,755
Horticulture	34,720	3,559
Citrus	13,100	2,048
Fruits	25,650	3,591
Pasture	20,010	860
Total	289,110	36,359

Table 3.3 The Pampas de Concon - Topara y Chincha Alta with Project Condition

Anticipated Annual Production

Crop	Extent (ha)	Anticipated Yield (ton/ha)	Anticipated Annual Production (ton)
Cotton	5,400	3.7	19,980
Starchy maize	3,510	12.0	42,120
Potato	8,910	35.0	311,850
Yellow maize for feed	2,700	9.0	24,300
Horticulture	4,500	40.0	180,000
Citrus	540	16.0	8,640
Fruits	2,700	15.0	40,500
Asparagus	3,000	8.0	24,000
Pasture	3,750	30.0	112,500

Anticipated Unit Price

Crop	Unit	Anticipated Price
Cotton	US$/kg	0.73
Starchy maize	US$/kg	0.15
Potato	US$/kg	0.10
Yellow maize for feed	US$/kg	0.26
Horticulture	US$/kg	0.15
Citrus	US$/kg	0.25
Fruits	US$/kg	0.24
Asparagus	US$/kg	0.90
Pasture	US$/kg	0.08

Crop Budget

(US$/ha)

Crop	Gross Income	Production Cost	Net Income
Cotton	2,700	1,440	1,260
Starchy maize	1,800	1,130	670
Potato	3,500	1,990	1,510
Yellow maize for feed	2,340	1,130	1,210
Horticulture	6,000	1,900	4,100
Citrus	4,000	1,500	2,500
Fruits	3,600	1,500	2,100
Asparagus	7,200	2,900	4,300
Pasture	2,400	1,110	1,290

Production Value

Crop	Production (ton)	Production Value (US$ 1,000)
Cotton	19,980	6,804
Starchy maize	42,120	2,352
Potato	311,850	13,454
Yellow maize for feed	24,300	3,267
Horticulture	180,000	18,450
Citrus	8,640	1,350
Fruits	40,500	5,670
Asparagus	24,000	12,900
Pasture	112,500	4,837
Total	763,890	69,084

Table 3.4 Tha Pampas de Alta de Imperial with Project Condition

Anticipated Annual Production

Crop	Extent (ha)	Anticipated Yield (ton/ha)	Anticipated Annual Production (ton)
Cotton	300	3.7	1,110
Starchy maize	280	12.0	3,360
Sweet Potato	600	30.0	18,000
Horticulture	320	40.0	12,800
Fruits	210	15.0	3,150
Forest	1,365	-	-

Anticipated Unit Price

Crop	Unit	Anticipated Price
Cotton	US$/kg	0.73
Starchy maize	US$/kg	0.15
Sweet Potato	US$/kg	0.10
Horticulture	US$/kg	0.15
Fruits	US$/kg	0.24
Forest		-

Crop Budget

(US$/ha)

Crop	Gross Income	Production Cost	Net Income
Cotton	2,700	1,440	1,260
Starchy maize	1,800	1,130	670
Sweet Potato	3,000	1,500	1,500
Horticulture	6,000	1,900	4,100
Fruits	3,600	1,500	2,100
Forest	-	-	-

Production Value

Crop	Production (ton)	Production Value (US$ 1,000)
Cotton	1,110	378
Starchy maize	3,360	188
Sweet Potato	18,000	900
Horticulture	12,800	1,312
Fruits	3,150	441
Forest	-	-
Total	38,420	3,219

Table 3.5 The Coastal Areas (Rio Qmas, Rio Mala and Quebrada Chilca) with Project Conditio

Anticipated Annual Production

Crop	Extent (ha)	Anticipated Yield (ton/ha)	Anticipated Annual Production (ton)
Cotton	1,390	3.7	5,140
Starchy maize	900	12.0	10,800
Potato	2,290	35.0	80,150
Yellow maize for feed	690	9.0	6,210
Horticulture	1,160	40.0	46,400
Citrus	140	16.0	2,240
Fruits	690	15.0	10,350
Asparagus	770	8.0	6,160
Pasture	970	30.0	29,100

Anticipated Unit Price

Crop	Unit	Anticipated Price
Cotton	US$/kg	0.73
Starchy maize	US$/kg	0.15
Potato	US$/kg	0.10
Yellow maize for feed	US$/kg	0.26
Horticulture	US$/kg	0.15
Citrus	US$/kg	0.25
Fruits	US$/kg	0.24
Asparagus	US$/kg	0.90
Pasture	US$/kg	0.08

Crop Budget

(US$/ha)

Crop	Gross Income	Production Cost	Net Income
Cotton	2,700	1,440	1,260
Starchy maize	1,800	1,130	670
Potato	3,500	1,990	1,510
Yellow maize for feed	2,340	1,130	1,210
Horticulture	6,000	1,900	4,100
Citrus	4,000	1,500	2,500
Fruits	3,600	1,500	2,100
Asparagus	7,200	2,900	4,300
Pasture	2,400	1,110	1,290

Production Value

Crop	Production (ton)	Production Value (US$ 1,000)
Cotton	5,140	1,751
Starchy maize	10,800	603
Potato	80,150	3,458
Yellow maize for feed	6,210	835
Horticulture	46,400	4,756
Citrus	2,240	350
Fruits	10,350	1,449
Asparagus	6,160	3,311
Pasture	29,100	1,251
Total	196,550	17,764

Table 4.1 Comparison of ETO Estimated by the Different Methods

Station: Cañete - Latitude 13°07' S
Longitude 76°12' W

Month	Hargreaves		Radiation		Blanny - Criddle		Modified Penman	
	ET_0 (mm/month)	ET_0 (mm/day)	ET_0 (mm/month)	ET_0 (mm/day)	ET_0 (mm/month)	ET_0 (mm/day)	ET_0 (mm/month)	ET_0 (mm/day)
Jan.	151.25	4.88	151.94	4.90	169.01	5.45	128.03	4.13
Feb.	136.65	4.88	139.63	5.00	152.65	5.45	121.80	4.35
Mar.	138.03	4.45	142.47	4.60	163.79	5.28	118.42	3.82
Apr.	108.33	3.61	128.38	4.28	147.96	4.93	105.00	3.50
May	80.17	2.59	92.84	3.00	139.24	4.49	78.74	2.54
Jun.	70.93	2.36	53.40	1.78	125.10	4.17	60.30	2.01
Jul.	65.89	2.13	49.48	1.60	126.33	4.08	55.80	1.80
Aug.	75.15	2.42	52.71	1.70	128.73	4.15	59.21	1.91
Sept.	86.06	2.87	65.45	2.18	129.65	4.32	69.90	2.33
Oct.	109.87	3.54	91.27	2.94	143.07	4.62	88.66	2.86
Nov.	124.96	4.17	110.12	3.67	148.39	4.95	105.00	3.50
Dec.	142.90	4.61	136.02	4.39	163.20	5.26	121.52	3.92
Total / Average	1,290.19	3.54	1,213.71	3.34	1,737.12	4.76	1,112.38	3.06

Note: In estimating consumptive water requirements, it is recommended to use modified Penman method as calculated by the JICA Study Team.
ET_0 : Potential Evapotranspiration

Table 4.2 Irrigation Water Demand at the Existing Condition

in the Valle de Cañete (24,052 Ha)

(Unit : MCM)

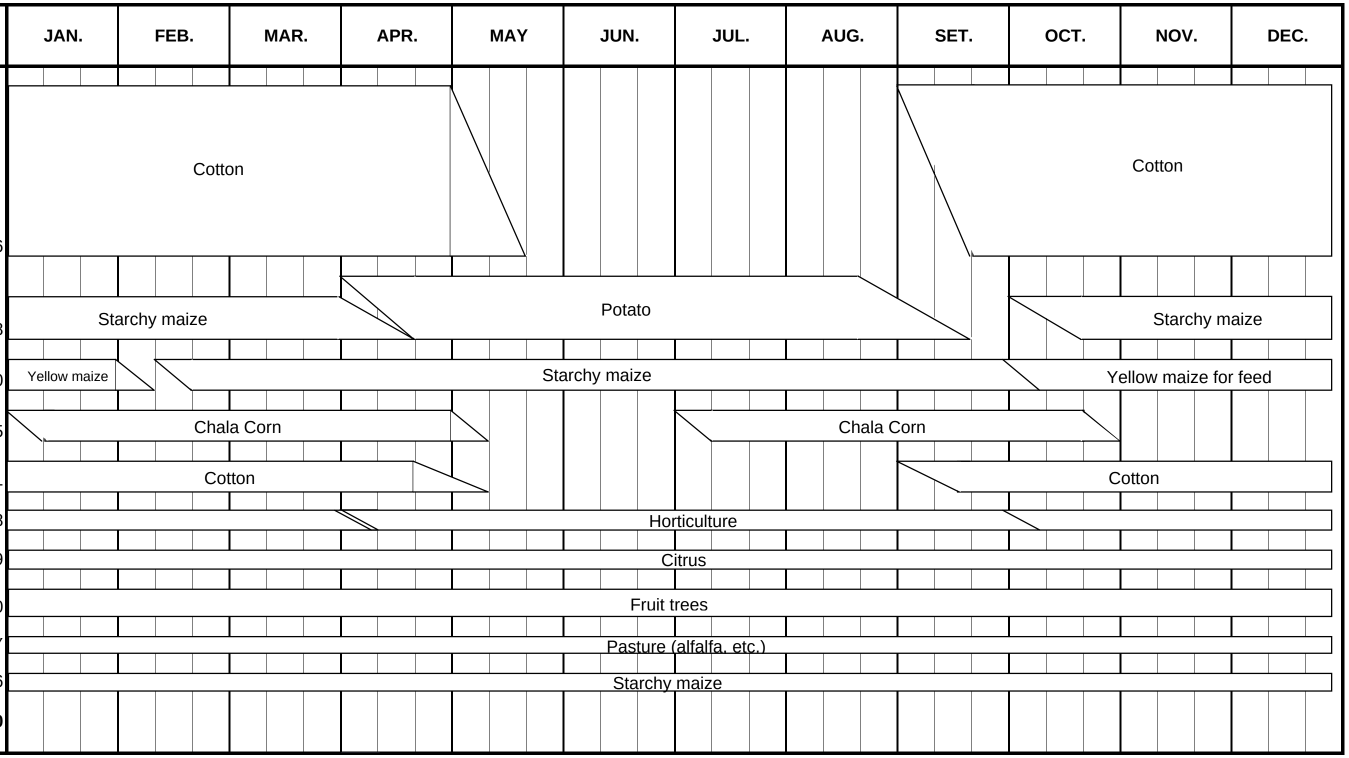
Crops (ha)	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cotton	10,726	31.03	32.68	28.39	16.50					6.24	10.73	20.02	28.79	174.38
Starchy maize	1,373	3.96	4.15	2.86							0.92	1.66	3.06	16.61
Potato	2,745				2.34	2.67	3.84	3.46	3.35	0.56				16.22
Yellow maize for feed	1,965	5.56									1.34	3.32	5.35	15.57
Starchy maize	1,965		2.14	2.65	3.45	3.36	2.77	2.47	2.29	0.94				20.07
Yellow maize for feed	1,965	2.34	4.84	5.25	3.86			0.82	2.02	3.21	1.84			24.18
Cotton in the submerged	1,811	5.24	5.52	4.56	2.79					1.05	1.81	3.38	3.78	28.13
Horticulture	868	0.94	2.01	2.21	1.42	0.56	0.93	1.04	0.77	0.54	1.32	2.03	1.59	15.36
Citrus	819	1.46	1.55	1.35	1.34	0.94	0.77	0.74	0.78	0.89	1.09	1.34	1.39	13.64
Orchard (apple, grape, etc.)	1,710	2.83	2.97	2.61	1.99	1.99	1.99	1.99	1.99	1.99	1.99	1.99	2.68	27.01
Pasture (alfalfa, etc.)	667	1.56	1.65	1.45	1.33	0.93	0.76	0.68	0.72	0.88	1.08	1.33	1.48	13.85
Starchy maize	776	2.20	2.35	1.61	0.66	0.76	0.96	0.98	0.95	0.16	0.52	0.92	1.73	13.80
Total	27,390	57.12	59.86	52.94	35.68	11.21	12.02	12.18	12.87	16.46	22.64	35.99	49.85	378.82

Note : Irrigation efficiency is estimated at 45%.

Table 5.1(1/3)

Proposed Cropping Pattern
for the Valle de Cañete (24,052 Ha)

	CROP ha	LAND AREA ha	CROP AREA ha
1	Cotton	10,726	10,726
2	Starchy maize / Potato	2,745	4,118
3	Yellow maize for feed / Starchy maize	1,965	3,930
4	Yellow maize for feed	1,965	1,965
5	Cotton in the submerged area	1,811	1,811
6	Horticulture	868	868
7	Citrus	819	819
8	Fruit trees (apple, grape, etc.)	1,710	1,710
9	Pasture (alfalfa, etc)	667	667
#	Starchy maize	776	776
	Total	**24,052**	**27,390**



Irrigation Water Demand after Implementing
The Improvement Project of the Valle de Cañete (24,052 Ha)

(Unit : MCM)

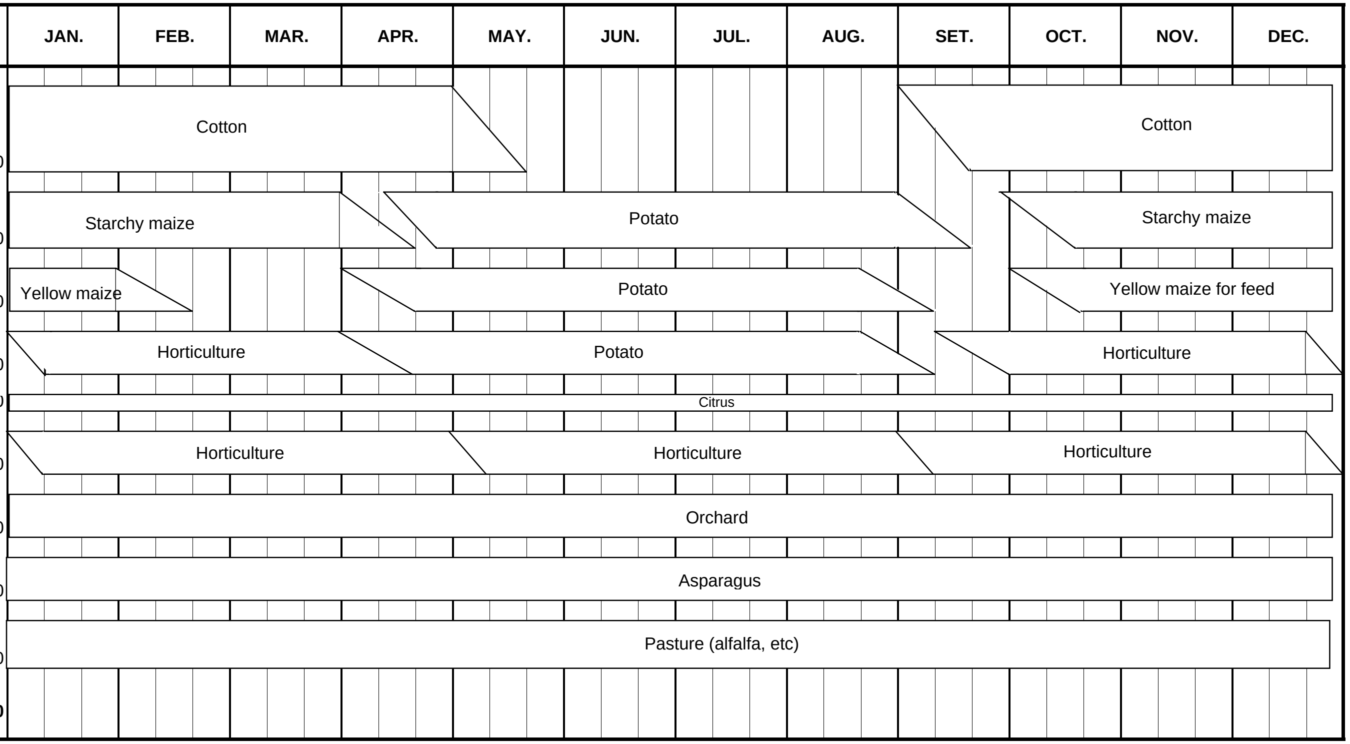
Crops	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cotton	10,726	27.93	29.41	25.55	14.85					5.62	9.66	18.02	25.91	156.95
Starchy maize	1,373	3.56	3.74	2.57							0.82	1.49	2.76	14.94
Potato	2,745				2.11	2.40	3.05	3.11	3.02	0.51				14.20
Yellow maize for feed	1,965	5.00									1.20	2.99	4.81	14.00
Starchy maize	1,965		1.93	2.22	3.10	3.03	2.49	2.23	2.06	0.85				17.91
Yellow maize for feed	1,965	2.11	4.36	4.73	3.47			0.74	1.82	2.89	1.66			21.78
Cotton in the submerged area	1,811	4.72	4.97	4.11	2.51					0.95	1.63	3.04	3.40	25.33
Horticulture	868	0.84	1.81	1.99	1.28	0.51	0.84	0.94	0.70	0.48	1.19	1.82	1.43	13.83
Citrus	819	1.31	1.39	1.22	1.21	0.85	0.69	0.67	0.70	0.80	0.86	1.21	1.25	12.16
Fruit trees (apple, grape, etc.)	1,710	2.54	2.68	2.35	1.79	1.79	1.79	1.79	1.79	1.79	1.79	1.79	2.41	24.30
Pasture (alfalfa, etc.)	667	1.40	1.48	1.30	1.19	0.83	0.68	0.61	0.65	0.79	0.94	1.19	1.33	12.39
Starchy maize	776	1.98	2.12	1.45	0.59	0.68	0.86	0.88	0.85	0.14	0.47	0.83	1.56	12.41
Total	27,390	51.39	53.89	47.49	32.10	10.09	10.40	10.97	11.59	14.82	20.22	32.38	44.86	340.20

Note : Irrigation efficiency is estimated at 50%.

Table 5.1(2/3)

Proposed Cropping Pattern for
The Pampas de Concon - Topara and Chincha Alta (27,000 Ha)

CROP ha	LAND AREA ha	CROP AREA ha
1 Cotton	5,400	5,400
2 Starchy maize / Potato	3,510	7,020
3 Yellow Maize for feed / Potato	2,700	5,400
4 Horticulture / Potato	2,700	5,400
5 Citrus	540	540
6 Horticulture	2,700	2,700
7 Orchard (apple, grape,etc).	2,700	2,700
8 Asparagus	3,000	3,000
9 Pasture (alfalfa, etc.)	3,750	3,750
Total	**27,000**	**35,910**



Irrigation Water Demand after Implementing the Project of
The Pampas de Concon - Topara y Chincha Alta (27,000 Ha)

70

(Unit : MCM)

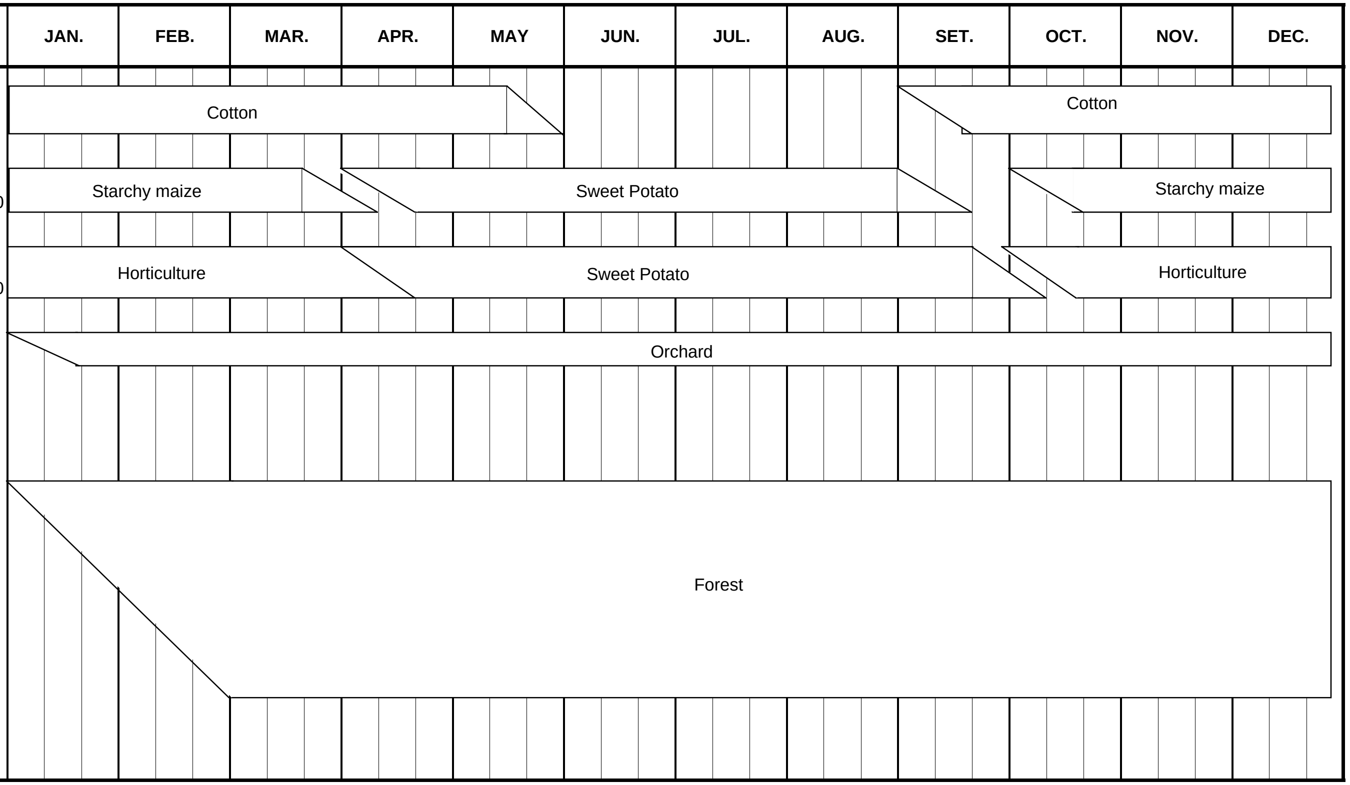
Crops	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cotton	5,400	11.72	12.34	10.16	6.24					2.36	4.06	7.56	10.87	65.31
Starchy maize	3,510	3.00	7.60	5.47							1.75	3.18	5.87	26.87
Potato	3,510				2.25	2.56	3.25	3.31	3.22	0.54				15.13
Yellow maize for feed	2,700	5.72	0.93								1.38	3.42	5.51	16.96
Potato	2,700				2.09	2.25	2.64	2.54	1.92					11.44
Horticulture	2,700	2.19	4.73	5.15						1.23	3.09	4.72	3.71	24.82
Potato	2,700				2.09	2.24	2.60	2.50	1.92					11.35
Citrus	540	0.72	0.76	0.71	0.66	0.46	0.38	0.36	0.38	0.44	0.54	0.66	0.69	6.76
Horticulture	2,700	2.19	4.69	5.15	3.31	1.31	2.17	2.43	1.80	1.23	3.09	4.72	3.71	35.80
Orchard (apple, grape, etc.)	2,700	3.35	3.52	3.09	2.36	2.36	2.36	2.36	2.36	2.36	2.36	2.36	3.17	32.01
Asparagus	3,000	5.26	5.55	4.88	4.47	3.12	2.56	2.29	2.43	2.97	3.64	4.47	5.00	46.64
Pasture (alfalfa, etc.)	3,750	6.58	6.94	6.09	5.59	3.90	3.21	2.87	3.04	3.71	4.56	5.59	6.24	58.32
Total	35,910	40.73	47.06	40.70	29.06	18.20	19.17	18.66	17.07	14.84	24.47	36.68	44.77	351.41

Note : Irrigation efficiency is estimated at 60%.

Table 5.1(3/3)

Proposed Cropping Pattern
for the Pampas de Altas de Imperial (2,475 Ha)

CROP ha	LAND AREA ha	CROP AREA ha
1 Cotton	300	
2 Starchy maize / Sweet Potato	280	280
3 Horticulture / Sweet Potato	320	320
4 Orchard (citrus, apple, etc.) Orange : 40% Apple : 35% Tuna : 25%	210	
5 Tree planting (eucalyptus, etc.)	1,365	
Total	**2,475**	



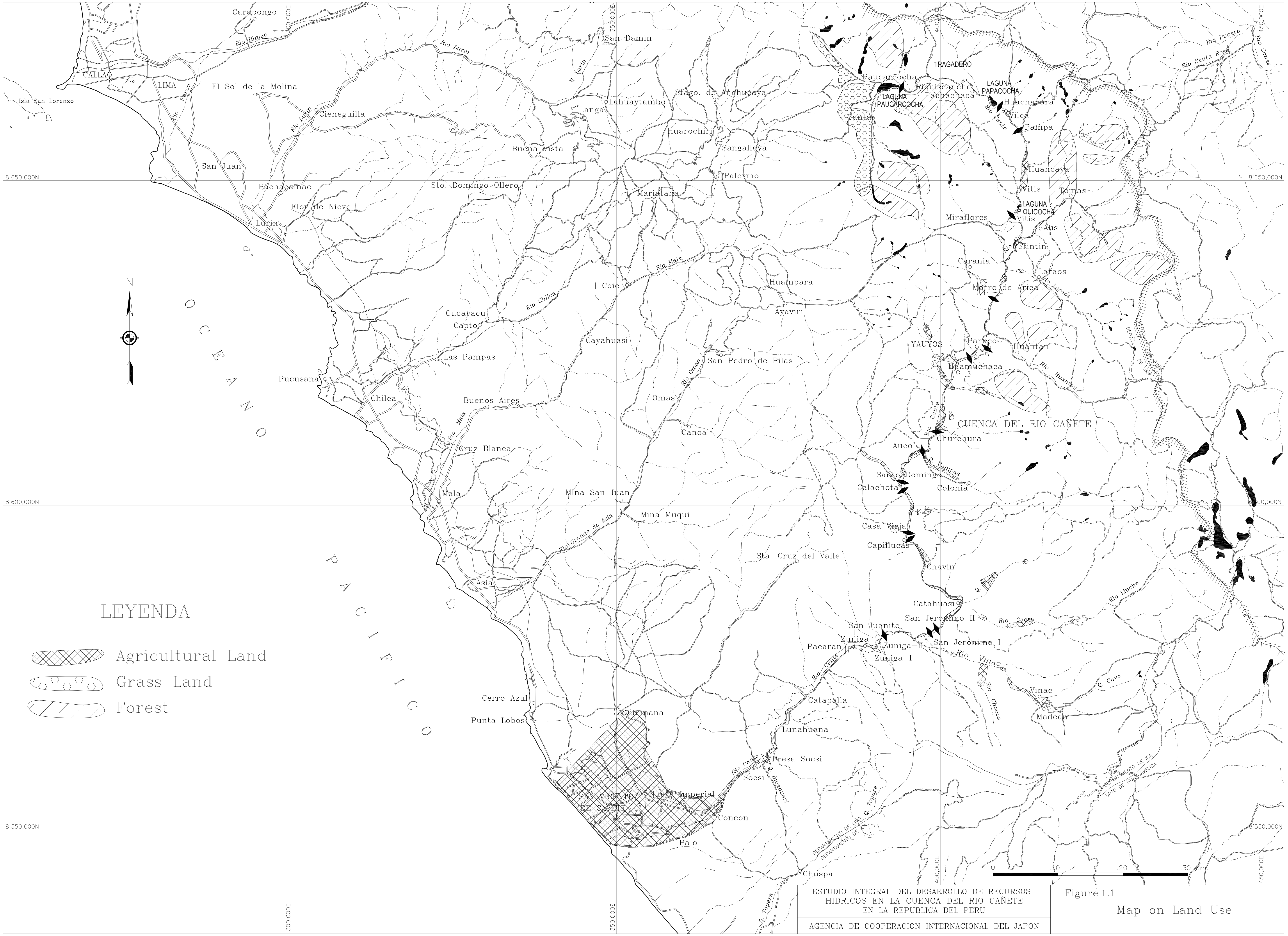
Irrigation Water Demand after Implementing the Project
of the Pampas de Altas de Imperial (2,475 Ha)

(Unit : MCM)

Crops	Area (ha)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Cotton	300	0.75	0.79	0.66	0.40					0.15	0.26	0.49	0.70	4.20
Starchy maize	280	0.70	0.73	0.51							0.16	0.29	0.54	2.93
Sweet potato	280				0.21	0.34	0.30	0.31	0.30	0.05				1.51
Horticulture	320	0.30	0.64	0.70						0.17	0.42	0.65	0.51	3.39
Sweet Potato	320				0.29	0.31	0.36	0.35	0.26					1.57
Orchard (citrus, apple, etc.)	210	0.32	0.34	0.30	0.29	0.21	0.17	0.16	0.17	0.20	0.24	0.29	0.20	2.89
Planting trees (eucalyptus,	1,365	1.48	1.56	1.37	1.36	0.82	0.78	0.75	0.79	0.90	1.10	1.36	1.41	13.68
Total	3,075	3.55	4.06	3.54	2.55	1.68	1.61	1.57	1.52	1.47	2.18	3.08	3.36	30.17

Note : Irrigation efficiency is estimated at 52%.

FIGURES



ESTUDIO INTEGRAL DEL DESARROLLO DE RECURSOS HIDRICOS EN LA CUENCA DEL RIO CAÑETE EN LA REPUBLICA DEL PERU

AGENCIA DE COOPERACION INTERNACIONAL DEL JAPON

Figure.1.1

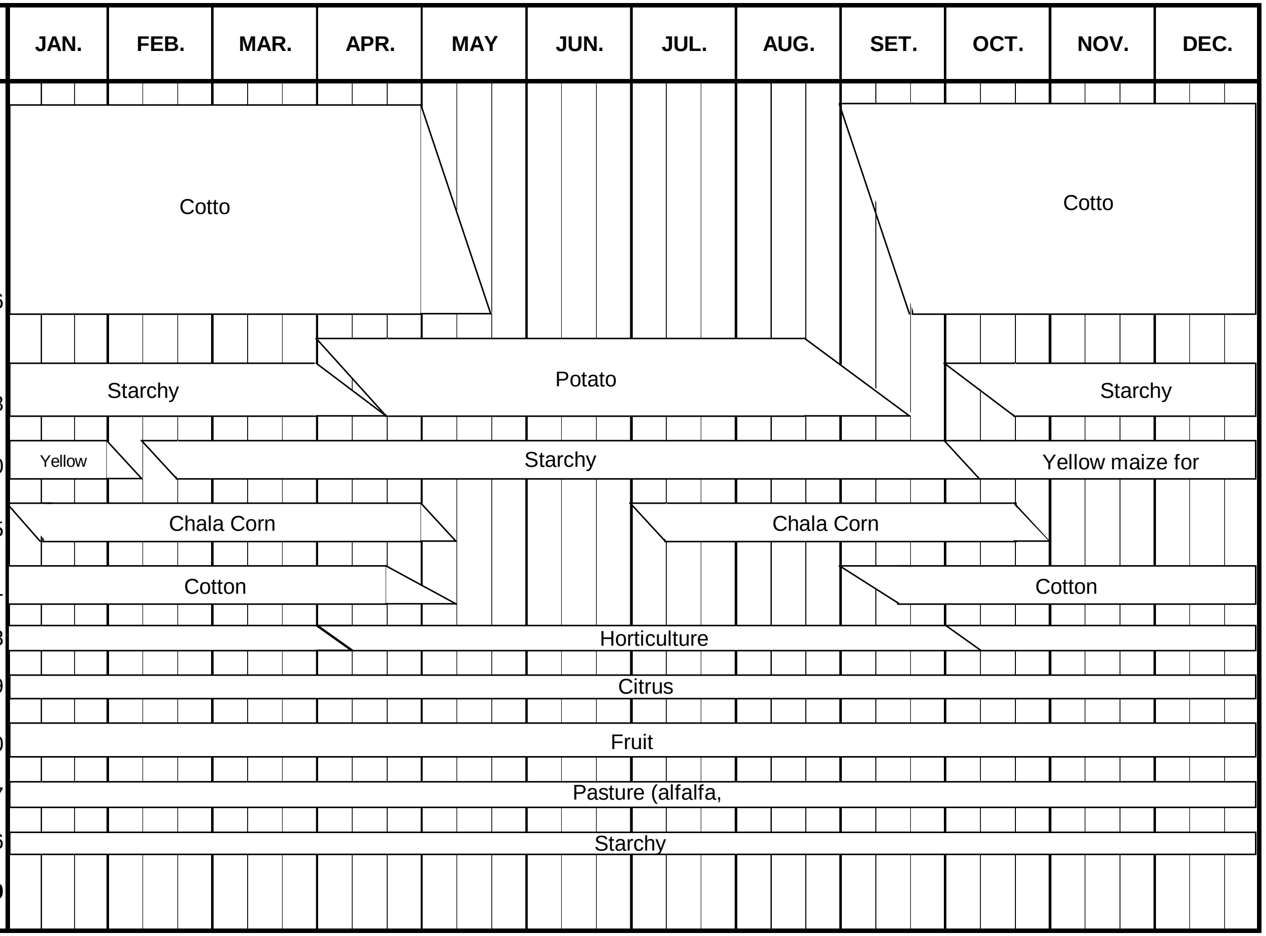
Map on Land Use

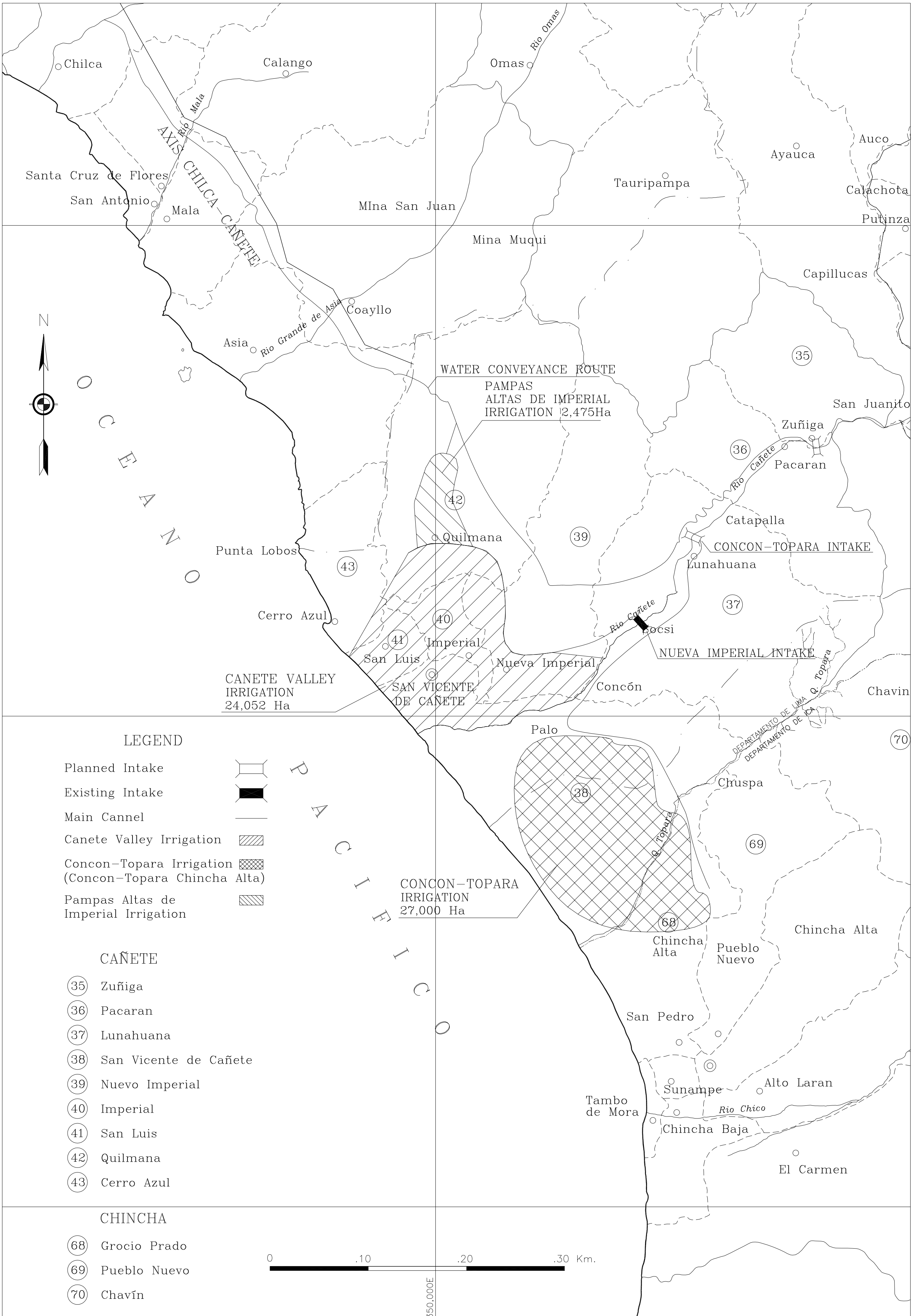
STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT
IN
THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.1
Existing Cropping Pattern in the Valle de Cañete
(24,052 ha)

CROP ha	LAND AREA ha	CROP AREA ha
1 Cotton	10,726	10,726
2 Starchy maize / Potato	2,745	4,118
3 Yellow maize for feed / Starchy maize	1,965	3,930
4 Yellow maize for feed	1,965	1,965
5 Cotton in the submerged ar	1,811	1,811
6 Horticulture	868	868
7 Citrus	819	819
8 Fruit trees (apple, grape, et	1,710	1,710
9 Pasture (alfalfa, etc)	667	667
10 Starchy maize	776	776
Total	**24,052**	**27,390**





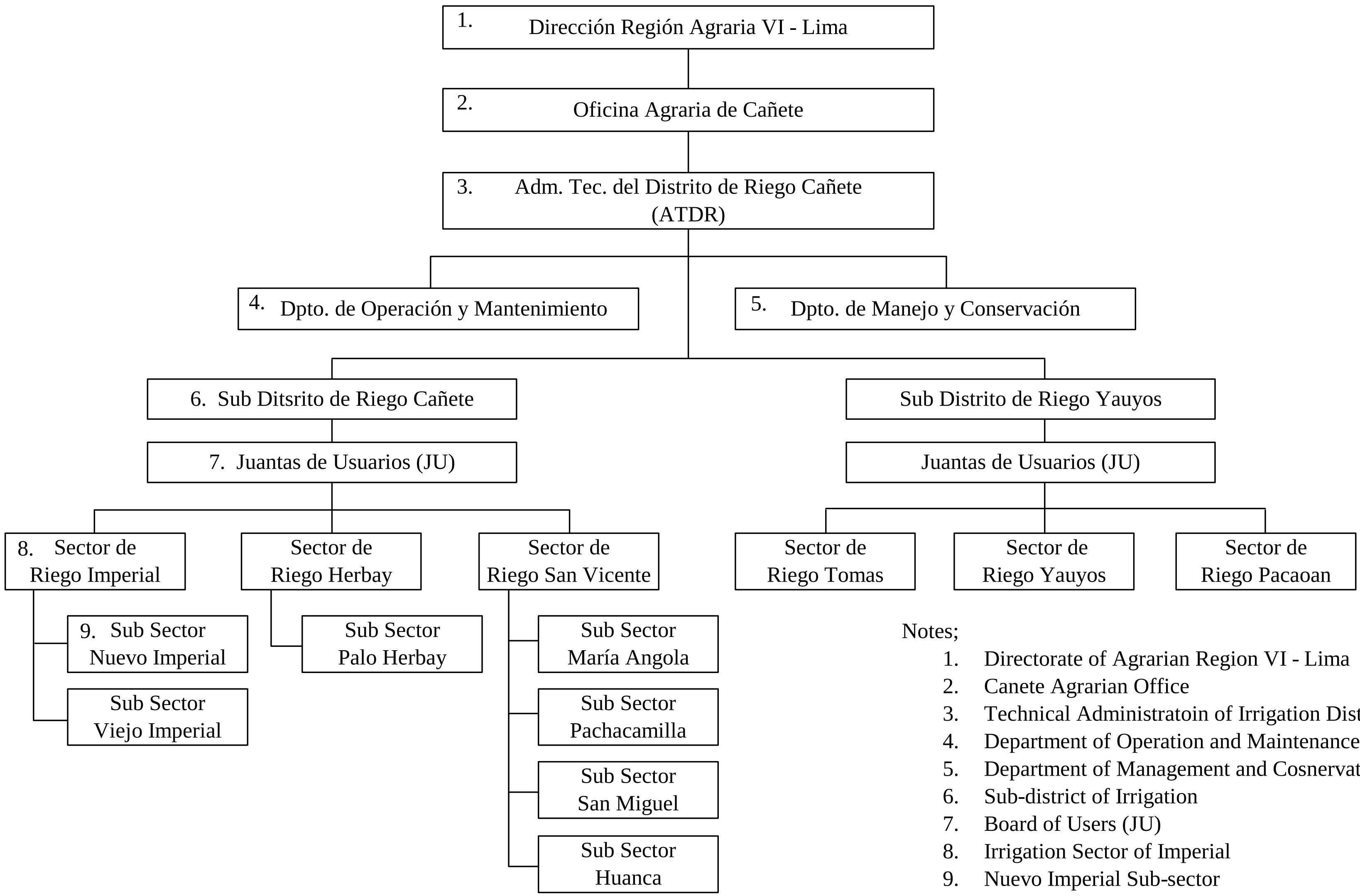
STUDY ON INTEGRATED WATER RESOURCES DEVELOMENT
IN
THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 5.1

Map on Irrigation Areas

STUDY ON INTEGRATED WATER RESOURCES DEVELOPMENT
IN
THE CAÑETE RIVER BASIN IN THE REPUBLIC OF PERU
JAPAN INTERNATIONAL COOPERATION AGENCY



Notes;
1. Directorate of Agrarian Region VI - Lima
2. Canete Agrarian Office
3. Technical Administratoin of Irrigation District (ATDR)
4. Department of Operation and Maintenance
5. Department of Management and Cosnervation
6. Sub-district of Irrigation
7. Board of Users (JU)
8. Irrigation Sector of Imperial
9. Nuevo Imperial Sub-sector

Figure 6.1
Organization Structure of Technical Administration of Irrigation District