Ministry of Agriculture
Republic of Peru

THE PREPARATORY STUDY ON PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOOD IN THE REPUBLIC OF PERU

FINAL REPORT
MAINREPORT
I-2 PROJECT REPORT (CAÑTE RIVER)
I-3 PROJECT REPORT (CHINCHA RIVER)
I-4 PROJECT REPORT (PISCO RIVER)
I-5 PROJECT REPORT (MAJES-CAMANA RIVER)
(TEMPORARY VERSION)

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
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Composition of Final Report

I. Feasibility Study Report
- I-1 Program Report
- I-2 Project Report (Cañete River) (This Report)
- I-3 Project Report (Chincha River)
- I-4 Project Report (Pisco River)
- I-5 Project Report (Majes-Camana River)
- I-6 Supporting Report
  - Annex – 1 Metrology /Hydrology /Run-off Analysis
  - Annex – 2 Inundation Analysis
  - Annex – 3 River Bed Fluctuation Analysis
  - Annex－4 Flood Control Plan
  - Annex – 5 Forecasting and Warning System in Chira River
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II. Pre- Feasibility Study Report
- II-1 Program Report
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- II-7 Project Report (Majes-Camana River River)

Study Area Map

Abbreviation

Abbreviation	Official Name or meaning
ANA	Autoridad Nacional del Agua(Water National Authority)
ALA	Autoridad Local del Agua(Water Local Authority)
B/C	Cost-Benefit Ratio(Cost-Benefit relation)
GDP(PBI)	Producto Bruto Interno(PBI)(Gross Domestic Product)
GIS	Sistema de información geográfica (Geographic Information System)
DGAA	Dirección General de Asuntos Ambientales(Environmental Affairs General Direction)
DGFFS	Dirección General de Forestal y de Fauna Silvestre (Forestry and Fauna General Direction)
DGIH	Dirección General de Infraestructura Hidráulica (Hydraulic Infrastructure General Direction)
DGPI(previous DGPM)	Dirección General de Política de Inversiones (Investment Policy General Direction), (Dirección General de Programación Multianual del Sector Público)(Public Sector Multiannual Program General Direction)
DGETP(previous DNEP)	Dirección General de Endeudamiento y Tesoro Público (Public Indebtedness National Direction), Dirección Nacional de Endeudamiento Público
DRA	Dirección Regional de Agricultura (Agriculture Regional Direction)
EIA	Estudio de impacto ambiental (Environmental Impact Assessment - EIA)
FAO	Organización de las Naciones Unidas para la Agricultura y la Alimentación (Food and Agriculture Organization of the United Nations)
F/S	Estudio de Factibilidad (Feasibility Study)
GORE	Gobiernos Regionales (Regional Governments)
HEC-HMS	Sistema de Modelado Hidrológico del Centro de Ingeniería Hidrológica (Hydrologic Model System from the Hydrology Engineer Center)
HEC-RAS	Sistema de Análisis de Ríos del Centro de Ingeniería Hidrológica (Hydrologic Engineering Centers River Analysis System)
IGN	Instituto Geográfico Nacional (National Geographic Institute)
IGV	Impuesto General a Ventas (TAX)
INDECI	Instituto Nacional de Defensa Civil (Civil defense National Institute)
INEI	Instituto Nacional de Estadística (Statistics National Institute)
INGEMMET	Instituto Nacional Geológico Minero Metalúrgico (Metallurgic Mining Geologic National Institute)
INRENA	Instituto Nacional de Recursos Naturales (Natural Resources National Institute)
IRR	Tasa Interna de Retorno (Internal Rate of Return - IRR)
JICA	Agencia de Cooperación Internacional del Japón (Japan International Cooperation Agency)
JNUDRP	Junta Nacional de Usuarios de los Distritos de Riego del Perú (Peruvian Irrigation Disctrict Users National Board)
L/A	Acuerdo de Préstamo (Loan Agreement)
MEF	Ministerio de Economía y Finanzas (Economy and Finance Ministry)

MINAG	Ministerio de Agricultura (Agriculture Ministry)
M/M	Minuta de Discusiones (Minutes of Meeting)
NPV	VAN (Valor Actual Neto) (NET PRESENT VALUE)
O&M	Operación y mantenimiento (Operation and maintenance)
OGA	Oficina General de Administración (Administration General Office)
ONERRN	Oficina Nacional de Evaluación de Recursos Naturales (Natural Resources Assessment National Office)
OPI	Oficina de Programación e Inversiones (Programming and Investment Office)
PE	Proyecto Especial Chira-Piura (Chira-Piura Special Project)
PES	PSA (Pago por Servicios ambientales) (Payment for Environmental Services)
PERFIL	Estudio del Perfil (Profile Study)
Pre F/S	Estudio de prefactibilidad (Pre-feasibility Study)
PERPEC	Programa de Encauzamiento de Ríos y protección de Estructura de Captación (River Channeling and Protection of Collection Structures Program)
PRONAMACHIS	Programa Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos (Water Basins Management and Soil Conservation National Program)
PSI	Programa Sub Sectorial de irrigaciones (Sub-Sectorial Irrigation Program)
SCF	Factor de conversión estándar (Standard Conversion Factor)
SENAMHI	Servicio Nacional de Meteorología y Hidrología (Meteorology and Hydrology National Service)
SNIP	Sistema Nacional de Inversión Pública (Public Investment National System)
UE	Unidad Ejectora(Execution Units)
UF	Unidades Formuladoras (Formulator Units)
VALLE	Llanura aluvial, llanura de valle (Alluvial Plain, Valley Plain)
VAT	Impuesto al valor agregado (Value added tax)

THE PREPARATORY STUDY
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FINAL REPORT
I-2 MAIN REPORT
PROJECT REPORT
(CAÑETE RIVER)
（TEMPORARY VERSION）

Table of Contents

1. EXECUTIVE SUMMARY

1.1 Project Name

“Protection program for valleys and rural communities vulnerable to floods Implementation of prevention measures to control overflows and floods of Cañete River, Lima Department.”

1.2 Project’s Objective

The ultimate impact that the project is design to achieve is to alleviate the vulnerability of valleys and the local community to flooding and boost local socioeconomic development.

1.3 Supply and Demand Balance

It has been calculated the theoretical water level in case of flow design flood based on the cross sectional survey of the river with an interval of 500m, in the Cañete river watershed, assuming a design flood flow equal to the flood flow with a return period of 50 years. Then, we determined the dike height as the sum of the design water level plus the dike’s free board.

This is the required height of the dike to control the damages caused by design floods and is the indicator of the demand of the local community.

The height of the existing dike or current ground height is the required height to control the current flood damages, and is the indicator of the current offer.

The difference between the dike design height (demand) and the height of the embankment or ground at present ground (supply) is the difference or gap between demand and supply.

Table 1.3-1 shows the average water levels floods, calculated with a return period of 50 years, of the required height of the dike (demand) to control the flow by adding the design water level plus the free board of the dike; of dike height or current ground height (supply), and the difference between these two (difference between demand and supply) of the river. Then, in Table 4.2-2 the values at each point are shown. The current height of the dike or the current ground height is greater than the required height of the dike, at certain points. In these, the difference between supply and demand is considered null.

Table 1.3-1 Demand and supply analysis

Watershed	Dike Height / current land (supply)		Theoretical water level with a return period of 50 years	Dike Freeboard	Required dike's heigth (demand)	Diff. demand/supply	
	Left bank	Right bank				Left bank	Right bank
	①	②	③	④	⑤=③+④	⑥=⑤-①	⑦=⑤-②
Cañete	188.40	184.10	184.77	1.20	185.97	1.18	2.03

1.4 Technical Proposal

1.4.1 Structural Measures

Structural measures are a subject that must be analyzed in the flood control plan covering the entire watershed. The analysis results are presented in section 1.14 “medium and long term plan.” This plan proposes the construction of dikes for flood control throughout the watershed. However, the plan requires a large project investing at an extremely high cost, far beyond the budget for this Project, which makes this proposal it impractical. Therefore, assuming that the dikes to control floods throughout the whole watershed will be progressively built over a medium and long term period, therefore this study focused on the most urgent works with high priority for flood protection.

(1) Design flood flow

The Methodological Guide for Protection Projects and/or Flood Control in Agricultural or Urban Areas（Guia Metodologica para Proyectos de Proteccion y/o Control de Inundaciones en Áreas Agricolas o Urbanas, 3.1.1 Horizonte de Proyectos）prepared by the Public Sector Multi Annual Programming General Direction (DGPM) (present DGPI) of the Ministry of Economy and Finance (MEF) recommends a comparative analysis of different return periods: 25, 50 and 100 years for the urban area and 10, 25 and 50 years for rural and agricultural land.

Considering that the present Project is aimed at protecting the rural and agricultural land, the design flood flow is to be determined in a return period of 10 years to 50 years t in the mentioned Guide.

It was confirmed that the flood discharge with return period of 50 years in the basin is determined as design flood discharge and it is almost same as the past maximum observed discharge.

In Peru the flood protection works in the basins are developed almost nil, therefore it is not necessary to adopt the design discharge more than the past maximum discharge. However, the large disasters occurred in the past so that the design flood discharge with return period of 50 years, which is almost equal to the past maximum, is to be adopted considering to avoid the flood damage nearly equal to the damage occurred in the past.

The relation among flood discharge with different return period, damage caused by the floods and inundation areas is analyzed in the basin. The results are that the more the return periods of flood increase the more inundation area and damage amount increase in the basin, however the increase tendency of damage with project is more gentle compared with former two items, and the reduction of damage with project reaches to maximum in the case of the flood with return period of 50 years within the cases of flood with less return period of 50 years.

As described above, the adopted design flood discharge with return period of 50 years is almost same as the past maximum discharge and damage reduction amount in the adopted case becomes more than that of the flood discharges with less return period, and the result of social evaluation is also high.

(2) Selection of prioritized flood prevention works

We applied the following five criteria for the selection of priority flood control works.

- Demand from the local community (based on historical flood damage)
- Lack of discharge capacity of river channel (including the sections affected by the scouring)
- Conditions of the adjacent area (conditions in urban areas, farmland, etc.).
- Conditions and area of inundation (type and extent of inundation according to
- inundation analysis)
- Social and environmental conditions (important local infrastructures)

Based on the river survey, field investigation, discharge capacity analysis of river channel, inundation analysis, and interviews to the local community (irrigation committee needs, local governments, historical flood damage, etc...) a comprehensive evaluation was made applying the five evaluation criteria listed above. After that we selected a total of five (5) critical points (with the highest score in the assessment) that require flood protection measures.

Concretely, since the river cross sectional survey was carried out every 500m interval and discharge capacity analysis and inundation analysis were performed based on the survey results, the integral assessment was also done for sections of 500 meters. This sections have been assessed in scales of 1 to 3 (0 point, 1 point and 2 points) and the sections of which score is more than 6 were selected as prioritized areas. The lowest limit (6 points) has been determined also taking into account the budget available for the Project in general

1.4.2 Non-Structural Measures

(1) Reforestation and vegetation recovery

1) Basic Policies

The reforestation plan and vegetation recovery that meets the objective of this project can be divided into: i) reforestation along river structures, and ii) reforestation in the upper watershed. The first has a direct effect on flood prevention expressing its impact in a short time, while the second one requires high cost and a long period for its implementation, as indicated later in the section 1.14 “Medium and long term Plan”, and also it is impractical to be implemented within the framework of this project. Therefore, this study focused on the first alternative.

2) Regarding reforestation along river structures

This alternative proposes planting trees along the river structures, including dikes and bank protection works.

- Objective: Reduce the impact of flooding of the river when an unexpected flood or by the presence of obstacles, using vegetation strips between the river and the objects to be protected.
- Methodology: Create vegetation stripes of a certain width land side of river structures.
- Execution of works: Plant vegetation with certain width in land side of the river structures (dikes, etc.).
- Maintenance after reforestation: Maintenance will be taken by irrigation committees under their own initiative.

The width, length and area of reforestation along river structures are 11m, 3.4km and 3.7ha respectively.

(2) Sediment control plan

The sediment control plan must be analyzed within the general plan of the watershed. The results of the analysis are presented in section 1.14“Medium and long term plan (3) Sediment control”. To sum up, the sediment control plan for the entire watershed requires a high investment cost, which goes far beyond the budget of this project, which makes it impractical to adopt. So, the sediments control plan in this project was focused on the alluvial fan.

The Plantanal dam was constructed, which retains sedimentation in the reservoir. This will lead that the amount of sediments that flows down to the lower stream will be reduced drastically. In the lower river channel the erosion and sedimentation will be repeated locally in flooding, however from the point of long term view the riverbed elevation will be reduced. As to the sediment control in the lower area, the required maintenance of the river channel is to be performed based on the monitoring the change of river channel, however the urgent countermeasures are not required at present.

1.4.3 Technical Support

Based on the technical proposals of structural and nonstructural measures, it is also intends to incorporate in this project technical assistance to strengthen the measures.

The objective of the technical assistance is to "improve the capacity and technical level of the local community, to manage risk to reduce flood damage in selected valleys."

It is proposed to design the adequate support for Cañete river watershed, to offer training adapted to the characteristics of this watershed. The beneficiaries are the representatives of the committees and irrigation groups from the watershed of the Cañete river, governments employees (provincial and district), local community representatives, local people etc...

Qualified as participants in the training, people with ability to replicate and disseminate lessons learned in the courses to other community members, through meetings of the organizations to which they belong.

In order to carry out the technical assistance goal, the three activities propose the following:

- Bank protection activity and knowledge enhancement on agriculture and natural environment
- Community disaster prevention planning for flood damages
- Watershed (slope) management against fluvial sedimentation

1.5 Costs

In the Table 1.5-1 the costs of this Project in Cañete watershed is shown. The cost of the watersheds is around million soles.

Table 1.5-1 Project cost

1.6 Social Assessment

The objective of the social assessment in this study is to evaluate the efficiency of investments in the structural measures from the point of view of national economy. To do this, we determined the economic evaluation indicators (B/C relation, Net Present Value-NPV, and Internal return rate - IRR).

The benefits of the evaluation period were estimated, from the first 15 years since the start of the project. Because, from these 15 years, two are from the work execution period, the evaluation was conducted for the 13 years following the completion of works.
Below the social assessment results for this Project based on the above economic evaluation indicators are shown.

Table 1.6-1 Social evaluation

Regarding social prices costs, the project may show a positive economic impact in Cañete, the relation B/C will be over 1.0.

Next, the positive effects of the Project are shown, which are quite difficult to quantify in economic values:

① Contribution to local economic development to alleviate the fear to economic activities suspension and damages
② Contribution to increase local employment opportunities thanks to the local construction project
③ Strengthening the awareness of local people regarding damages from floods and other disasters
④ Contribution to increase from stable agricultural production income, relieving flood damage
⑤ Rise in farmland prices

From the results of the economic evaluation presented above, it is considered that this project will substantially contribute to the development of the local economy.

1.7 Sustainability Analysis

This project will be co-managed by the central government (through the DGIH), irrigation committees and regional governments, and the project cost will be covered with the respective contributions of the three parties. On the other hand, the operation and maintenance (O & M) of completed works is taken by the irrigation committees. Therefore, the sustainability of the project is depends on the profitability of the project and the ability of O & M of irrigation committees.

The profitability of the project is high enough as described in the clause 1.6 so that the sustainability of the project is guaranteed. In the Table 1.7-1 the budget data from last year of the irrigation commissions is shown.

Table 1.7-1 Irrigation Commission's budget

River	Annual Budget (Unit/ S)			
	2007	2008	2009	2010
Cañete	2,355,539.91	2,389,561.65	2,331339.69	2,608,187.18

On the other hand the annual O/M cost required after implementation of the Project is as shown in the Table-1.7-2, of which detail is described in the clause 4.4.1. The percentage of O/M cost to the annual budget of irrigation committee in each basin and the annual flood damage reduction amount is also as shown in the same table.

The percentage of O/M cost to the annual budget of irrigation committee is 11.1% in Cañete And the percentage of O/M cost to the annual flood damage reduction amount is 2.1%, which is very low, Although the percentage of O/M cost to the annual budget is relatively high, the percentage of O/M cost to the yearly average damage reduction amount is very low. Since the benefit of agriculture increases due to the reduction of flood damage, therefore it is possible enough that the irrigation committees will bear the O/M cost.

The technical capacity of irrigation committee for O/M seems to be enough by the technical assistance of MINAG and regional government because the flood prevention facilities such as embankment, bank protection and weir are familiar structures to the committee

Table 1.7-2 Percentage of O/M cost to annual budget and damage reduction amount

Irrigation Committee	Annual Budget(1,000soles)	O/M Cost(1,000soles)	Percentage of O/M cost(%)	Average Yearly Damage Reduction(1,000soles)	Percentage of O/M cost(%)
	①	②	③=②/①	④	⑤=②/④
Cañete	2,331	260	11.1	12,274	2.1

1.8 Environmental Impact

（1）Procedure of environmental impact assessment

Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The Project holder should submit the Environmental Impact Statement (DIA, in Spanish) for all Projects under Category I. The project holder should prepare an EIA-sd or an EIA-d if the Project is categorized under Category II or III, respectively, to be granted the Environmental Certification from the relevant Ministry Directorate.

First, the Project holder applies for the Project classification, by submitting the Preliminary

Environmental Assessment (PEA). The relevant sector assesses and categorizes the Project. The Project's PEA that is categorized under Category I becomes an EID, and those Projects categorized under Category II or III should prepare an EIA-sd or EIA-d, as applicable.

The preliminary environmental assessment (EAP) for Cañete was carried out between December 2010 and January 2011and by a consulting firm registered in the Ministry of Agriculture (CIDES Ingenieros S.A.). EAP for Cañete was submitted to DGIH January 25, 2011 by JICA Study Team and from DGIH to DGAA July 19, 2011.

DGAA examined EAP and issued approval letter of Category I. Therefore, no further environmental impact assessment is required for Cañete.

（2）Results of environmental impact assessment

The procedures to review and evaluate the impact of the natural and social environment of the Project are the following. First, we reviewed the implementation schedule of the construction of river structures, and proceeded to develop the Leopold matrix.

The impact at environmental level (natural, biological and social environment) was evaluated and at Project level (construction and maintenance stage). The quantitative levels were determined by quantifying the environmental impact in terms of impact to nature, manifestation possibility, magnitude (intensity, reach, duration and reversibility).

The EAP showed that the environmental impact would be manifested by the implementation of this project in the construction and maintenance stages, mostly, it is not very noticeable, and if it were, it can be prevented or mitigated by appropriately implementing the management plan environmental impact.

On the other hand, the positive impact is very noticeable in the maintenance stage, which manifests at socioeconomic and environmental level, specifically, in greater security and reduced vulnerability, improved life quality and land use.

1.9 Institutions and Management

The institutions and its administration in the investment stage and in the operation and maintenance stage after the investment are as shown in the Figures 1.9-1 and 1.9-2.

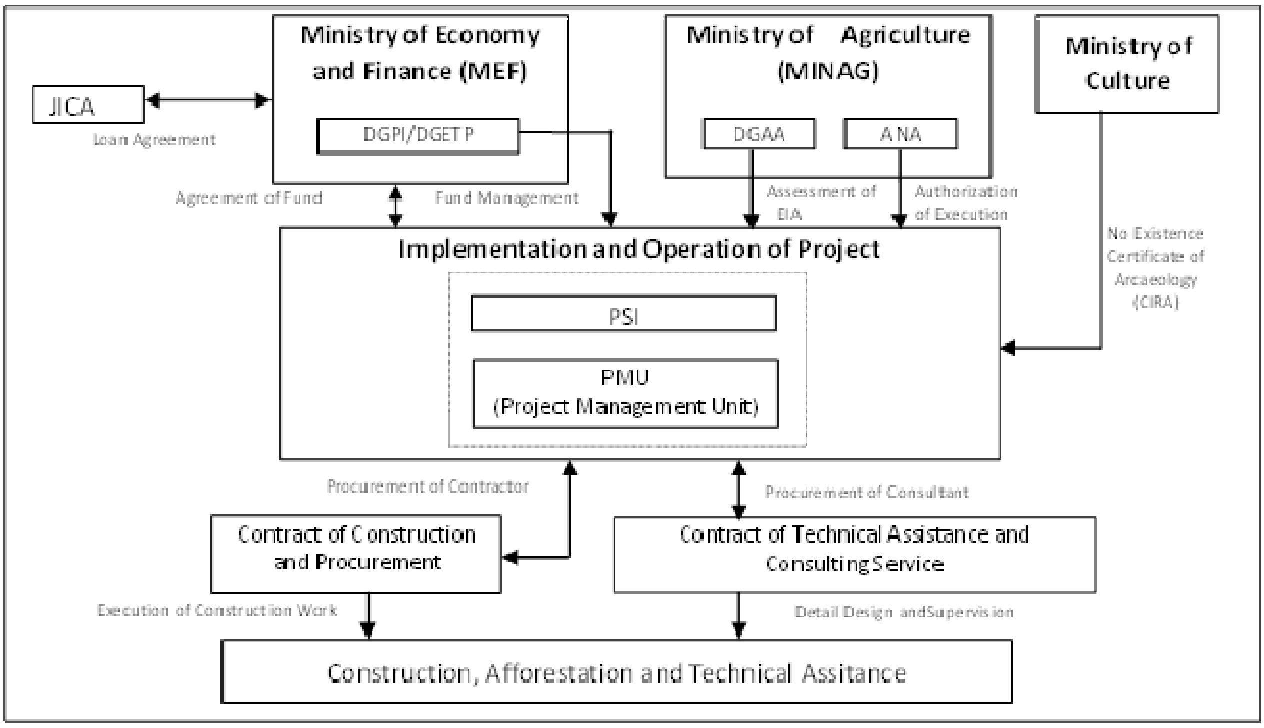


Figure 1.9-1 Related agencies in implementation stage of project

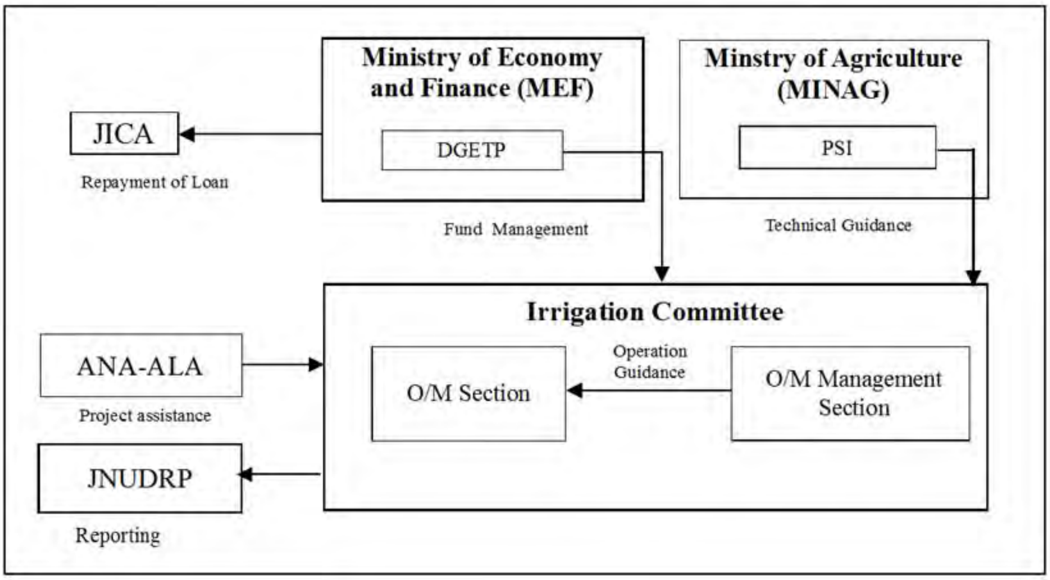
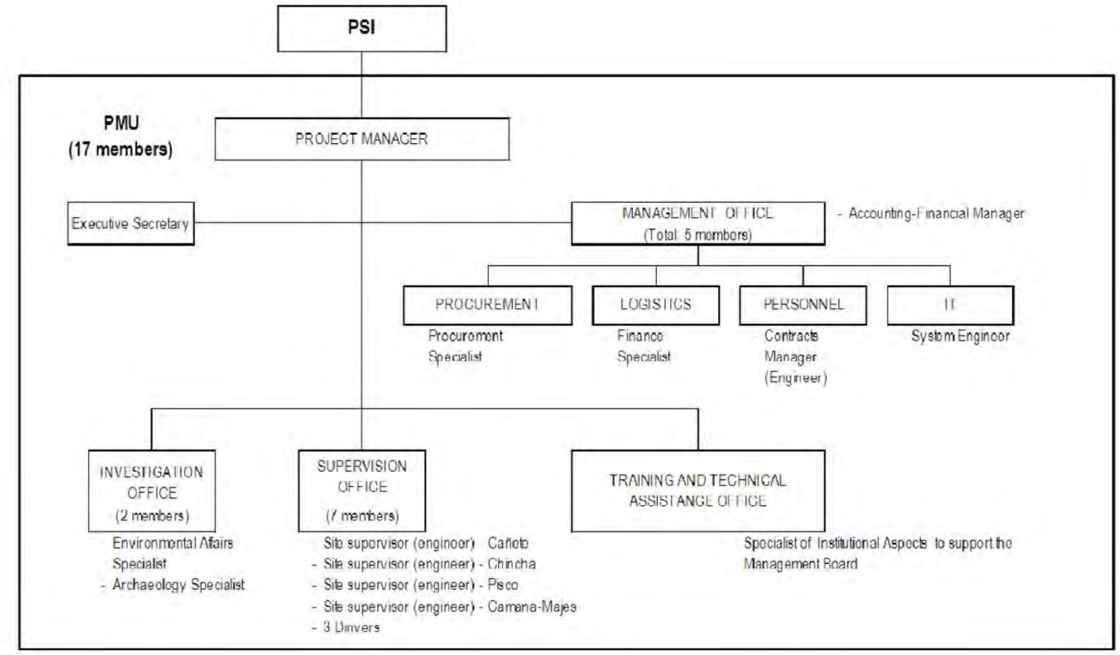


Figure 1.9-2 Related agencies in operation stage of project

The Project Management Unit (PMU) is to be organized under the Irrigation Infrastructure Direction of PSI, of which organization is as shown in the Figure-1.9-3 and 13 professionals are arranged. The operation cost of PMU is estimated as 8.5 million soles.



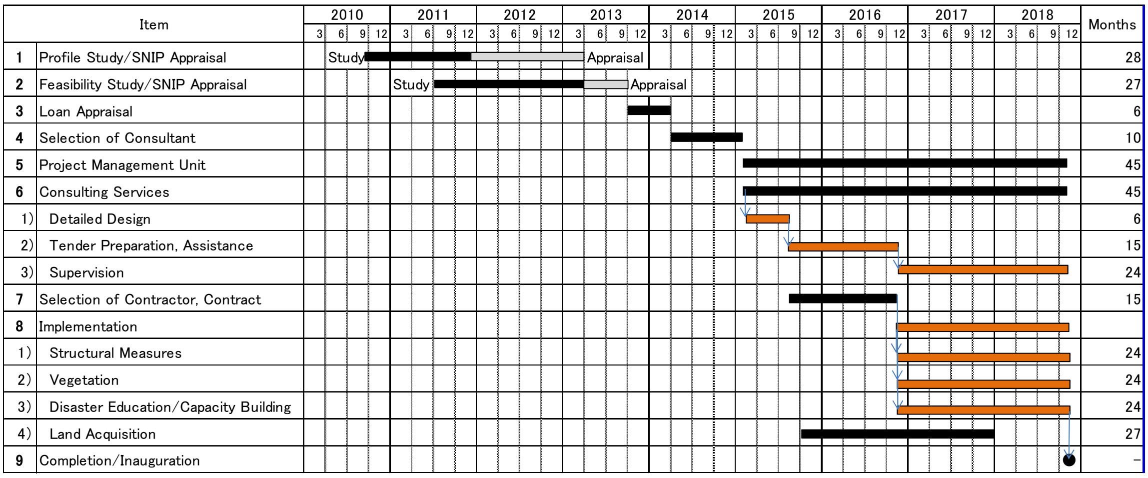
Note: ( )shows number of personnel

Figure-1.9-3 Organization of PMU

1.10 Execution Plan

Table 1.10-1 presents the Project execution plan.

Table 1.10-1 Execution plan



	Item	Months
1	Profile Study/SNIP Appraisal	28
2	Feasibility Study/SNIP Appraisal	27
3	Loan Appraisal	6
4	Selection of Consultant	10
5	Project Management Unit	45
6	Consulting Services	45
1)	Detailed Design	6
2)	Tender Preparation, Assistance	15
3)	Supervision	24
7	Selection of Contractor, Contract	15
8	Implementation	
1)	Structural Measures	24
2)	Vegetation	24
3)	Disaster Education/Capacity Building	24
4)	Land Acquisition	27
9	Completion/Inauguration	-

1) Employment of consultants

The employment of consultant is to be made according the following itmes:

① The consultants should be active in international market and have enough qualification and experience.

② The consultants are to have efficiency, transparency and non-discrimination among eligible consultants

③ The selection procedure should be taken in accordance with the stipulation in the Loan Agreement and the guideline for the Employment of Consultants under Japanese ODA Loans prepared by JICA

2) Procurement of contractor

The procurement of contractors is to be made according to the following items:

① The procurement of contractors is to be made using due attention to consideration s of economy, efficiency, transparency and non-discrimination among eligible bidders.

② The procurement procedure should be taken in accordance with the stipulation in the Loan Agreement and the guideline for the Employment of Consultants under Japanese ODA Loans prepared by JICA

③ The International Competitive Bidding: ICB is to be applied.

④ The pre-qualification (PQ) of bidders is to be applied in order to confirm the technical and financial capability of bidders. The following items are to be considered in PQ: a) experience of and past performance on similar contracts, b) capabilities with respect to personnel, equipment and plant, c) financial position.

1.11 Financial Planning

This Project will be implemented by the central government, local government and irrigation committee. The cost sharing ratio among central government, local governments and irrigation committees is provisionally assumed to be 80%, 15% and 5% respectively. The final cost sharing ratio among stakeholders shall be determined through the discussions among them as soon as possible.

Table 1.11-1 Financial planning in implementation of project

1.12 Conclusion and Recommendation

1.12.1 Conclusion

The flood prevention facilities selected finally in this Project are safe in structural, and have high viability and give scarcely impact to the environment. It is concluded that the Project should be implemented as soon as possible so that the high vulnerability against flood in the valley (Valles) and rural communities could be reduced and the social economic development will be promote d in the Project area.

1.12.2 Recommendation

Based on the knowledge and experience obtained from this Study, the following recommendations are presented on the implementation of this Project and the future flood control measures in Peru. For further detail refer to the main text 5.2.2.

(1) Recommendation on implementation of this project

1) Problems to be solved at present

- ＊Sharing ratio of Project cost among the central government(MINAG), the local governments and Irrigation committees in each basin
- ＊Negotiation of land acquisition and compensation with local people
- ＊Confirmation of implementation agency of the Project
- ＊Acuisition of CIRA（Certificación de Inexistente de Restos Arqueológicos）
- ＊Technical and economic assistance for the maintenance performed by irrigation committees by MINAG and local government

2) Structural measures

- ＊Basic policy of flood control
- ＊Problems for flood control planning in Cañete river
- ＊Problems in design and construction work
  - Construction work period is to be 9 months from April to December considering transition period to dry season from May to November
  - Stability of embankment
    - ･Requirement of stability analysis and infiltration analysis in the detail design stage
    - ･Method of compaction of embankment and supervision
      Reduction of bank protection cost which occupies 80% of construction cost
      Balance of embankment volume and excavation volume

3) Non-structural measures

- ＊Necessity of reforestation such as i）Short term plan、ii）Medium term plan(upstream area of Chincha river) and iii）Long term plan
- ＊Sediment control and riverbed fluctuation
  - Sediment control facility plan and soft counter measures
  - Riverbed fluctuation and necessity of monitoring

4) Disaster prevention education/capacity development

- ＊Soft counter measures for reduction of flood damage
- ＊Promotion of community disaster prevention

(2) Recommendation for future flood control plan in Peru

1）Preparation of comprehensive mater pan for flood control
2）Establishment of implementation agency for integral flood control project
3）Execution of strict river management
4）Establishment of nationwide network of rainfall observation stations and discharge observation stations

1.13 Logical Framework

Table 1.13-1 presents the logical framework of the final selected alternative.

Table 1.13-1 Logical framework of the final selected alternative

Narrative Summary	Verifying Indicators	Verifying Indicators Media	Preliminary Conditions
Superior Goal			
Promote socioeconomic local development and contribute in communities' social welfare.	Improve local productivity, generate more jobs, increase population's income and reduce poverty index	Published statistic data	Socio-economic and policy stability
Objectives			
Relief the high vulnerability of valleys and local continuity to floods	Types, quantity and distribution of flood control works, population and beneficiaries areas	Monitoring annual calendar works and financial plan, budget execution control	Ensure the necessary budget, active intervention from central and regional governments, municipalities, irrigation communities, local population, etc.
Expected results			
Reduction of number and flooded areas, functional improvement of intakes, irrigation channels protection, bank erosion control	Number of areas and flooded areas, water intake flow variation, bank erosion progress	Site visits, review of the flood control plan and flood control works reports and periodic monitoring of local inhabitants	Maintenance monitoring by regional governments, municipalities and local community, provide timely information to the superior organisms
Activities			
Component A: Structural Measures	Dikes rehabilitation, intake and margin protection works construction of 23 works, including dike's safety	Detailed design review, works reports, executed expenses	Ensure the works budget, detailed design/works execution/good quality works supervision
Component B: Non-Structural Measures (Reforestation and vegetation recovery)	Reforested area, coastal forest area	Works advance reports, periodic monitor by local community	Consultants support, NGO's, local community, gathering and cooperation of lower watershed community
Component C: Disaster prevention and capabilities development education	Number of seminars, trainings, workshops, etc	Progress reports, local governments and community monitoring	Predisposition of the parties to participate, consultants and NGO's assessments
Project's execution management			
Project's management	Detailed design, work start order, work operation and maintenance supervision	Design plans, work's execution plans, costs estimation, works specifications, works management reports and maintenance manuals	High level consultants and contractors selection, beneficiaries population participation in operation and maintenance

1.14 Middle and Long Term Plans

While it is true that due to the limited budget available for the Project, this study is focused mainly on the flood control measures analysis that must be implemented urgently. It is considered necessary to timely implement other necessary measures within a long term. In this section we will discuss the medium and long term plans.

(1) Flood control general plan

There are several ways to control floods in the entire watershed, for example, the building of dams, retarding basin, dikes or a combination of these. The options to build dams or retarding basin are not viable because in order to answer to a flood flow with a return period of 50 years, enormous works would be necessary to be built. So, the study was focused here on dikes' construction because it was the most viable option.

Flood water level was calculated in the watershed adopting a designed flood flow with a return period of 50 years. At this water level, freeboard was added in order to determine the required dikes height. After, sections of the rivers where the dikes or ground did not reach the required height were identified. These sections, altogether, add up to approx.30km. Also, from maintaining these works, annually a dragged of the rivers has to be done in the sections where, according to the bed fluctuation analysis the sediment gathering is elevating the bed's height. The volume of sediments that shall be eliminated annually was determined in approximately 9,000 m3.

In Tables 1.14-1 and 1.14-2 the flood control general plan project cost is shown as well as the social assessment results in terms of private and social costs.

Table 1.14-1 Project Cost and Social Assessment of the general flood control plan (private prices costs)

流域名	年平均被害軽減額	評価期間被害軽減額(15年)	事業費	維持管理費	B/C	NPV	IRR(%)
Basin	Annual Average Damage Reduction	Damage Reduction in Evaluation Period(15years)	Project Cost	O&M Cost	Cost Benefit Ration	Net Present Value	Internal Return of Rate
Cañete	181,369,899	81,903,051	104,475,371	8,236,962	0.86	−13,204,737	7%

Table 1.14-2 Project cost and social assessment of the general flood control plan (social prices costs)

流域名	年平均被害軽減額	評価期間被害軽減額(15年)	事業費	維持管理費	B/C	NPV	IRR(%)
Basin	Annual Average Damage Reduction	Damage Reduction in Evaluation Period(15years)	Project Cost	O&M Cost	Cost Benefit Ration	Net Present Value	Internal Return of Rate
Cañete	267,429,377	120,765,806	83,998,198	6,622,517	1.58	44,299,144	19%

In case of executing flood control works in the all Cañete watershed, the Projects' cost would elevate to 104.5 million soles, which is a huge amount. Regarding the social evaluation at social prices, the Project has enough viability.

(2) Reforestation plan and vegetation recovery

The forestry option was analyzed, in a long term basis, to cover every area that requires being covered with vegetation in the upper watershed. The objective is improving this areas' infiltration capacity, reduce of surface water and increase semi-underground and underground water. So, the flood maximum flow will be decreased, also it could be possible to increase the water reserve in the mountain areas and prevent and soothe floods. The areas to be reforested will be the afforested areas or where the forest mass in the water infiltration areas has been lost.

In Table 1.14-3 the area to be afforested and the project's cost for the watershed is shown. These were calculated based on forestry plan of Chincha River (refer to Annex-7 Afforestation and Vegetation Recovery Plan, 3.2 Long Term Plan). The total surface would be approximately 110,000hectares and in order to forest them the required time would be 35 years and 297.2 million soles. To sum up, the Project has to cover an extensive area, with an investment of much time and at a high price.

Table 1.14-3 General Plan for forestry on upper stream watersheds

Watershed	Forestry Area (ha） A	Required Period for the project (years) B	Required Budget (1,000soles) C
Cañete	110,114	35	297,212

(3) Sediment control plan

As long term sediment control plan, it is recommended to perform necessary works on the upper watershed. These works will mainly consist of dams and margin protection. In Table 1.14-4 the estimate work cost is shown. There are two costs, one for executing works in the entire watershed and another one for executing works only in prioritized areas based on the slope of river channel (refer to Annex-6, Sediment Control, Table-1.5.1).

All the chosen watersheds for this Project are big. So, if bank protection works and sediment control dams want to be built, not only the works' cost would elevate but also a very long period of investment would have to be done in every watershed. This means that it's positive impact will be seen in a long time.

Table 1.14-4 Projects' general costs of the sediment control installations

Watersheds	Areas	Bank Protection		Riverbed Bands		Dams		Works direct cost (total)	Project Cost (in millions de s/.)
		Qty. (km)	Works direct costs (million s/.)	Qty. (No.)	Works direct costs (million s/.)	Qty. (No.	Works direct costs (million s/.)		
Cañete	Totally	325	S/.347	32	S/.1	201	S/.281	S/.629	S/..1,184
	Prioritized areas	325	S/.347	32	S/.1	159	S/.228	S/.576	S/..1,084

2. GENERAL ASPECTS

2.1 Name of the Project

“Protection program for valleys and rural communities vulnerable to floods Implementation of prevention measures to control overflows and floods of Cañete River, Lima Department”

2.2 Formulator and Executor Units

(1) Formulator Unit (UF)

Name: Hydraulic Infrastructure General Direction, Agriculture Ministry
Responsible: Gustavo Adolfo Canales Kriljenko
General Director of the Water Infrastructure General Direction
Address: Av. Guillermo Prescott No. 490, San Isidro – Perú
Phone: (511) 6148100, (511) 6148101
Email: gcanales@minag.gob.pe

(2) Executor Unit (UE)

Name: Sub-sectorial Irrigation Program, Agriculture Ministry
Manager: Jorge Zúñiga Morgan
Executive Director
Address: Jr. Emilio Fernandez N° 130 Santa Beatriz, Lima-Peru
Phone: (511) 4244488
Email: postmast@psi.gob.pe

2.3 Involved Entities and Beneficiaries Participation

Here are the institutions and entities involved in this project, as well as beneficiaries.

(1) Agriculture Ministry (MINAG)

MINAG, as manager of natural resources of watersheds promotes agricultural development in each of them and is responsible of maintaining the economical, social and environmental to benefit agricultural development.

To accomplish effectively and efficiently this objective, the MINAG has been working since 1999 in the River Channeling and Collection Structures Protection Program (PERPEC). The river disaster prevention programs that are been carried out by regional governments are funded with PERPEC resources.

1) General Administration Office (OGA)
  - Manages and executes the program’s budget
  - Establishes the preparation of management guides and financial affairs

2) Hydraulic Infrastructure general Direction (DGIH)
  - Performs the study, control and implementation of the investment program
  - Develops general guidelines of the program together with OPI

3) Planning and Investment Office (OPI), present Planning and Budgetary Office (OPP)
  - Conducts the preliminary assessment of the investment program
  - Assumes the program's management and the execution of the program's budget
  - Plans the preparation of management guides and financial affairs

4) Irrigation Sub-Sectorial Program (PSI)
  - Carries-out the investment program approved by OPI and DGPM

(2) Economy and Finance Ministry (MEF)

Investment Policy General Direction (DGPI; previous DGPM) is in charge of approving public investment works according to procedures under the Public Investment National System (SNIP) to assess the relevance and feasibility of processing the disbursement request of the national budget and the loan from JICA.

(3) Japan's International Cooperation Agency (JICA)

It is a Japanese government institution with the objective of contributing in the socioeconomic development of developing countries through international cooperation. JICA has extended financial assistance to carry out profile and feasibility studies of this Project.

(4) Regional Governments (GORE)

Regional governments assume the promotion of integrated and sustainable regional development following the national and regional plans and programs, trying to increase public and private investment, generating employment opportunities, protecting citizens rights and ensuring equal opportunities.

The regional governments' participation with their possible financial support is a very important factor to ensure the Project's sustainability.

(5) Irrigation Commission

Currently there are 42 irrigation commissions in the Cañete River Watershed. These have expressed a strong desire for the starting of works because these will help constructing dikes, protecting margins, repairing water intakes, etc. These commissions are currently suffering major damages due to rivers flooding. Next, a brief overview of the Cañete River Watershed is described (for more details, see Section 3.1.3). Currently, the operation and maintenance of dikes, margin protection works, irrigation intakes and channels linked to agricultural land and irrigation systems in the Watershed, are mainly made by irrigation commissions and their members, with the assistance of local governments.

Number of irrigation blocks:	**42**
Number of Irrigation Commissions:	**7**
Irrigated Area:	**22,242 ha**
Beneficiaries:	**5,843 producers**

(6) Meteorology and Hydrology National Service (SENAMHI)

It is an agency from the Environment Ministry responsible for all activities related to meteorology, hydrology, environment and agricultural meteorology. Take part in global level monitoring, contributing to sustainable development, security and national welfare, and gathering information and data from meteorological stations and hydrological observation.

(7) Civil Defense National Institute (INDECI)

INDECI is the main agency and coordinator of SINAGERD (Sistema Nacional de Gestioh del Riesgo de Desastiv, established in May 2011. It is responsible for organizing and coordinating the community, elaborating plans and developing disaster risk’s management processes. Its objective is to prevent or alleviate human life loss due to natural and human disasters and prevent destruction of property and the environment.

(8) Water National Authority (ANA)

It is the highest technical regulating authority in charge of promoting, monitoring and controlling politics, plans, programs and regulations regarding sustainable use of water resources nationwide.

Its functions include sustainable management of these resources, as well as improving the technical and legal framework on monitoring and assessment of water supply operations in each region.

Along with maintaining and promoting a sustainable use of water resources, it is also responsible for conducting the necessary studies and developing main maintenance plans, national and international economic and technical cooperation programs.

(9) Agriculture Regional Directorates (DRA’s)

Agricultural regional addresses fulfill the following functions under the respective regional government:

1) Develop, approve, assess, implement, control and manage national agriculture policies, sectorial plans as well as regional plans and policies proposed by municipalities

2) Control agriculture activities and services fitting them to related policies and regulations, as well as on the regional potential

3) Participate in the sustainable management of water resources agreeing with the watershed’s general framework, as well as the policies of the Water National Authority (ANA)

4) Promote the restructure of areas, market development, export and agricultural and agro-industrial products consumption

5) Promote the management of: irrigation, construction and irrigation repair programs, as well as the proper management and water resources and soil conservation

2.4 Framework

2.4.1 Background

(1) Study background

The Republic of Peru (hereinafter “Peru”) is a country with high risk of natural disasters such as earthquakes, Tsunamis, etc. Among these natural disasters there are also floods. In particular, El Niño takes place with an interval of several years and has caused major flood of rivers and landslides in different parts of the country. The most serious disaster in recent years due to El Niño occurred in the rainy season of 1982-1983 and 1997-1998. In particular, the period of 1997-1998, the floods, landslides, among others left loss of 3,500 million of dollars nationwide. The latest floods in late January 2010, nearby Machupicchu World Heritage Site, due to heavy rains interrupted railway and roads traffic, leaving almost 2,000 people isolated. In Majes-Camana river the flood with discharge of over 1,100m3/sec (equivalent to about 10years probability flood) occurred at the midnight in February 13, 2012 causing flood disaster in the project area. The total area of inundation was 1,085 ha, the total length of 780m of dike was destroyed , and the main irrigation canal of 800m and secondary canal of 1,550m were damaged. And in Pisco river the dike in various areas was damaged and the Miraflores road bridge in Humay area was washed away.

In this context, the central government has implemented「El Niño phenomenon I and II contingency plans」in 1997-1998, throughout the Ministry of Agriculture (MINAG) in order to rebuild water infrastructures devastated by this phenomenon. Next, the Hydraulic Infrastructure General Direction (DGIH) of the Ministry of Agriculture (MINAG) began in 1999 the River Channeling and Intake Structures Protection Program (PERPEC) in order to protect villages, farmlands, agricultural infrastructure, etc. located within flood risk areas. The program consisted of financial support for regional government to carry out works of bank protection. In the multiyear PERPEC plan between 2007-2009 it had been intended to execute a total of 206 bank protection works nationwide. These projects were designed to withstand floods with a return period of 50 years, but all the works have been small and limited, without giving a full and integral solution to control floods. So, every time floods occur in different places, damages are still happening.

MINAG planned a “Valley and Rural Populations Vulnerable to Floods Protection Project” for nine watersheds of the five regions. However, due to the limited availability of experiences, technical and financial resources to implement a pre-investment study for a flood control project of such magnitude, MINAG requested JICA’s assistance to implementation this study. In response to this request, JICA and

MINAG held discussions under the premise of implementing it in the preparatory study scheme to formulate a loan from JICA, about the content and scope of the study, the implementation's schedule, obligations and commitments of both parties, etc. expressing the conclusions in the Minutes of Meeting (hereinafter "M/M") that were signed on January 21 and April 16, 2010. This study has been implemented in accordance with this M/M

(2) Progress of study

The Profile Study Report for this Project at Program's level for nine watersheds of five provinces was elaborated by DGIH and sent to the Planning and Investment Office (OPI) on December 23, 2009, and approved on the 30th of the same month. Afterwards, DGIH presented the report to the Public Sector Multiannual Programming General Direction (DGPM) (present DGPI) of the Economy and Finance Ministry (MEF) on January 18, 2010. On March 19th, DGPM informed DGIH about the results of the review and the correspondent comments.

The JICA Study Team began the study in Peru on September 5th, 2010. At the beginning, nine watersheds were included in the study. One, the Ica River was excluded of the Peruvian proposal leaving eight watersheds. The eight watersheds were divided into two groups: Group A with five watersheds and Group B with three watersheds. The study for the first group was assigned to JICA and the second to DGIH. Group A includes Chira, Cañete, Chincha, Pisco and Yauca Rivers' Watersheds and Group B includes the Cumbaza, Majes and Camana Rivers' Watersheds.

The JICA Study Team conducted the Profile Study of the five watersheds of Group A, with accuracy of pre-feasibility study level and handed DGIH the Program Report of group A and the Project Reports of the five watershed by the end of June 2011. Also, the feasibility study has already started, omitting the pre-feasibility study.

For the watersheds of Group B which study corresponded to DGIH, this profile study took place between mid-February and early March 2011 (and not with a pre-feasibility level, as established in the Meetings Minutes), where Cumbaza River Watershed was excluded because it was evident that it would not have an economic effect. The report on the Majes and Camana rivers watersheds were delivered to OPI, and OPI official comments were delivered to DGIH on April 26th, indicating that the performed study for these two watersheds did not meet the accuracy level required and it was necessary to study them again. Also, it was indicated to perform a single study for both rivers (Majes and Camana) because they belong to a single watershed.

On the other hand, due to the austerity policy announced on March 31st, prior to the new government assumption by new president on July 28th, it has been noted that it is extremely difficult to obtain new budget, DGIH has requested JICA on May 6th to perform the prefeasibility and feasibility studies of the Majes-Camana watershed.

JICA accepted this request and decided to perform the mentioned watershed study modifying the Minutes of Meeting for the second time (refer to Second Amendment of Minutes of Meetings on the Inception Report, Lima, July 22nd, 2011).

In accordance with the amendment, the JICA Study Team began in August the prefeasibility study for the watershed above mentioned, which was completed in the end of November.

Based on the Profile Study with Pre-Feasibility level, the four rivers of Cañete, Chincha, Pisco and Majes-Camana excluding Chira and Yauca rivers are selected for the objective rivers for the feasibility study under the restriction of total budget for the Project and viability of social evaluation of each river (refer to Minutes of Meetings on Main Points of Interim Report, Lima , December 5, 2011

DGIH registered 4 rivers to SNIP on July 21, 2011 based on the Profile Study reports (for each basin) except Yauca. Yauca river was not registered due to its low viability of the social evaluation judged by DGIH. And DGIH registered Majes-Camana river to SNIP on January 9, 2012. DGIH submitted the Profile Study reports of 4 rivers (Chira, Cañete, Chincha, Pisco excluding Yauca) with pre-FS level accuracy to OPI, which issued their observations on the reports to DGIH on September 22, 2011, and on the report of Majes-Camana river on August 4, 2012.

DGIH revised these Profile Study reports in accordance with the OPI's observation and submitted them to OPI in May 2012 for 3 rivers of Cañete, Chincha, Pisco, and December 12, 2012 for Majes-Camana river.

OPI examined the revised reports of 3 rivers and transferred them to DGPI, MEF together with their comments in July 2012. DGPI, MEF examined the reports and approved the implementation of Feasibility Study for 3 rivers with their comments in October 2012

Since the examination process of OPI and DGPI based on SNIP regulation had delayed, JICA executed the feasibility study on the 4 watersheds which were selected based on the Profile Study and submitted the program report of 4 watersheds and the project reports of each watersheds were submitted to DGIH on March 9, 2012 in draft form.

DGIH has been revising the feasibility study reports in accordance with the comments of MEF, after completion of revision will obtain the approval on the reports from OPI and MEF. And DGIH will take same process for the Majes-Camana river for which the examination and approval process of OPI and MEF delay.

On the other hand, JICA headquarter commented the run-off study on Majes-Camana river in the feasibility study, and JICA Study Team has to begin the review of the study (June 29, 2012). JICA Study Team started the review study in July 2012 and completed the revised run-off study and related various studies in November 2012. The process of the above is as shown in the Table-2.4.1-1.

Table-2.4.1-1 Process of study and submission of report

Items	Date	Chira	Ica	Chincha	Pisco	Yauca	Cañete	Majes	Camana	Cumbaza
Perfil Program		December 30, 2009：prepared and submitted by DGIH, January 18, 2010：approved by DGPI								
Start of JICA Study	2010/9/5	A group 5 rivers to be studied by JICA					B group 4 rivers to be studied by DGIH			
Amendment of M/M on ICR (No.1)	2010/11/12	－	excluded by DGIH	－	－	－	transferred to A group	－	－	－
Responsible Organization	－	JICA	－	JICA				DGIH		
Perfil Program Report	2011/3中旬	－	－	－	－	－	－	Preparation and Submission		
DGIH excluded Cumbaza		－	－	－	－	－	－	－	－	excluded by DGIH
OPI Observation	2011/4/26	－	－	－	－	－	－	Combination of both rivers and upgrade of study directed by OPI		—
Amendment of M/M on ICR (No2)	2011/6/22	－	－	－	－	－	－	DGIH requested study of this river to JICA		—
Pre-F/S Level Study	2011/6/30	Submission to DGIH	－	Submission to DGIH				－		—
SNIP Registration	2011/7/21	Registration to SNIP	－	Registration to SNIP		No registration to SNIP	Registration to SNIP	－		—
OPI Observation	2011/9/22	OPI Observation	－	OPI Observation		—	OPI Observation	－		—
Objectives for F/S Study	2011/12/5	excluded	－	Selected		－	Selected	Selected		－
Pre-F/S Level Study on Majes-Camana	2011/12/15	－	－	－	－	—		Submission to DGIH		—
Pre F/S Program Report of 6 rivers	2011/12/28	Submission to DGIH	－	Submission to DGIH			Submission to DGIH	Submission to DGIH		—
FS Draft Report	2012/3/9	－	－	Submission to DGIH		—	Submission to DGIH	Submission to DGIH		—
DGIH revised report to OPI	－	－	－	2012/5/15	2012/5/14	－	2012/5/21	2012/12/12		－
OPI report to MEF	－	－	－	2012/7/26			2012/7/26	Unknown		－
MEF approval for FS	－	－	－	2012/10/4	2012/10/16	2012/10/17		Unknown		－
DGIH revision of FS report	－	－	－	Under preparation		－	Under preparation	Unknown		－
OPI&MEF approval of revised FS report	－	－	－	Unknown	Unknown	－	Unknown	Unknown		－
Revised Study of Majes-Camana	－	－	－	－	－	－		2012/8～2012/11		－
Expalanation of the above	－	－	－	－	－	－		Scheduled in 2013/2/27		－
Submission of final FS report	－	－	－	scheduled in 2013/3		－	schedled in 2013/3	scheduled in 2013/3		－

2.4.2 Laws, Regulations, Policies and Guidelines Related to the Program

This program has been elaborated following the mentioned laws and regulations, policies and guidelines:

(1) Water Resources Law N° 29338

1）Article 75 .- Protection of water

The National Authority, in view of the Watershed Council, must ensure for the protection of water, including conservation and protection of their sources, ecosystems and natural assets related to it in the regulation framework and other laws applicable. For this purpose, coordination with relevant government institutions and different users must be done.

The National Authority, throughout the proper Watershed Council, executes supervision and control functions in order to prevent and fight the effects of pollution in the oceans, rivers and lakes. It can also coordinate for that purpose with public administration, regional governments and local governments sectors.

The State recognizes as environmentally vulnerable areas the headwater watersheds where the waters originate. The National Authority, with the opinion of the Environment Ministry, may declare protected areas the ones not granted by any right of use, disposition or water dumping.

2) Article 119 .- Programs flood control and flood disasters
The National Authority, together with respective Watershed Board, promotes integral programs for flood control, natural or manmade disasters and prevention of flood damages or other water impacts and its related assets. This promotes the coordination of structural, institutional and necessary operational measures.
Within the water planning, the development of infrastructure projects for multi-sectorial advantage is promoted. This is considered as flood control, flood protection and other preventive measures.

(2) Water Resources Law Regulation N° 29338

1) Article 118 .- From the maintenance programs of the marginal strip
The Water Administrative Authority, in coordination with the Agriculture Ministry, regional governments, local governments and water user organizations will promote the development of programs and projects of marginal strips forestry protection from water erosive action.

2) Article 259 º - Obligation to defend margins
All users have as duty to defend river margins against natural phenomenon effects, throughout all areas that can be influenced by an intake, whether it is located on owned land or third parties' land. For this matter, the correspondent projects will be submitted to be reviewed and approved by the Water National Authority.

(3) Water regulation

Article 49. Preventive measures investments for crop protection are less than the recovery and rehabilitation cost measures. It is important to give higher priority to these protective measures which are more economic and beneficial for the country, and also contribute to public expenses savings.

Article 50. In case the cost of dikes and irrigation channels protection measures is in charge of family production units or it exceeds the payment capacity of users, the Government may pay part of this cost.

(4) Multi-annual sectorial strategic plan of the Agriculture Ministry for the period 2007-2011 (RM N° 0821-2008-AG)

Promotes the construction and repair of irrigation infrastructure works with the premise of having enough water resources and their proper use.

(5) Organic Law of the Agriculture Ministry, N° 26821

In Article 3, it is stipulated that the agricultural sector is responsible for executing river works and agricultural water management. This means that river works and water management for agricultural purposes shall be paid by the sector.

(6) Guidelines for Peruvian Agricultural Policy - 2002, by the Policy Office of MINAG

Title 10 - Sectorial Policies

"Agriculture is a high risk productive activity due to its vulnerability to climate events, which can be anticipated and mitigated... The damage cost to infrastructure, crops and livestock can be an obstacle for the development of agriculture, and as consequence, in the deterioration of local, regional and national levels."

(7) River Channeling and Collection Structures Protection Program, PERPEC

The MINAG's DGIH started in 1999 the River Channeling and Collection Structures Protection Program (PERPEC) in order to protect communities, agricultural lands and facilities and other elements of the region from floods damages, extending financial support to margin protection works carried out by regional governments.

3. IDENTIFICATION

3.1 Diagnosis of the Current Situation

3.1.1 Nature

(1) Location

Figure 3.1.1-1 shows the location map of the Cañete River of this study.

Figure 3.1.1-1 Objective River for the Study

(2) Watershed overall description

The Cañete River runs 130km to the south of the Capital of Lima and it is the closest river to this city among the six rivers chosen. Its area covers 6,100 km^2. It’s characterized by the small width of its lower watershed and for the great extension of the middle and upper watershed. Approximately, 50%

of the watershed it is located above 4,000 m.a.s.l and only 10% below 1,000 m.a.s.l. The lower watershed, which is the study area, where the river has a slope approximately of 1/90 with a 200 meters of average width.

Annual rainfalls of Cañete River vary according the altitude. For example, in areas with more than 4,000 m.a.s.l , annually 1,000mm of rain happen and in areas with less than 500 m.a.s.l, only 20mm fall, suiting the desert. However, the water watershed area is wide and the flow is pretty abundant too.

As to vegetation, middle and upper watersheds are covered with scrublands. In the lower basin, most of it is desert, excepting crop land developed at the river sides. The main products are apple and grapes. Also, the river is used for prawn catch and for tourism (rafting, canoeing, etc.)

3.1.2 Socio-Economic Conditions of the Study Area

(1) Administrative division and surface

The Cañete River is located in the provinces of Cañete in the Lima Region. Table 3.1.2-1 shows the main districts surrounding this river, with their corresponding surface.

Table 3.1.2-1 Districts surrounding the Cañete river with areas

Region	Province	District	Area(㎢)
Lima	Cañete	San Vicente de Cañete	513.15
		Cerro Azul	105.17
		Nuevo Imperial	329.3
		San Luis	38.53
		Lunahuaná	500.33

(2) Population and number of households

The following Table 3.1.2-2 shows how population varied within the period 1993-2007. In 2007, from 120.663 inhabitants, 85% (102.642 inhabitants) lived in urban areas while 15% (18.021 inhabitants) lived in rural areas. Population is increasing in all districts. However, while the urban area registers an annual medium increase of 2.7%, exceeding the national average, the rural area experiments a decrease of 0.1%.

Table 3.1.2-2 Variation of the urban and rural population

District	Total Population 2007					Total Population 1993					Variation (%)	
	Urban	%	Rural	%	Total	Urban	%	Rural	%	Total	Urban	Rural
San Vicente de Cañete	37.512	81 %	8.952	19 %	46.464	22.244	68 %	10.304	32 %	32.548	3,8 %	-1,0 %
Cerro Azul	5.524	80 %	1.369	20 %	6.893	3.271	64 %	1.853	36 %	5.124	3,8 %	-2,1 %
Imperial	33.728	93 %	2.612	7 %	36.340	28.195	92 %	2.459	8 %	30.654	1,3 %	0,4 %
Nuevo Imperial	15.144	80 %	3.882	20 %	19.026	9.403	72 %	3.733	28 %	13.136	3,5 %	0,3 %
San Luis	10.734	90 %	1.206	10 %	11.940	7.725	76 %	2.434	24 %	10.159	2,4 %	-4,9 %
Total	**102.642**	**85 %**	**18.021**	**15 %**	**120.663**	**70.838**	**77 %**	**20.783**	**23 %**	**91.621**	**2,7 %**	**-1,0 %**

Source: Prepared by JICA Study Team, Statistics National Institute- INEI, 2007 and 1993 Population and Housing Census.

Table 3.1.2-3 shows the number of households and members per home in 2007. The number of members per household has been 4.4 in average, except for Nuevo Imperial that had a minor number of 3.91.

The number of members per family is around 4,1 persons, with exception of Nuevo Imperial, with a lower Figure of 3.77.

Table 3.1.2-3 Number of households and families

Variables	District				
	San Vicente de Cañete	Cerro Azul	Imperial	Nuevo Imperial	San Luis
Population (inhabitants)	46,464	6,893	36,340	19,026	11,940
Number of households	10,468	1,549	8,170	4,867	2,750
Number of families	11,267	1,662	8,922	5,052	2,940
Members per household (person/home)	4.44	4.45	4.45	3.91	4.34
Members per family (person/family)	4.12	4.15	4.07	3.77	4.06

(3) Occupation

Table 3.1.2-4, shows occupation lists of local inhabitants itemized by sector. It highlights the primary sector in all districts representing between 27. and 56.5% of the economically active population (EAP). Especially the primary sector in Nuevo Imperial、San Luis occupies as high as 56.5％ and 49.7％.

Table 3.1.2-4 Occupation

	District									
	San Vicente de Cañete		Cerro Azul		Imperial		Nuevo Imperial		San Luis	
	People	%	People	%	People	%	People	%	People	%
EAP	19,292	100	2,562	100	15,114	100	7,770	100	4,723	100
Primary Sector	5,910	30.6	742	29.0	4,213	27.9	4,393	56.5	2,349	49.7
Secondary Secto	2,310	12.0	550	21.5	1,590	10.5	621	8.0	504	10.7
Tertiary Sector	11,072	57.4	1,270	49.6	9,311	61.6	2,756	35.5	1,870	39.6

* Primary Sector: agriculture, livestock, forestry and fishing; secondary: mining, construction, manufacture; tertiary: services and others

(4) Poverty index

Table 3.1.2-5, shows the poverty index. 34.7% of the districts' population (41,840 inhabitants) belongs to the poor segment, and 3.1% (3,793 inhabitants) belong to extreme poverty. Particularly, the Nuevo Imperial district stands out for its high poverty percentage with 42.8%, and 4.6% of extreme poverty.

Table 3.1.2-5 Poverty index

	Distrito											
	San Vicente		Cerro Azul		Imperial		Nuevo Imperial		San Luis			
	People	%	People	%	People	%	People	%	People	%	Total	%
Regional Populatio	46,464	100	6,893	100	36,340	100	19,026	100	11,940	100	120,663	100
In poverty	14,068	30.3	2,097	30.4	12,947	35.6	8,152	42.8	4,576	38.3	41,840	34.7
In extreme poverty	1,382	3.0	129	1.9	1,029	2.8	878	4.6	375	3.1	3,793	3.1

(5) Type of housing

The walls of the houses are made 39% of bricks or cement, and 42% of adobe and mud. The floor is made 94% of earth or cement. Except Nuevo Imperial, the public drinking water service covers approximately 58%, while the sewage service is 52%. In the specific case of Nuevo Imperial there is a low coverage of both services, with 25.1% and 11.3% respectively.

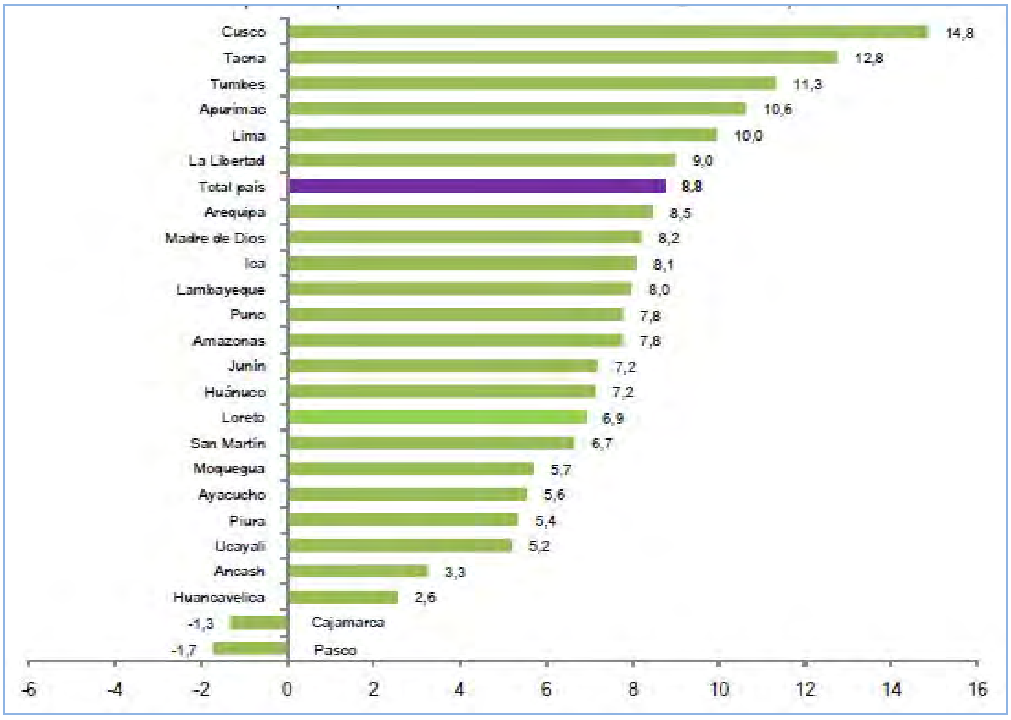
Table 3.1.2-6 Type of housing

Variable/Indicator	**District**									
	San Vicente de Cañete		**Cerro Azul**		**Imperial**		**Nuevo Imperial**		**San Luis**	
	Households	%	Households	%	Households	%	Households	%	Households	%
Variable/Indicator										
	10.468	78,8	1.549	45,1	8.170	88,9	4.867	77,1	2.750	84,5
Name of housings	4.685	44,8	853	55,1	2.661	32,6	1.220	25,1	848	30,8
Common residents housing	3.518	33,6	210	13,6	4.075	49,9	2.105	43,3	1.145	41,6
Walls materials	783	7,5	288	18,6	161	2,0	650	13,4	183	6,7
Bricks or cement	1.482	14,2	198	12,8	1.273	15,6	892	18,3	574	20,9
Adobe and mud										
Bamboo + mud or wood	4.196	40,1	661	42,7	4.279	52,4	2.842	58,4	1.501	54,6
Others	4.862	46,4	781	50,4	3.432	42	1.925	39,6	1.109	40,3
Floor Materials	1.342	12,8	100	6,5	421	5,2	67	1,4	102	3,7
Soil	68	0,6	7	0,5	38	0,5	33	0,7	38	1,4
Cement										
Ceramics, parquet, quality wood	5.729	54,7	886	57,2	5.642	69,1	1.220	25,1	1.457	53,0
Others	584	5,6	66	4,3	373	4,6	334	6,9	166	6,0
Running water system	666	6,4	52	3,4	234	2,9	80	1,6	346	12,6
Public network within household										
Public network within building	4.987	47,6	824	53,2	5.115	62,6	549	11,3	1.167	42,4
public use	482	4,6	32	2,1	364	4,5	70	1,4	118	4,3
Sewage	2.002	19,1	317	20,5	1.206	14,8	3.564	73,2	203	7,4
Public sewage within household										
Public sewage within building	8.373	80	1.217	78,6	6.733	82,4	3.520	72,3	2.110	76,7
Septic Tank										
Electricity	**11.267**	**100**	**1.662**	**100**	**8.922**	**100**	**5.052**	**100**	**2.940**	**100**
Public electric service										
Member quantity	4.844	43,0	648	39	2.822	31,6	1.237	24,5	1.045	35,5
Common residents housing										
Appliances	9.391	83,3	1.373	82,6	5.759	64,5	2.708	53,6	1.728	58,8

Source: Prepared by JICA Study Team, Statistics National Institute- INEI, 2007 Population and Housing Census.

(6) GDP

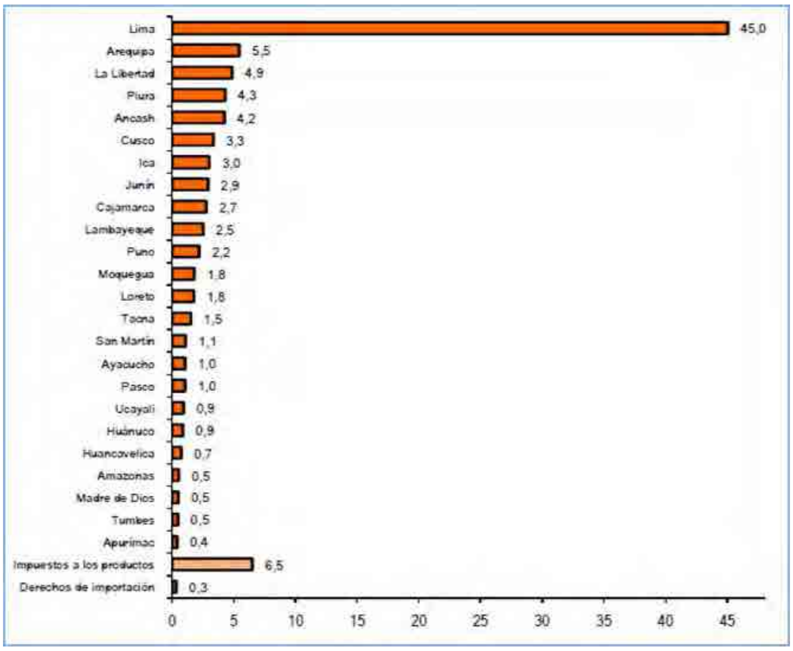
Peru’s GDP in 2010 was US$ 153.919.000.000. The growth rate in the same year was of + 8.8 % compared with the previous year. Itemized by regions, Ica registered a growth of 8.1 %, Piura 5.4 %, Lima 10.0 % and Arequipa 8.5 %. Particularly Lima regions registered Figures that were beyond the national average.



Fuente INEI – Dirección Nacional de Cuentas Nacionales-2010、国立統計局 －INEIと中央準備銀行 －BCR

Figure 3.1.2-1 Growth rate of GDP per region (2010/2009)

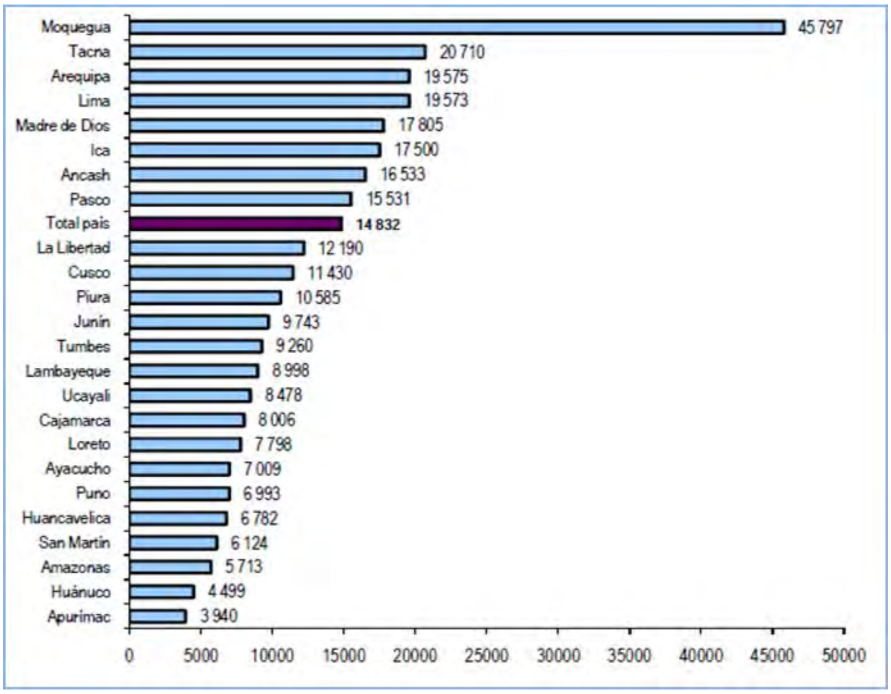
The table below shows the contribution of each region to the GDP. Lima Region represents almost half of the total, that is to say 45.0%. Arequipa contributed with 5.5 %, Piura 4.3 % and Ica 3.0 %. Taxes and duties contributed with 6.5 % and 0.3 %, respectively.



Fuente INEI – Dirección Nacional de Cuentas Nacionales-2010、

Figure 3.1.2-2 Region contribution to GDP

The GDP per capita in 2010 was of S/.14,832 (5,727 US$). The Table below shows data per region: Lima S/.19,573(7,557 US$), Arequipa S/.19,575(7,558US$), Ica S/.17,500(6,757US$) show the higher value than national average, but Piura S/.10,585(4,087 US$) is lower than the national average.



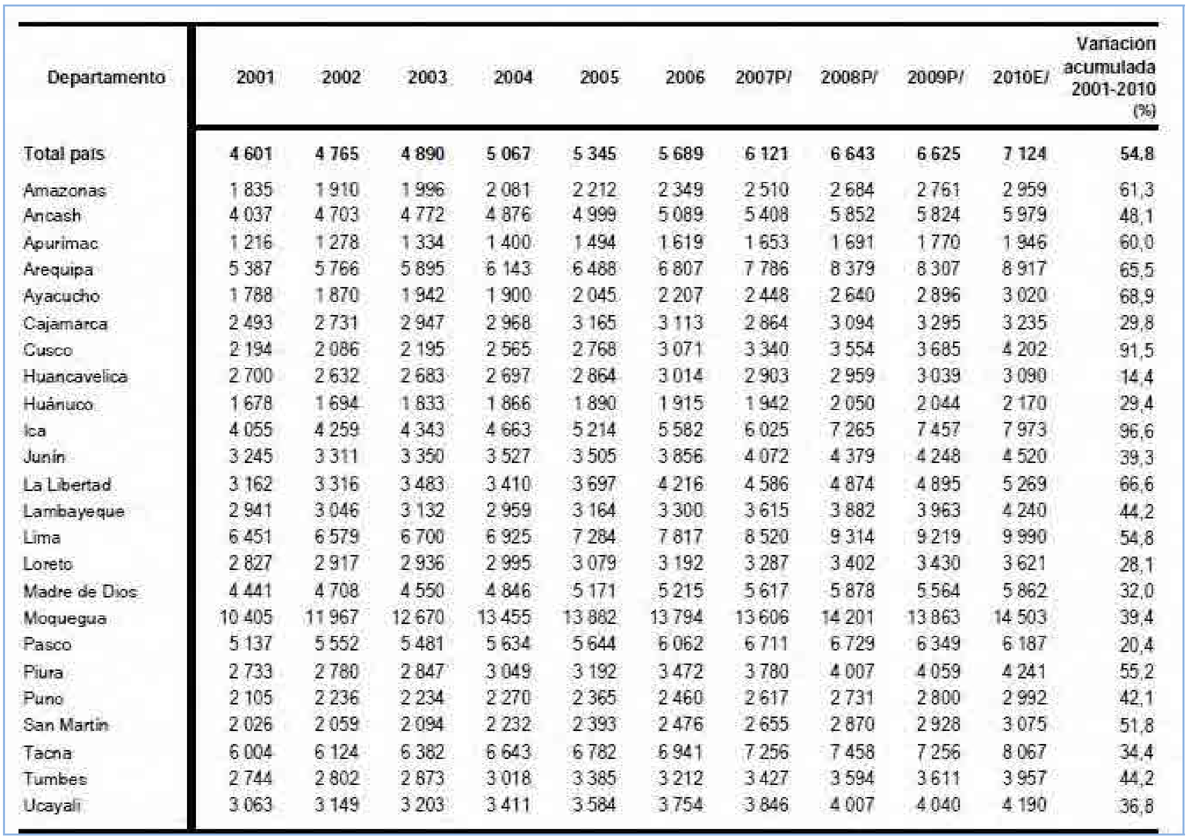
Fuente INEI – Dirección Nacional de Cuentas Nacionales-2010

Figure 3.1.2-3 GDP per capita (2010)

Table 3.1.2-7 shows the variation along the years of the GDP per capita per region, during the last 10 years (2001-2010). The GDP national average increased in 54.8% within 10 years from 2001 until 2010. The Figures per region are: +96.6 % for Ica, +65.5 % for Arequipa, +55.2 % for Piura y +54.8 % for Lima. Figures in Table 3.1.2-7 were established taking 1994 as base year.

Table 3.1.2-7 Variation of the GDP per capita (2001-2009)

(1994 Base year, S/.)



Departamento	2001	2002	2003	2004	2005	2006	2007P/	2008P/	2009P/	2010E/	Variacion acumulada 2001-2010 (%)
Total país	4 601	4 765	4 890	5 067	5 345	5 689	6 121	6 643	6 625	7 124	54,8
Amazonas	1 835	1 910	1 996	2 081	2 212	2 349	2 510	2 684	2 761	2 959	61,3
Ancash	4 037	4 703	4 772	4 876	4 999	5 089	5 408	5 852	5 824	5 979	48,1
Apurimac	1 216	1 278	1 334	1 400	1 494	1 619	1 653	1 691	1 770	1 946	60,0
Arequipa	5 387	5 766	5 895	6 143	6 488	6 807	7 786	8 379	8 307	8 917	65,5
Ayacucho	1 788	1 870	1 942	1 900	2 045	2 207	2 448	2 640	2 896	3 020	68,9
Cajamarca	2 493	2 731	2 947	2 968	3 165	3 113	2 864	3 094	3 295	3 235	29,8
Cusco	2 194	2 086	2 195	2 565	2 768	3 071	3 340	3 554	3 685	4 202	91,5
Huancavelica	2 700	2 632	2 683	2 697	2 864	3 014	2 903	2 959	3 039	3 090	14,4
Huánuco	1 678	1 694	1 833	1 866	1 890	1 915	1 942	2 050	2 044	2 170	29,4
Ica	4 055	4 259	4 343	4 663	5 214	5 582	6 025	7 265	7 457	7 973	96,6
Junín	3 245	3 311	3 350	3 527	3 505	3 856	4 072	4 379	4 248	4 520	39,3
La Libertad	3 162	3 316	3 483	3 410	3 697	4 216	4 586	4 874	4 895	5 269	66,6
Lambayeque	2 941	3 046	3 132	2 959	3 164	3 300	3 615	3 882	3 963	4 240	44,2
Lima	6 451	6 579	6 700	6 925	7 284	7 817	8 520	9 314	9 219	9 990	54,8
Loreto	2 827	2 917	2 936	2 995	3 079	3 192	3 287	3 402	3 430	3 621	28,1
Madre de Dios	4 441	4 708	4 550	4 846	5 171	5 215	5 617	5 878	5 564	5 862	32,0
Moquegua	10 405	11 967	12 670	13 455	13 882	13 794	13 606	14 201	13 863	14 503	39,4
Pasco	5 137	5 552	5 481	5 634	5 644	6 062	6 711	6 729	6 349	6 187	20,4
Piura	2 733	2 780	2 847	3 049	3 192	3 472	3 780	4 007	4 059	4 241	55,2
Puno	2 105	2 236	2 234	2 270	2 365	2 460	2 617	2 731	2 800	2 992	42,1
San Martín	2 026	2 059	2 094	2 232	2 393	2 476	2 655	2 870	2 928	3 075	51,8
Tacna	6 004	6 124	6 382	6 643	6 782	6 941	7 256	7 458	7 256	8 067	34,4
Tumbes	2 744	2 802	2 873	3 018	3 385	3 212	3 427	3 594	3 611	3 957	44,2
Ucayali	3 063	3 149	3 203	3 411	3 584	3 754	3 846	4 007	4 040	4 190	36,8

Fuente INEI – Dirección Nacional de Cuentas Nacionales-2010

3.1.3 Agriculture

Next is a summarized report on the current situation of agriculture in the Watershed of the Cañete River, including irrigation commissions, crops, planted area, performance, sales, etc.

(1) Irrigation sectors

Table 3.1.3-1 shows basic data on the irrigation commissions. In the Cañete River Watershed there are 42 irrigation sectors, 7 irrigation commissions with 22,242 beneficiaries. The surface managed by these sectors reach a total of 5.843 hectares.

Table 3.1.3-1 Basic data of the irrigation commissions

Irrigation Sectors	Irrigation Commissions	Areas under irrigation		Nº of Beneficiaries (People)	River
		ha	%		
Roma Rinconada. La Huerta	Canal Nuevo Imperial	7.883	35	2.202	Cañete
Lateral A					
Cantera Almenares					
Lateral B					
Lateral T					
Túnel Grande					
Quebrada Ihuanca					
Cantagallo-U Campesina					

Caltopa Caltopilla					
Casa Pintada Sn Isidro	Canal Viejo Imperial	3.715	17	1.080	
Cerro Alegre Huaca Chivato					
Conde Chico Ungara					
Josefina Sta. Gliceria					
Tres Cerros	Canal María Angola	1.785	8	470	
Montejato					
La Quebrada					
Hualcara					
Cerro de Oro					
Chilcal					
Montalván-Arona-La Qda.-Tupac	Canal San Miguel	3.627	16	860	
Lúcumo - Cuiva - Don Germán					
Lateral 74-La Melliza-Sta Bárbara					
Casa Blanca - Los Lobos					
Lúcumo - Cuiva - Don Germán	Canal Huanca	2.301	10	421	
Huanca Media					
Huanca Baja					
Huanca Alta					
Gr.9.2 lateral 4	Canal Pachacamilla	928	4	234	
Gr.9.1 lateral 3					
Gr.8.2 lateral 2					
Gr.8.1 lateral 1					
Gr.7 compuerta 10 Y 11					
Gr.6 compuerta 9					
Gr.5 compuerta 6,7 Y 8					
Gr.4 compuerta 5					
Gr.3 compuerta 4 Y 12					
Gr.2 compuerta 2 Y 3					
Gr.11 Basombrio					
Gr.10 Pachacamilla Vieja					
Gr.1 compuerta 1					
Palo	Canal Palo Herbay	2.003	9	576	
Herbay Alto					
Total		**22.242**	**100**	**5.843**	

Source: Prepared by JICA Study Team, Users Board of Camana-Majes, September 2011

(2) Main crops

Table 3.1.3-2 shows the variation between 2004 and 2009 of the planted surface and the performance of main crops.

In the Cañete River Watershed, in 2005 and 2007 the planted area, performance and sales decreased, but later increased so that during the period of 2009 levels of 2004-2005 were recovered. The profits of 2008-2009 were of S/.219.095.280. Main crops in this watershed were represented by: corn, cotton, beets, grapes and fresh corn.

Table 3.1.3-3 Sowing and sales of main crops

	Variables	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Corn (yellow)	Planted Area (ha)	10,700	9,203	7,802	11,285	12,188
	Unit performance (kg/Ha)	8,225	8,278	8,591	8,711	8,411
	Harvest (Kg)	88,010,215	76,182,249	67,023,861	98,302,605	102,512,719
	Unit Price (S/./kg)	0.53	0.57	0.69	0.80	0.69
	Sales (S/.)	46,645,414	43,423,882	46,246,464	78,642,084	70,733,776
Cotton	Planted Area (ha)	6,750	6,241	4,146	4,887	1,697
	Unit performance (kg/Ha)	3,015	3,290	3,295	3,502	3,448
	Harvest (Kg)	20,350,647	20,533,219	13,662,388	17,112,523	5,850,911
	Unit Price (S/./kg)	2.14	2.13	2.77	2.67	1.85
	Sales (S/.)	43,550,385	43,735,756	37,844,815	45,690,436	10,824,186
Beets	Planted Area (ha)	2,794	1,804	2,823	1,475	3,855
	Unit performance (kg/Ha)	24,367	24,434	18,953	21,768	20,088
	Harvest (Kg)	68,088,708	44,081,379	53,500,528	32,112,154	77,429,196
	Unit Price (S/./kg)	0.24	0.33	0.45	0.58	0.37
	Sales (S/.)	16,341,290	14,546,855	24,075,238	18,625,049	28,648,803
Grapes	Planted Area (ha)	1,725	1,898	1,780	2,100	2,247
	Unit performance (kg/Ha)	14,891	15,735	17,928	19,088	18,702
	Harvest (Kg)	25,685,486	29,857,163	31,911,840	40,077,165	42,023,394
	Unit Price (S/./kg)	0.62	0.84	1.12	1.11	0.99
	Sales (S/.)	15,925,001	25,080,017	35,741,261	44,485,653	41,603,160
Corn	Planted Area (ha)	2,617	2,602	2,453	2,796	2,563
	Unit performance (kg/Ha)	47,095	47,125	48,377	54,848	52,276
	Harvest (Kg)	123,224,068	122,623,963	118,683,294	153,333,069	133,957,250
	Unit Price (S/./kg)	0.07	0.07	0.08	0.10	0.10
	Sales (S/.)	8,625,685	8,583,677	9,494,664	15,333,307	13,395,725
Tangerine	Planted Area (ha)	932	941	814	1,077	1,087
	Unit performance (kg/Ha)	38,670	41,261	42,913	43,596	SD
	Harvest (Kg)	36,032,706	38,818,349	34,944,056	46,957,252	
	Unit Price (S/./kg)	0.74	0.64	0.79	0.67	1.19
	Sales (S/.)	26,664,202	24,843,743	27,605,804	31,461,359	
Apples	Planted Area (ha)	769	802	752	865	833
	Unit performance (kg/Ha)	20,459	21,884	21,717	22,175	25,526
	Harvest (Kg)	15,726,833	17,540,026	16,329,012	19,185,810	21,270,816
	Unit Price (S/./kg)	0.52	0.63	0.63	0.75	0.75
	Sales (S/.)	8,177,953	11,050,216	10,287,278	14,389,358	15,953,112
Potatoes	Planted Area (ha)	1,161	739	772	878	1,053
	Unit performance (kg/Ha)	24,700	25,216	23,717	26,687	24,386
	Harvest (Kg)	28,681,640	18,637,146	18,302,409	23,420,511	25,676,019
	Unit Price (S/./kg)	0.37	0.44	0.35	0.74	0.43
	Sales (S/.)	10,612,207	8,200,344	6,405,843	17,331,178	11,040,688
Yucca	Planted Area (ha)	686	1,030	671	717	981
	Unit performance (kg/Ha)	33,162	33,594	32,856	36,007	37,963
	Harvest (Kg)	22,732,551	34,605,179	22,056,233	25,817,019	37,241,703
	Unit Price (S/./kg)	0.36	0.36	0.42	0.67	0.42
	Sales (S/.)	8,183,718	12,457,865	9,263,618	17,297,403	15,641,515
Avocado	Planted Area (ha)	306	411	403	662	765
	Unit performance (kg/Ha)	5,844	6,064	8,162	5,424	6,129
	Harvest (Kg)	1,790,602	2,494,123	3,285,205	3,589,603	4,689,298
	Unit Price (S/./kg)	2.69	3.02	2.54	2.66	2.40
	Sales (S/.)	4,816,718	7,532,252	8,344,421	9,548,345	11,254,315
Others	Planted Area (ha)	3,947	4,839	4,223	5,281	5,296

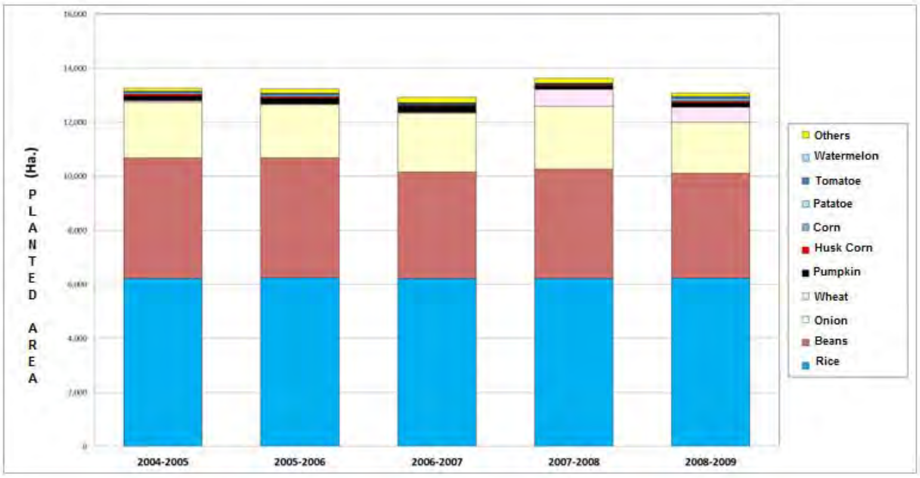


Figure 3.1.3-1 Planted surface

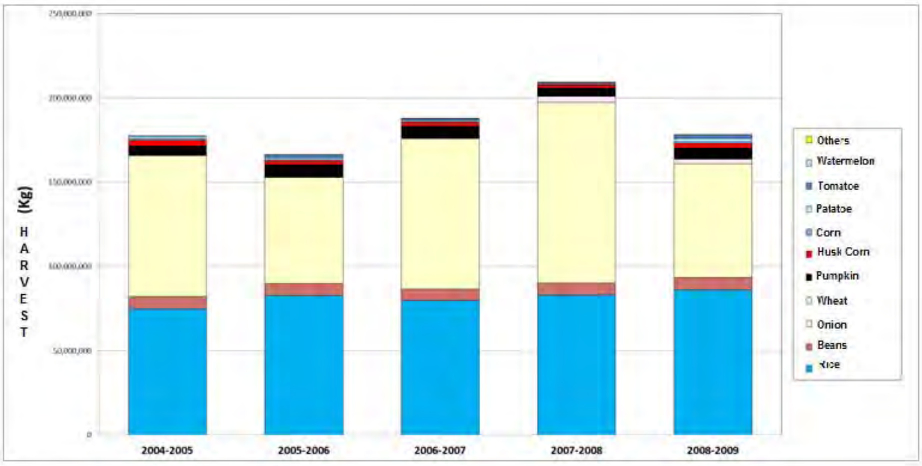


Figure 3.1.3-2 Harvest

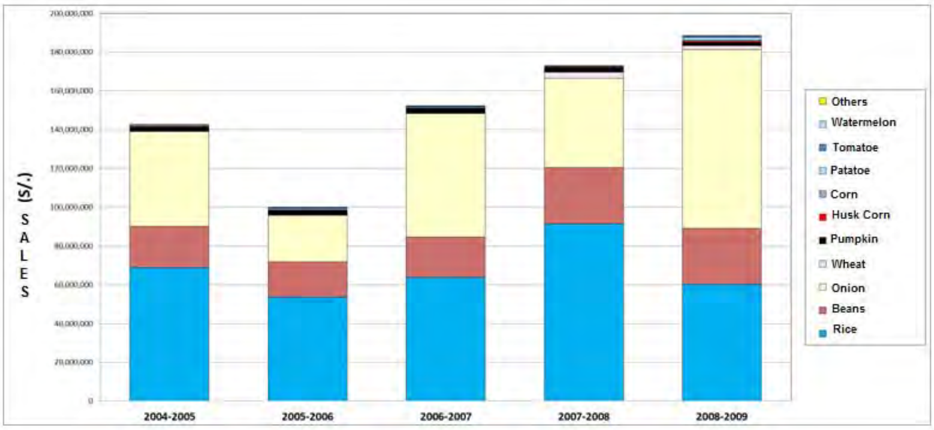


Figure 3.1.3-3 Sales

3.1.4 Infrastructure

(1) Road infrastructures

Table 3.1.4-1 shows road infrastructures in the watershed of the Cañete River. In total there are 822,39km of roads, 265,89km of them (32,3%) are national roads, 59,96km (7,3%) regional roads, and 496,54km (60,4%) municipal roads.

Table 3.1.4-1 Basic data of road infrastructure

（Km）

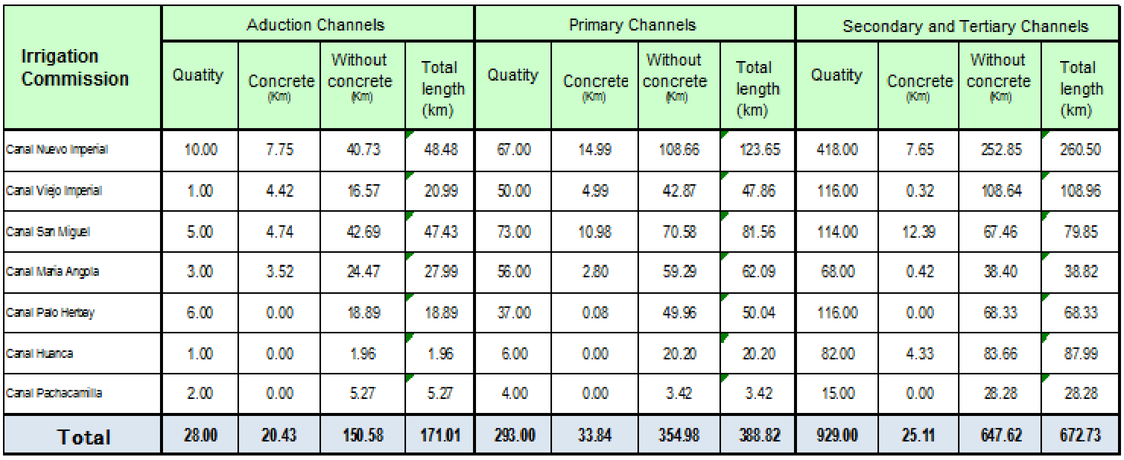
Roads	Total Length		Paving			
			Asphalted	Compacted	Non-	Soil
National roads	265.89	32.3%	205.75	60.14	0.00	0.00
Regional roads	59.96	7.3%	10.40	49.56		
Municipal roads	496.54	60.4%	39.83	213.18	211.37	32.16
Total	822.39	100.0%	255.98	322.88	211.37	32.16

(2) Irrigation systems

Intake:
In Cañete River Watershed, there are 4 intakes from which Nuevo Imperial, La Fortaleza and Palo Herbay are permanent

Irrigation Channels:
In Table 3.1.4-2, the gathered size of the existing irrigation channels is shown. Derivation channels of 1st, 2nd and 3rd order add up in total 1,232km, from this 80km are lagged (6% of the total amount).

Table 3.1.4-2 Existing irrigation channels

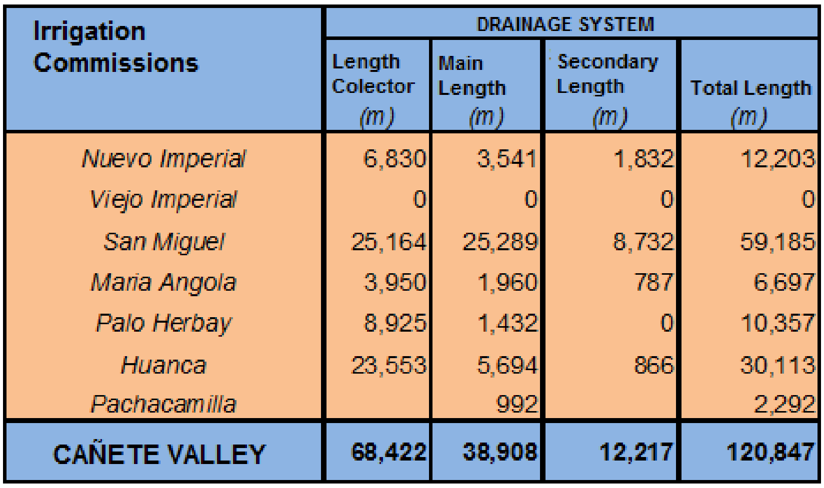


Irrigation Commission	Aduction Channels				Primary Channels				Secondary and Tertiary Channels			
	Quatity	Concrete (Km)	Without concrete (Km)	Total length (km)	Quatity	Concrete (Km)	Without concrete (Km)	Total length (km)	Quatity	Concrete (Km)	Without concrete (Km)	Total length (km)
Canal Nuevo Imperial	10.00	7.75	40.73	48.48	67.00	14.99	108.66	123.65	418.00	7.65	252.85	260.50
Canal Viejo Imperial	1.00	4.42	16.57	20.99	50.00	4.99	42.87	47.86	116.00	0.32	108.64	108.96
Canal San Miguel	5.00	4.74	42.69	47.43	73.00	10.98	70.58	81.56	114.00	12.39	67.46	79.85
Canal María Angola	3.00	3.52	24.47	27.99	56.00	2.80	59.29	62.09	68.00	0.42	38.40	38.82
Canal Palo Herbay	6.00	0.00	18.89	18.89	37.00	0.08	49.96	50.04	116.00	0.00	68.33	68.33
Canal Huanca	1.00	0.00	1.96	1.96	6.00	0.00	20.20	20.20	82.00	4.33	83.66	87.99
Canal Pachacamilla	2.00	0.00	5.27	5.27	4.00	0.00	3.42	3.42	15.00	0.00	28.28	28.28
Total	**28.00**	**20.43**	**150.58**	**171.01**	**293.00**	**33.84**	**354.98**	**388.82**	**929.00**	**25.11**	**647.62**	**672.73**

Drainage Channels:

In Table 3.1.4-3, the total size of the drainage channels according to the irrigation commissions is shown.

Table 3.1.4-3 Drainage channels



Irrigation Commissions	DRAINAGE SYSTEM			
	Length Colector (m)	Main Length (m)	Secondary Length (m)	Total Length (m)
Nuevo Imperial	6,830	3,541	1,832	12,203
Viejo Imperial	0	0	0	0
San Miguel	25,164	25,289	8,732	59,185
Maria Angola	3,950	1,960	787	6,697
Palo Herbay	8,925	1,432	0	10,357
Huanca	23,553	5,694	866	30,113
Pachacamilla		992		2,292
CAÑETE VALLEY	**68,422**	**38,908**	**12,217**	**120,847**

(3) PERPEC

Table 3.1.4-4 shows implemented projects by PERPEC between 2006 and 2009

Table 3.1.4-4 Projects implemented by PERPEC

Nº	Year	Work name	Location				Description			Total cost (S/.)
			Departamt	Province	District	Town				
1	2006	Cañete river Coastal defense - Huacre area	Lima	Cañete	San Vicente de Cañete	Huacre	Dike structure	1	Km	250,482.00
2	2007	Cañete river upper basin Irrigation structure rehabilitation	Lima	Cañete	Colonia, Madean, Putinza, Yauyos, Huantan	Several	Channel sheathing	3.48	Km	201,250.00
3	2007	Cañete river medium basin infrastructure rehabilitation	Lima	Cañete	Zuñiga , Pacaran, Lunahuana	Several	Channel sheathing	1.66	Km	261,363.00
4	2007	Cañete river lower basin infrastructure rehabilitation	Lima	Cañete	San Vicente de Cañete, San Luis, Nuevo Imperial	Several	Chanel rehabilitation	12.56	Km	483,522.00
5	2007	Cañete valley drain rehabilitation and cleansing	Lima	Cañete	San Luis, San Miguel, Quilmana	Several	Rock filled dike	13.1	Km	169,363.00
6	2007	Mala valley irrigation and drain infrastructure rehabilitation	Lima	Cañete	Mala-San Antonio	Santa Cruz de Flores, Mala , Sta Cruz de Flores, La Huaca	Channel sheathing	1.7	Km	219,502.00
7	2007	Mala river Coastal defense Area: Santa Clorinda	Lima	Cañete	Mala	Mala	Rock filled dike	1	Km	459,280.00
8	2008	Cañete river provisional coastal defense; areas: Carlos V, Sta. Teresa (Contingency)	Lima	Cañete	San Vicente de Cañete	Carlos V , Sta Teresa	Stream cleaning	1.6	Km.	282,794.55
9	2008	Mala river provisional coastal defense; areas: San José, Las Animas (Contingency)	Lima	Cañete	Mala	San Jose, Las Animas	Stream cleaning	1	Km.	207,713.00
10	2008	Mala river channeling and coastal defense Area : Correviento - Rinconada (Contingency)	Lima	Cañete	Mala	Correviento - Rinconada	Rock filled dike	0.56	Km	324,009.64

3.1.5 Real Flood Damages

(1) Damages on a nationwide scale

Table 3.1.5-1 shows the present situation of flood damages during the last five years (2003-2007) in the whole country. As observed, there are annually dozens to hundreds of thousands of flood affected inhabitants.

Table 3.1.5-1 Situation of flood damages

		Total	2003	2004	2005	2006	2007
Disasters	Cases	1,458	470	234	134	348	272
Víctims	persons	373,459	118,433	53,370	21,473	115,648	64,535
Housing loss victims	persons	50,767	29,433	8,041	2,448	6,328	4,517
Decesased individuals	persons	46	24	7	2	9	4
Partially destroyed houses	Houses	50,156	17,928	8,847	2,572	12,501	8,308
Totally destroyed	Houses	7,951	3,757	1,560	471	1,315	848

Source : SINADECI Statistical Compendium

Peru has been hit by big torrential rain disasters caused by the El Niño Phenomenon. Table 3.1.5-2 shows damages suffered during the years 1982-1983 and 1997-1998 with extremely serious effects. Victims were approximately 6.000.000 inhabitants with an economic loss of about US$ 1.000.000.000 in 1982-1983. Likewise, victims number in 1997-1998 reached approximately 502.461 inhabitants with economic loss of US$ 1.800.000.000. Damages in 1982-1983 were so serious that they caused a decrease of 12 % of the Gross National Product.

Table 3.1.5-2 Damages

Damages	1982-1983	1997-1998
Persons who lost their homes	1.267.720	—
Victims	6.000.000	502.461
Injured	—	1.040
Deceased	512	366
Missing persons	—	163
Partially destroyed houses	—	93.691
Totally destroyed houses	209.000	47.409
Partially destroyed schools	—	740
Totally destroyed schools	—	216
Hospitals and health centers partially destroyed	—	511
Hospitals and health centers totally destroyed	—	69
Damaged arable lands (ha)	635.448	131.000
Head of cattle loss	2.600.000	10.540
Bridges	—	344
Roads (km)	—	944
Economic loss ($)	1.000.000.000	1.800.000.000

“–“: No data

(2) Disasters in the watersheds object of this study

Table 3.1.5-3 summarizes damages occurred in the Lima region, to which this study belongs to.

Table 3.1.5-3 Disasters in Lima region

Years	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Media
LANDSLIP																	0	
FLOOD																	0	
COLLAPSE									14	4	17	32	15	22	10	23	137	
LANDSLIDE	1	3	1	4	2	1	3	4	5	4	2	1	5	5	2	7	50	
AVALANCHE	6		2	17	17	4	2	11	8	4	0	7		3	3	3	87	
TOTAL DESASTRES DE SEDIMENTOS	7	3	3	21	19	5	5	15	27	12	19	40	20	30	15	33	274	17
TOTAL FLOODING	2	2	1	23	21	9	15	5	13	11	7	10	11	4	4	0	138	9

3.1.6 Results on the Visits to Study Sites

JICA Study Team made some technical visits to the selected watersheds and identified some challenges on flood control through visits and interviews to regional government authorities and irrigation associations on damages suffered in the past and the problems each watershed is currently facing.

（1） Field investigation and interviews

(On critical conditions)

- The area under Irrigation Commission control begins in SOCSI (Km 25) downwards
- Due to El Niño phenomenon, floods of 800m3/s happened. There is a monitoring place in SOCSI, where the normal stream is between 7 and 250m3/s
- The bridge on the Panamericana Road was impassable due to the sediments accumulation during the event. Also, the river flooded upstream the bridge when the level of water rose on the bridge. The overflow produced agricultural land erosion and the width of the river grew to 200mt. This section (only the critical section) has been protected with a dike built by PERPEC
- Downstream Panamericana Road, the river’s width grows year after year
- Under the Irrigation Commissions’ jurisdiction there are 4 intakes. From these four, three did not suffer important damages due to the El Niño Phenomenon because they were made of concrete. The only intake that was not made of concrete is being manually repaired
- There is a hydroelectric plant upstream SOCSI

(Other: visited sites by the Study Team)

○ Panamericana (km 4,3)

- The floods of 1998 reached over the bridge, the ricer flow grew approximately 2mt due to this event

- ➢ The bridge was re-built around the sixties. The former bridge was destroyed by 1960 El Niño Phenomenon
- ➢ Currently, a new bridge is being built in the Panamericana Road downstream the current bridge

○ Overflowing section (km 7,5)

- ➢ This is one of the three overflowing sections that exist in this area (Lucumo, Cornelio and Carlos Quinto). All of which overflow on their right bank
- ➢ The built dike 10 years ago was dragged by floods and has been re-built 5 years ago by Civil Defense
- ➢ The water and sediments that have overflow extend on agricultural lands, destroying all crops
- ➢ The scour product of floods cause dike collapse, this leads floodings

○ Fortresa Intake: km 10,2)

- ➢ Was repaired in 2001
- ➢ This intake has not suffered serious damages from the El Niño Phenomenon
- ➢ The beneficiary area reaches 6,000 ha

○ Nuevo Imperial Intake: km 24,5)

- ➢ The flow up to 150m3/s enters the intake and the excess is naturally derived to the left bank
- ➢ During El Niño Phenomenon of 1998 accumulated sediments in the intake stopped the water entrance and the water could not be taken for more than a month
- ➢ Agricultural lands of the right bank 500mt upstream the intake were flooded. It is possible that on the next El Niño Phenomenon floods erosion the road along the river

○ Stream observation Station (SOCSI: km 27,2)

- ➢ There is a SENAMI Observation Station
- ➢ The flow in the rainy season of an ordinary year is approximately 250 m3/s, which grow up to 350 m3/s during the El Niño Phenomenon of 1998
- ➢ Since 1986, the flow speed on the bridge is being monitored every year (The flow is measured by calculating the flow speed per meter over the bridge). Every data is delivered to SENAMI

(2) Description of the visit to the study sites

Figure 3.1.6-1 shows pictures of main sites visited.

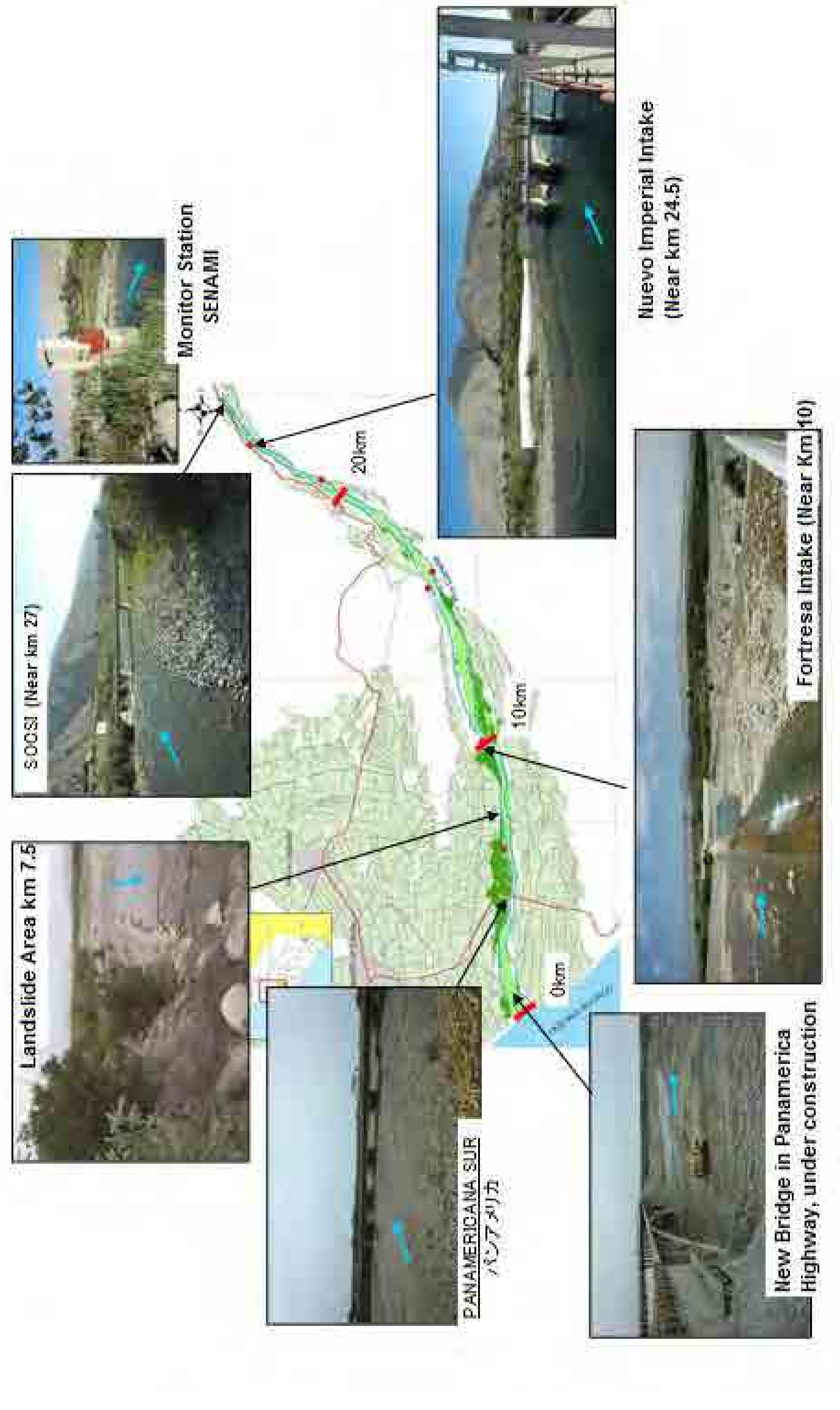


Figure 3.1.6-1 Visit to the study site (Cañete river)

(3) Challenges and measures

The following table shows challenges and possible solution measures for flood control considered at this moment, based on the results of technical visits.

1) Challenge 1: Intake and bank erosion (km 24-25)

Current situation and challenges	・During 1998 floods, accumulated sediments in the intake stopped water taking for more than a month. It is probable that this repeats, so, the measures to control the Entrance of sediments must be controlled ・Upstream the dam, banks have been eroded by the overflows that happened in the past, causing agricultural land loss. Because the erosioned section is near the road, future overflows that may happen with the same magnitude are risk to destroy vial infrastructure
Main elements to be conserved	・Road ・Intake
Basic measures	・Derivation Works building upstream the intake, aiming to control adequate flow distribution during overflowing ・Measures execution against bank erosion (breakwater, etc.)

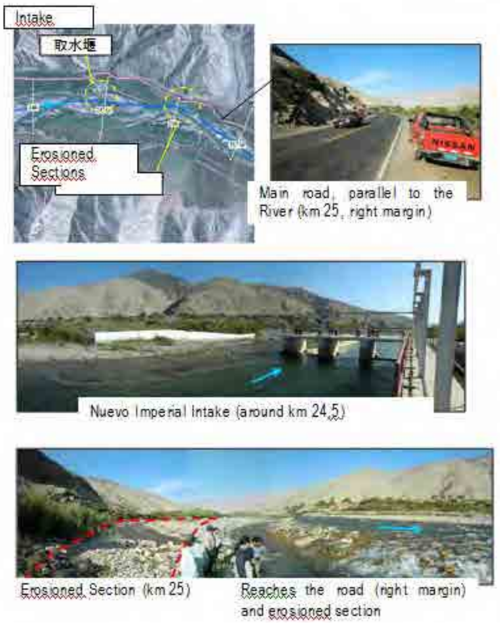


Figure 3.1.6-2 Local conditions related with Challenge 1 (Cañete river)

2) Challenge 2: Overflowing area (around km 7,5)

Current situation and challenges	・1998 floods destroyed the dike causing loss on agriculture field ・In this area there are three destroyed sections of the dike (all of them on the right bank) ・The water's greater impact area is on km 7,5, right bank. The fast and great flow causes scouring of the bed and consequently, the dike's destruction. Currently, the dike has been repaired, but there is still risk of destruction if great floods take place
Main elements to be conserved	・Crop land (main products: apple, grapes, cotton)
Basic measures	・Dike and bank protection building for bank erosion control

Figure 3.1.6-3 Local conditions related with Challenge 2 (Cañete river)

3) Challenge 3: Narrow section (km 4,3)

Current situation and challenges	・In 1998 floods, the river overflowed, flooding Panamericana Highway. The sediment accumulation did not allow transit temporarily ・Panamericana Highway coincides with the narrow section of the river. In this section, the water level rises upstream accumulating sediments and causing overflowing ・Only the critical section （dangerous for inundation）(approx 200 m) has been protected with a dike (7.5km, right bank, refer to Fig. 3.1.6-3), but not the other sections
Main elements to be conserved	・Panamericana Highway ・Crop land (main products: apples, grapes and cotton)
Basic measures	・It is not possible to execute bridge repair works at the moment, due to which it is necessary to take other actions to ensure the necessary hydraulic capacity (bed drilling, etc)

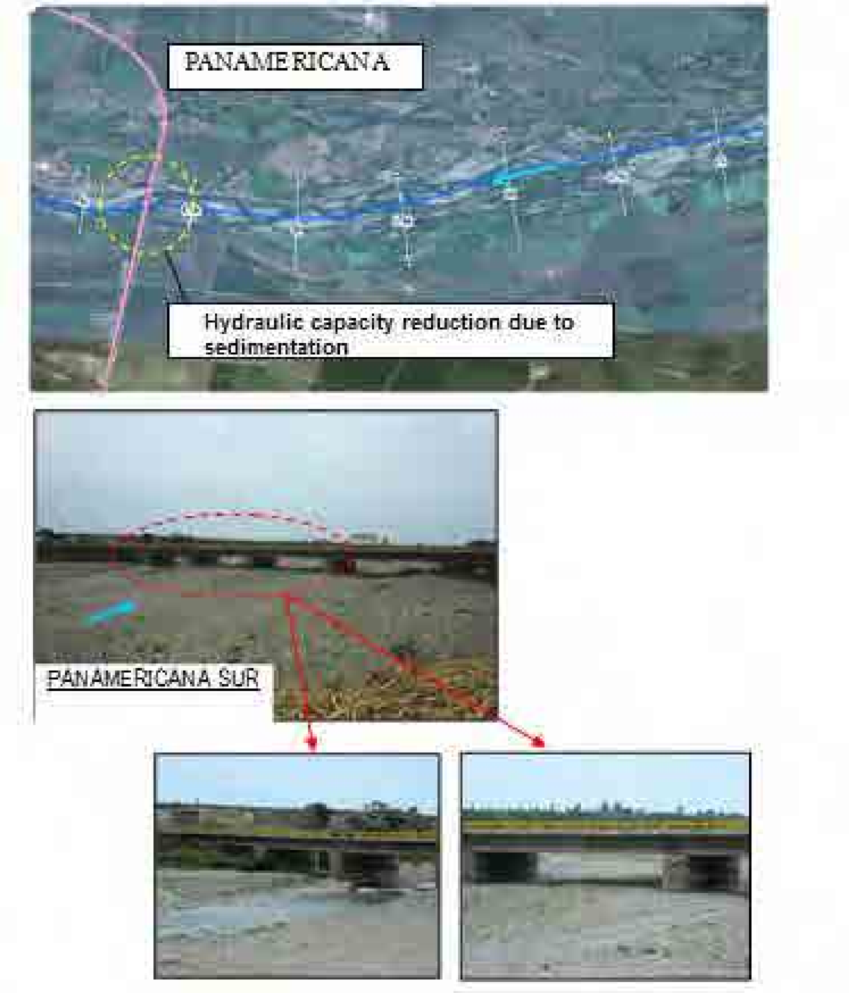


Figure 3.1.6-4 Local conditions related with Challenge 3 (Cañete river)

3.1.7 Current Situation of Vegetation and Reforestation

(1) Current vegetation

Pursuant to the 1995 Forest Map and its explanations, the Cañete watersheds extend from the coast to the Andean mountains; usually, featuring different vegetal coverage according to the altitude. From coast up to the 2,500m.a.s.l (Cu, Dc) have scarce vegetation. Some meters above in altitude, some scrubland can be noticed. Among 2500 and 3500m.a.s.l there are only scarce bushes disseminated in the area due to the rains. These bushes disappear due to the low temperatures and are seen again in the herbaceous areas. In the bush area the maximum height of tree is about 4 m. However, in zones close to the rivers, high trees have grown, even in arid zones.

Table 3.1.7-1 List of representative vegetable forming in the Cañete watersheds extending from the coast to the Andean mountains

Symbol	Life Zone	Distribution of Altitude	Rainfall	Representative Vegetation
1)Cu	Coast Crop Lands	Coast	Almost none.	Coastal crops
2)Dc	Coast Desert	0～1,500 m.a.s.l	Almost none, there are mist zones.	Almost none, there are vegetation slopes
3)Ms	Dry Thicket	1,500～3,900 m.a.s.l	120～220mm	Cactus and grass
4)Msh	Subhumid Forest	North-center: 2,900～3,500 m.a.s.l Inter Andean 2,000～3,700 m.a.s.l	220～1,000mm	Perennial bushes, less than 4m high
5)Mh	Humid Forest	North: 2,500～3,400 m.a.s.l South 3,000～3,900 m.a.s.l	500～2,000mm	Perennial bushes, less than 4m high
6)Cp	Puna grass	Approx 3,800 m.a.s.l	No description	Gramineae
7)Pj	Scrubland	3,200～3,300 m.a.s.l Center-South up to 3,800 m.a.s.l	South zone with low rainfall: less than 125mm East springs: higher than 4,000mm	Gramineae
8)N	Ice-capped mountains		—	—

Source: Prepared by the JICA Team based on the Forest Map. 1995

(2) Area and distribution of vegetation

The present study was determined by the surface percentage that each vegetation formation occupies on the total watershed's surface, overcoming the INRENA study results of 1995 to the GIS (see Tables 3.1.7-2 and Figures 3.1.7-1). Then, the addition of each ecologic life zone's surface, outstanding the coastal desert (Cu, Pj). In Table 3.1.7-3 shows the percentage of each ecologic area. It is observed that the desert occupies 20% of the total area, 10% of dried grass and puna grass 50%. Bushes occupy between 10 to 20%. They are distributed on areas with unfavorable conditions for the development of dense forests, due to which the surface of these bushes is not wide. So, natural conditions of the Cañete are set. In particular, the low precipitations, the almost non-fertile soil and accentuated slopes are the limiting factors for the vegetation growth, especially on high size species.

Table 3.1.7-2 Area of each classification of vegetation (Cañete river watershed)

Distribution	Classification of vegetation								
	Lo	Dc	Ms	Msh	Mh	Bf	Nv	Pj	Total
Area of distribution of vegetation (km^2)	61,35	1.072,18	626,23	1,024,77	70,39	187,39	2,956,65	66,78	6,065,74
Watershed area percentage (%)	1,0	17,7	10,3	16,9	1,2	3,1	48,7	1,1	100,0

Source: Prepared by the JICA Team based on the INRENA1995 Forest Map f

Table 3.1.7-3 Area percentage of large classification of vegetation (Cañete river watershed)

Watershed	Classification of vegetation					
	Desert（Cu, Dc)	Grass・Cactus（Ms）	Bush（Msh, Mh)	Grass land（Cp, Pj）	Snow area（N)	Total
（Percentage to watershed area：%）						
Cañete	18.7	10.3	18.1	51.8	1.1	100.0

Source: Prepared by the JICA Team based on the INRENA1995 Forest Map f

(3) Forest area variation

Although a detailed study on the variation of the forest area in Peru has not been performed yet, the National Reforestation Plan Peru 2005-2024, Annex 2 of INRENA shows the areas deforested per department until 2005. These areas subject matter of this study are included in the regions of Arequipa, Ayacucho, Huancavelica, Ica, Lima and Piura, but they only belong to these regions partially. Table 3.1.7-4 shows the Figures accumulated areas deforested in these regions. However, in relation to the Lima Region, data is not available.

Table 3.1.7-4 Area deforested until 2005

Department	Area (ha)	Area deforested accumulated (ha) and the percentage of such area in the department area (%)	Post-Felling Situation	
			Non used Area (ha)	Used area(ha)
Lima	3.487.311	-	-	-

Source: National Reforestation Plan, INRENA, 2005

The variation of the distribution of vegetation was analyzed per watershed, comparing data from the FAO study performed in 2005 (prepared based on satellite figures from 2000) and the results of the 1995 INRENA study (prepared base on satellite figures from 1995). (See Table 3.1.7-5).

Analyzing the variation of the surface of each vegetation formation, it is observed that the vegetation has reduced in the arid zones (desert and cactus: Cu, DC and Ms) and bushes increased (Msh, Mh), puna grass (Cp) and Ice-capped (N).

Table 3.1.7-5 Changes in the areas of distribution of vegetation from 1995 to 2000

Watershed	Vegetation Formation								
	Cu		Cu		Cu		Cu		Cu
(Surface of the vegetation cover: hectare)									
Cañete (a)	-13.46	-28.34	-50.22	7.24	23.70	34.89	-2.18	28.37	6,065.74
Current Surface (b)	61.35	1,072.18	626.23	1,024.77	70.39	187.39	2,956.65	66.78	6,065.74
Percentage of current surface (a/b) %	-21.9	-2.6	-8.0	+0.7	+33.7	+18.7	-0.1	+42.5	

Source: Prepared by the JICA Study Team based on the studies performed by the INRENA 1995 and FAO 2005

(4) Current situation of forestation

In the lower and medium watersheds, trees are planted mainly for three objectives: i) reforest along the river to prevent disasters; ii) for agricultural lands protection from wind and sand; and iii) as perimeter for housings. In any case, the surface is much reduced. The most planted specie is Eucalyptus and is followed by Casuarinaceae. The use of native species is not very common. On the other hand, in the

Mountain region, reforesting is done for logging, crops protection (against cold and livestock entrance) and to protect the recharge water areas. There are mostly eucalyptus and pines. Many reforest projects in the Mountain region have been executed following PRONAMACHS (currently, AGRORURAL). Such program gives throughout AGRORURAL seedlings to the community, which are planted and monitored by producers. There is also a reforest program implemented by the regional government, but in a very reduced way. In this case, the program establishes the needs to achieve consensus from the community to choose the areas to be reforested. However, in general, mostly all farmers want to have greater crop lands and achieving consensus always takes more time. Another limiting factor is the cold weather on altitudes greater than 3,800m.a.s.l. In general, no information has been able to be collected on reforestation projects to date, because these files were not available.

The National Reforestation Plan (INRENA, 2005) registers forestation per department from 1994 to 2003, from which the history data corresponding to the environment of this study was searched (See Table 3.1.7-6). It is observed that the reforested area increased in 1994, drastically decreasing later. Arequipa, Ica and Lima are departments located in the coast zone with scarce rainfall, thus the forestation possibility is limited, besides the scarce forest demand.

Table 3.1.7-6 History registry of forestation 1994-2003

(Units: ha)

Department	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Lima	6.692	490	643	1.724	717	1.157	nr	232	557	169	12.381

Source: National Reforestation Plan, INRENA, 2005

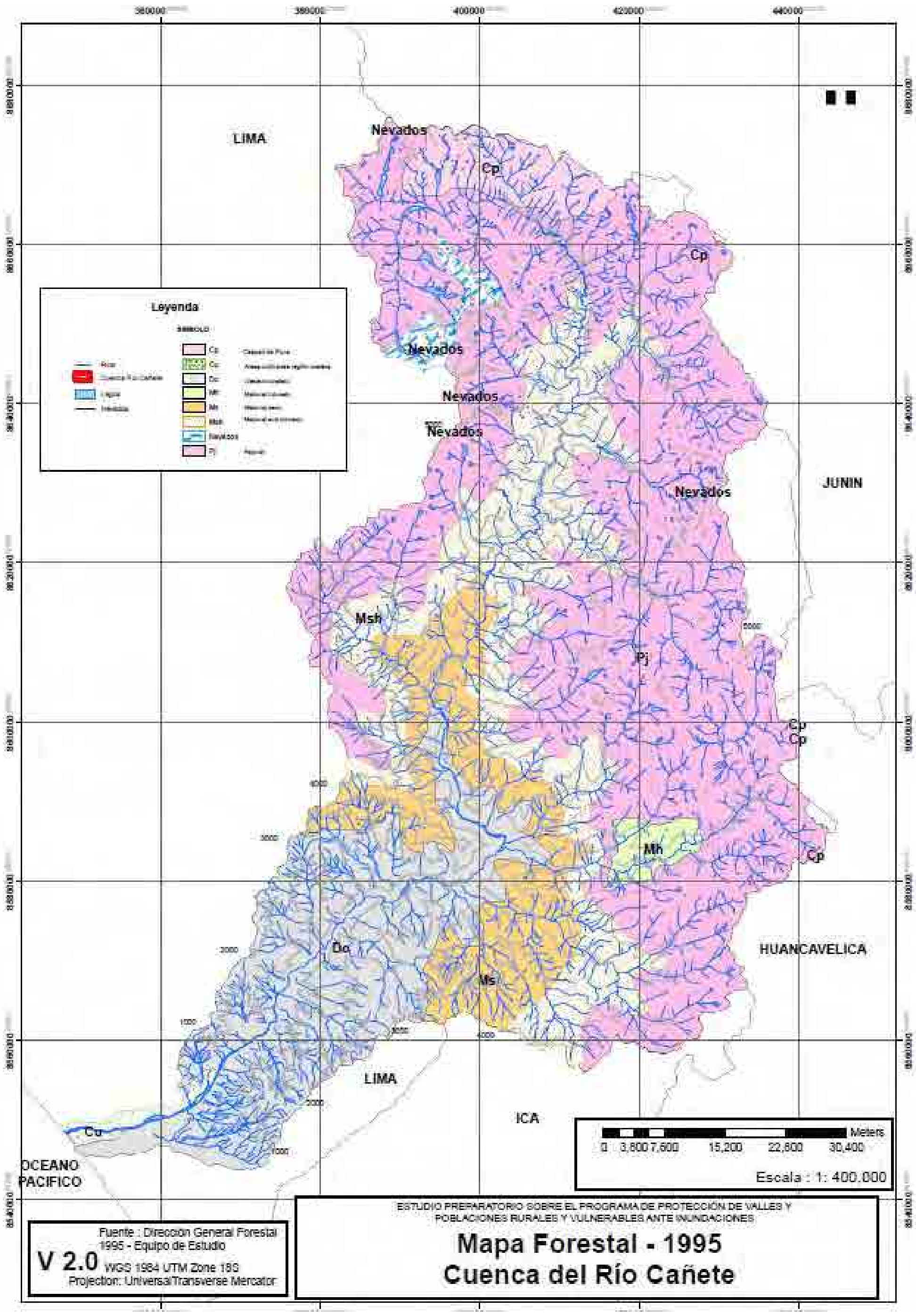


Figure 3.1.7-1 Forestry map of Cañete river watershed

3.1.8 Current Situation of the Soil Erosion

(1) Information gathering and basic data preparation

1) Information gathering

During this study the data and information indicated in Table 3.1.8-1 was collected in other to know the current situation of the sediment production behind the Study Area.

Table 3.1.8-1 List of collected information

	Forms	Prepared by:
Topographic map (Scale 1/50.000)	Shp	INSTITUTO GEOGRAFICO NACIONAL
Topographic map (Scale 1/100.000)	Shp,dxf	INSTITUTO GEOGRAFICO NACIONAL
Topographic map (Scale 1/250.000)	SHP	Geologic data systems
Topographic map (Scale 1/100.000)	Shock Wave	INGEMMET
30 m grid data	Text	NASA
River data	SHP	ANA
Watershed data	SHP	ANA
Erosion potential risk map	SHP	ANA
Soils map	SHP	INRENA
Vegetal coverage map	SHP2000 PDF1995	DGFFS
Rainfall data	Text	Senami

2) Preparation of basic data

The following data was prepared using the collected material. Details appear in Annex 6.

- Hydrographic watershed map (zoning by third order valleys)
- Slope map
- Geological Map
- Erosion and slope map
- Erosion and valley order map
- Soil map
- Isohyets map

(2) Analysis of the causes of soil erosion

1) Topographic characteristics

i) Surface pursuant to altitudes

Table 3.1.8-2 and Figure 3.1.8-1 show the percentage of surface according to altitudes of Cañete River watersheds. The Cañete River watersheds have an elevated percentage of areas located at more than 4.000 m.a.s.l. The hills at this height are little pronounced and several ice-capped mountains and reservoirs are distributed in the zone. This part of the Cañete River watershed is large and has plentiful and large hydrological resources compared to other watersheds.

Table 3.1.8-2 Surface according to altitude

Altitude (m.a.s.l)	Area (k m^2) Majes-Camana
0 – 1000	Cañete
1000 – 2000	381,95
2000 – 3000	478,2
3000 – 4000	1015,44
4000 – 5000	1012,58
5000 – More	3026,85
TOTAL	108,95
Maximum Altitude	6023,97

Source: Prepared by the JICA Study Team based on the 30 m grid data

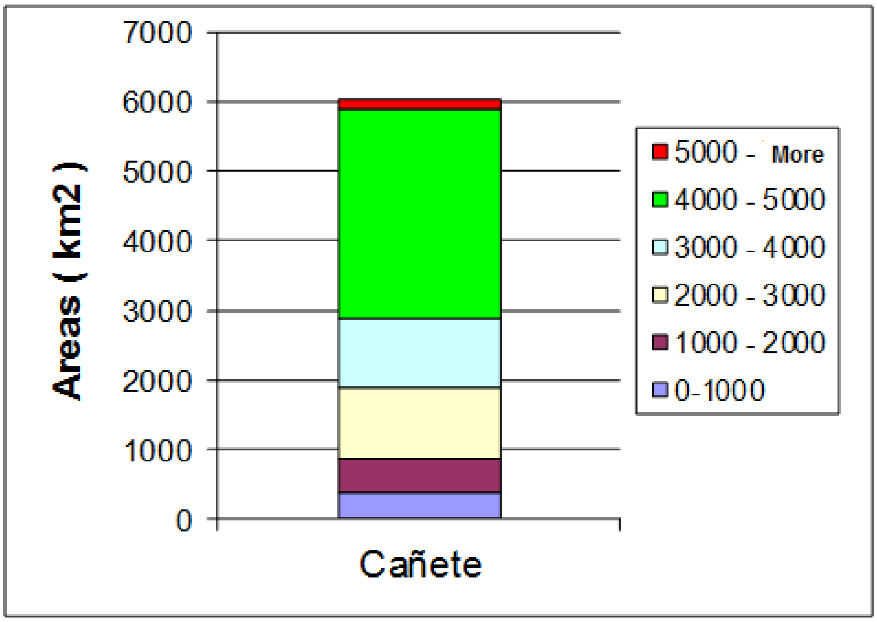


Figure 3.1.8-1 Surface according to altitude

ii) Zoning according to slopes

Table3.1.8-3 and Figure 3.1.8-2 show the slopes in each watershed.

Table 3.1.8-3 Slopes and surface

Watershed slope (%)	Cañete	
	Area (km^2)	Percentage
0 - 2	36,37	1%
2 - 15	650,53	11%
15 - 35	1689,81	28%
More than 35	3647,26	61%
TOTAL	6023,97	100%

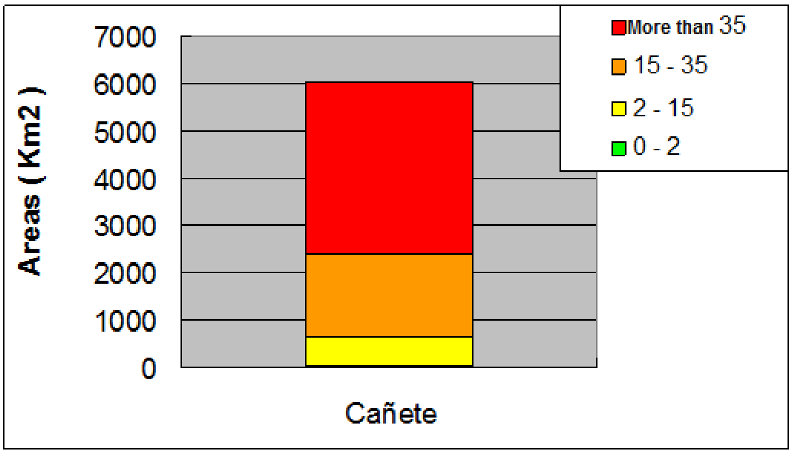


Figure 3.1.8-2 Slopes and surface

iii) River-bed slope

Table 3.1.8-4 and Figure 3.1.8-3 show the slope in every river and the length of streams including tributaries. Figure 3.1.8-4 shows the general relation of the movement of sediments and the river-bed slope. Supposedly, sections with more than 33,3 % of slope tend to produce higher amount of sediments, and hillsides with slopes between 3,33 % and 16,7 %, accumulate sediments easier.

Table 3.1.8-4 River-bed Slope and total length of stream

River-bed slope (%)	Cañete
0,00 - 1,00	12,82
1,00 - 3,33	173,88
3,33 - 16,67	1998,6
16,67 - 25,00	753,89
25,00 - 33,33	467,78
33,33 – More	975,48
TOTAL	4382,45

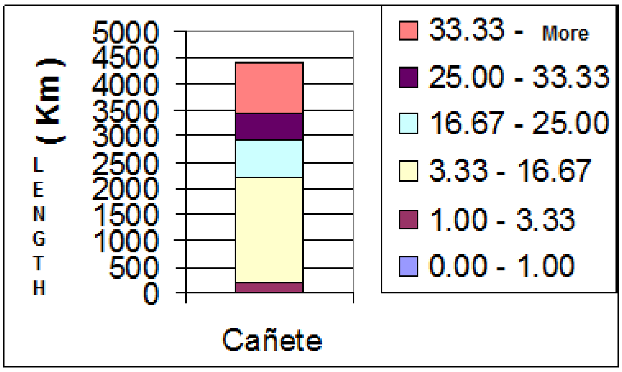


Figure 3.1.8-3 River-bed Slope and total length of streams

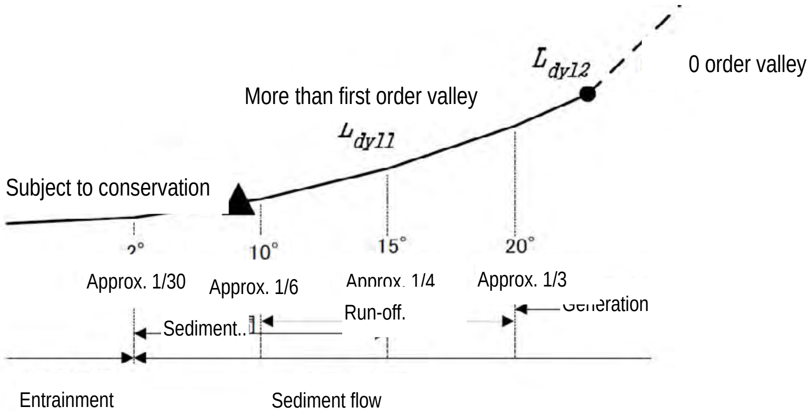
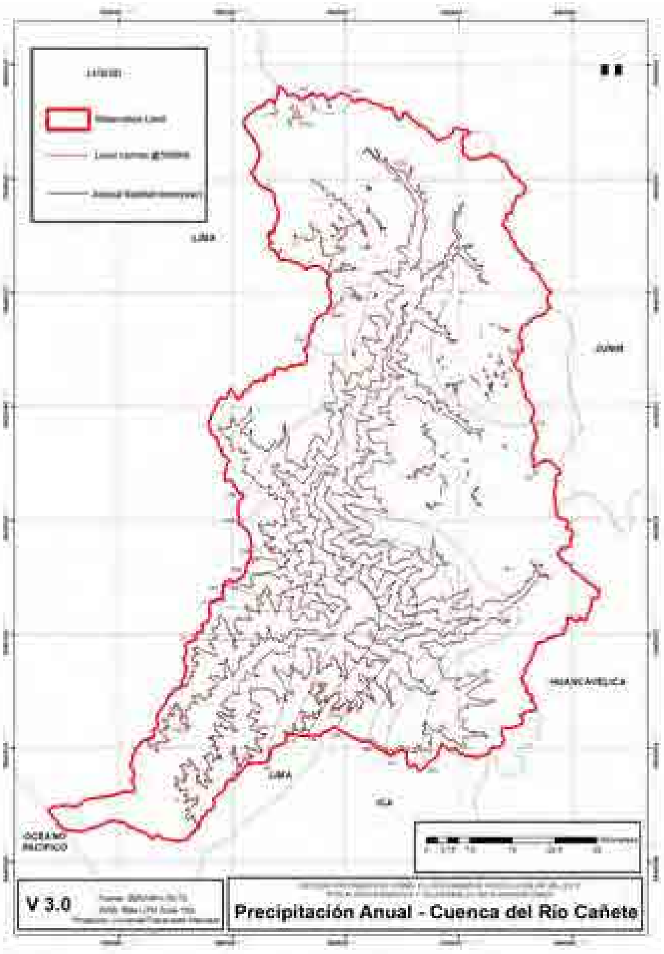


Figure 3.1.8-4 River-bed slope and sediment movement pattern

3) Rainfall

On the Pacific coast there is an arid area of 30 to 50km width and approx 3,000km long. This region belongs to a climate zone called Chala, where the middle annual temperature is about 20 °C and almost it does not rain along the year.

Altitudes between 2500 and 3000 m.a.s.l. belong to the Quechua zone, where annual precipitation exist between 200 and 300mm. On altitudes from 3500 and 4500m.a.s.l there is another region, called Suni, characterized by its sterility. Precipitations in this region occur annually with 700mm of rain. Figure 3.1.8-5 shows the isohyets map (annual rainfall) of each watershed.



Source: Prepared by the JICA Study Team based on the SENAMHI data

Figure 3.1.8-5 Isohyet Map of the Cañete river watershed

Annual precipitations in the flood analysis area fluctuate between 0 and 25mm. The average annual precipitation in the northern area of 4000m.a.s.l are between 750mm and 100mm.

4) Erosion

The characteristics of erosion of the watershed in general are presented below. This is divided in three large natural regions: Coast, Mountain/Suni and Puna. Figure 3.1.8-6 shows the corresponding weather and the rainfalls. It is observed that the area most sensitive to erosion is Mountain/Suni where the pronounced topography without vegetal coverage predominates.

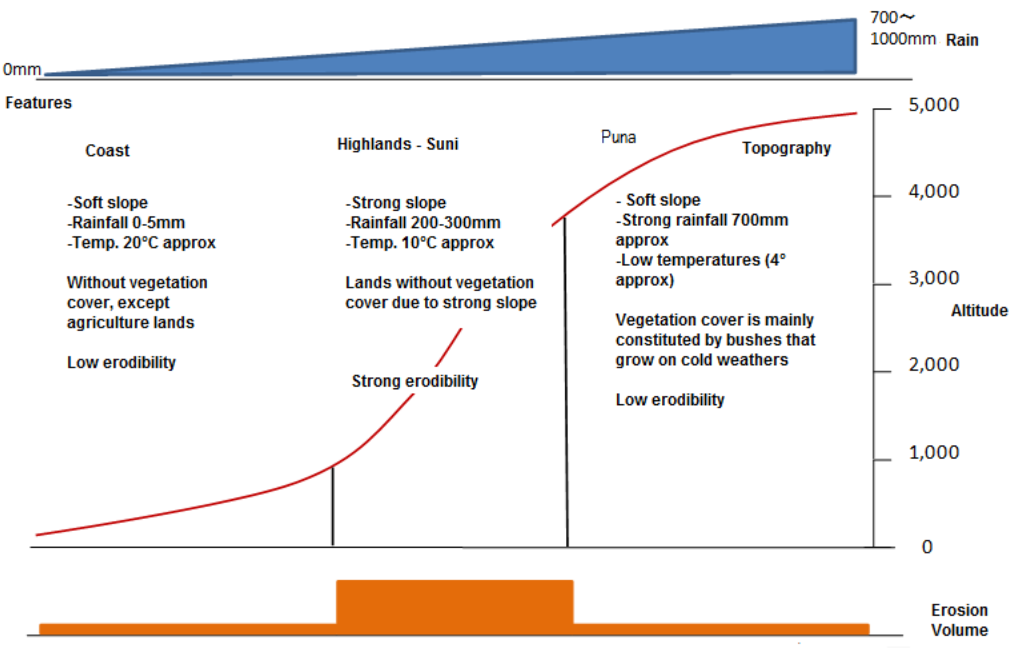


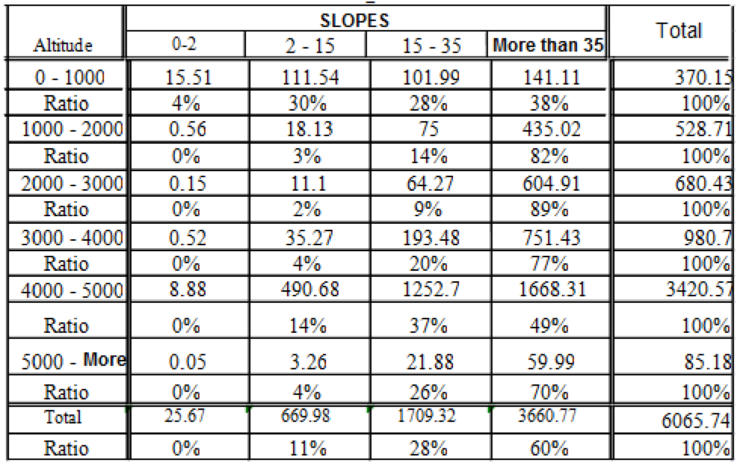
Figure 3.1.8-6 Relation between the erosion volume and the different causes

(3) Identification of the zones more vulnerable to erosion

The erosion map prepared by ANA considers the geology, hill sloping and rainfalls. Supposedly, the erosion depth depends on the hillside slope, and in such sense the erosion map and the slope map are consistent. Thus, it is deduced that the zones more vulnerable to erosion according to the erosion map are those were most frequently erosion happens within the corresponding watershed. Next, the tendencies regarding the watershed are described.

Between 2000 and 5000 m.a.s.l are located on slopes with more than 35 degrees. It is observed that more than approximately 60% of the watershed is constituted by slopes with these inclinations. In particular, between 1000 and 3000 more than 80% of slopes are more than 35° and are deduced to be more susceptible to erosion.

Table 3.1.8-5 Slopes according to altitudes of the Cañete river watershed



Altitude	SLOPES				Total
	0-2	2 - 15	15 - 35	More than 35	
0 - 1000	15.51	111.54	101.99	141.11	370.15
Ratio	4%	30%	28%	38%	100%
1000 - 2000	0.56	18.13	75	435.02	528.71
Ratio	0%	3%	14%	82%	100%
2000 - 3000	0.15	11.1	64.27	604.91	680.43
Ratio	0%	2%	9%	89%	100%
3000 - 4000	0.52	35.27	193.48	751.43	980.7
Ratio	0%	4%	20%	77%	100%
4000 - 5000	8.88	490.68	1252.7	1668.31	3420.57
Ratio	0%	14%	37%	49%	100%
5000 - More	0.05	3.26	21.88	59.99	85.18
Ratio	0%	4%	26%	70%	100%
Total	25.67	669.98	1709.32	3660.77	6065.74
Ratio	0%	11%	28%	60%	100%

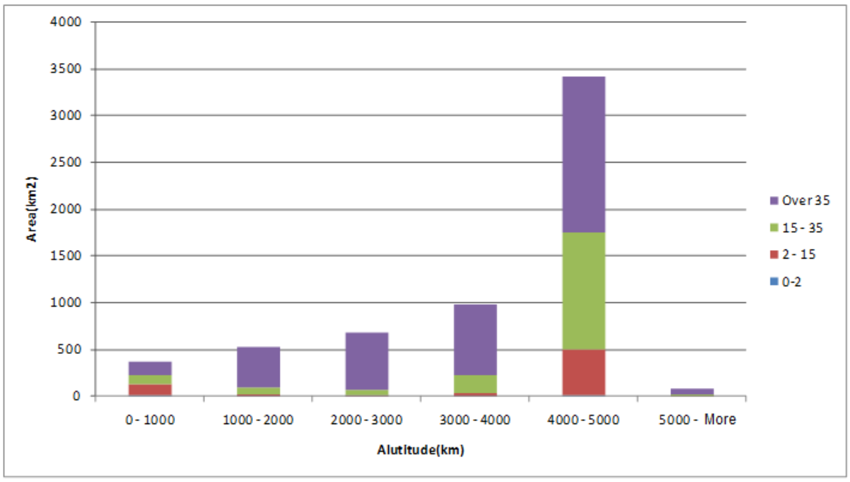


Figure 3.1.8-7 Slopes according to altitudes of Cañete river

(4)Production of sediments

1) Results of the geological study

The study results are described below.

- On mountain slopes there are formations of clastic deposits leaved by collapses or wind erosion
- Production patterns are differentiated according to the foundation rock geology. If this foundation is andesitic or basaltic, the mechanisms consists mainly in great gravel falling (see Figure 3.1.8-8 and 3.1.8-9)
- There is no rooted vegetation (Figure 3.1.8-10) due to the sediment in ordinary time. On the joints of the andesitic rock layer where few sediment movements occur, algae and cactus have developed
- In almost every stream lower terrace formation was observed. In these places, sediments dragged from slopes do not enter directly to the stream, but they stay as deposits on the terraces. Due to this, most of the sediments that enter the river probably are part of the deposits of the erosion terraces or accumulated sediments due to the bed's alteration (see Figure 3.1.8-11
- On the upper watershed there are less terraces and the dragged sediments of slopes enter directly to the river, even though its amount is very little

Figure 3.1.8-8 Andesitic and Basaltic lands collapse

Figure 3.1.8-9 Sediment production of the sedimentary rocks

Presence of cactus can be seen on the rough soil surface and some sediment is dragged

Figure 3.1.8-10 Cactus invasion

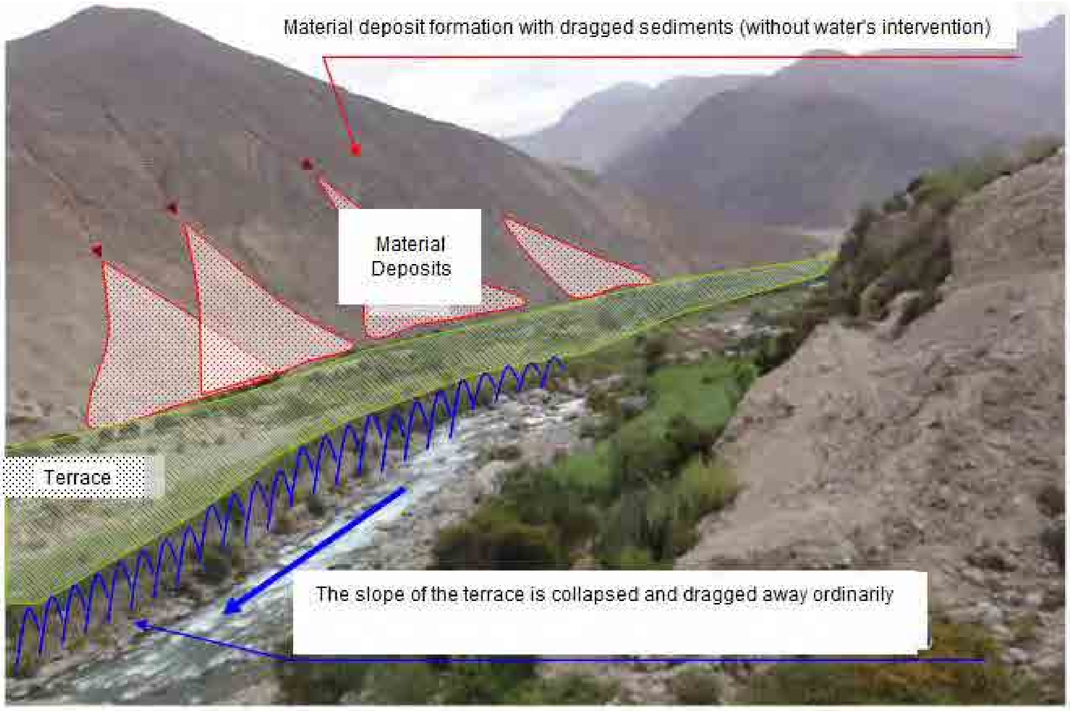


Figure 3.1.8-11 Movement of the sediment in the stream

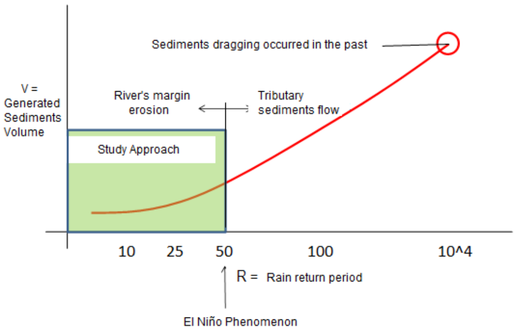
2） Sediments movement (in the stream)

In ravines terraces are developed (more than 10m of height of the Cañete River Watershed). The base of these terraces is directly contacted with channels and from these places the sediments will be dragged and transported with an ordinary stream (including small and medium overflows in rainy season).

3） Production forecast and sediments entrainment

It is expected that the amount of sediment production and entrainment will vary depending of the dimension of factors such as rainfall, volume of flow, etc.

Since a quantitative sequential survey has not been performed, nor a comparative study, here we show some qualitative observations for an ordinary year, a year with a rainfall similar to that of El Niño and one year with extraordinary overflow. The scope of this Study is focused on a rainfall with 50 year return period, as indicated in the Figure below, which is equivalent to the rainfall producing the sediment flow from the tributaries.



i) An ordinary year

- Almost no sediments are produced from the hillsides
- Sediments are produced by the encounter of water current with the sediment deposit detached from the hillsides and deposited at the bottom of terraces
- It is considered that the entrainment is produced by this mechanism: the sediments accumulated in the sand banks within the bed are pushed and transported downstream by the bed change during low overflows (see Figure 3.1.8-12)

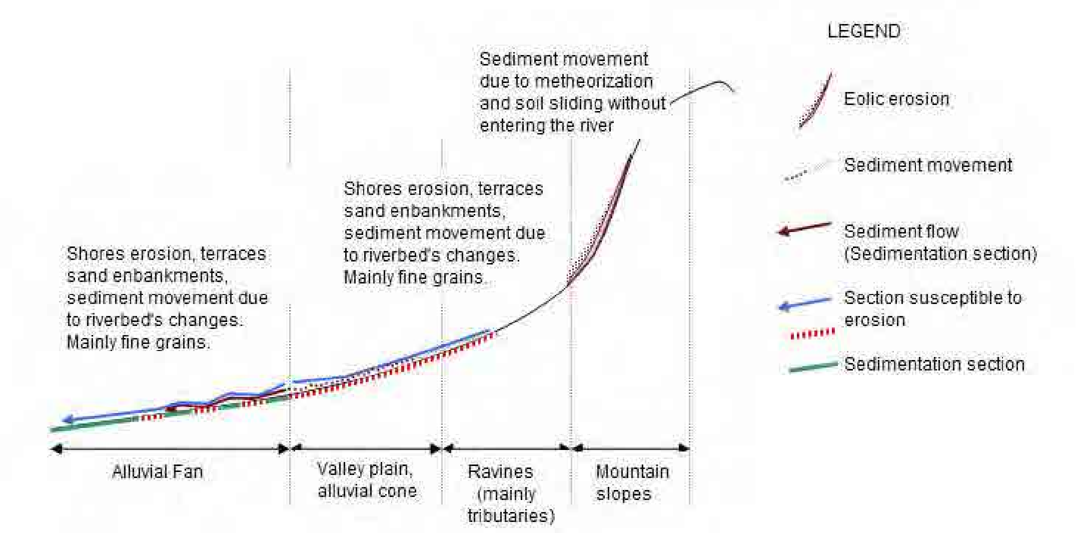


Figure 3.1.8-12 Production and entrainment of sediments in an ordinary year

ii) When torrential rains with magnitude similar to that of the El Niño happen (50 years return period)

Pursuant to the interviews performed in the locality, every time El Niño phenomenon occurs the tributary sediment flow occurs. However, since the bed has enough capacity to regulate sediments, the influence on the lower watershed is reduced.

- The amount of sediments entrained varies depending on the amount of water running by the hillsides
- The sediment flow from the tributaries reaches to enter to the main river
- Since the bed has enough capacity to regulate the sediments, the influence in the watershed is reduced

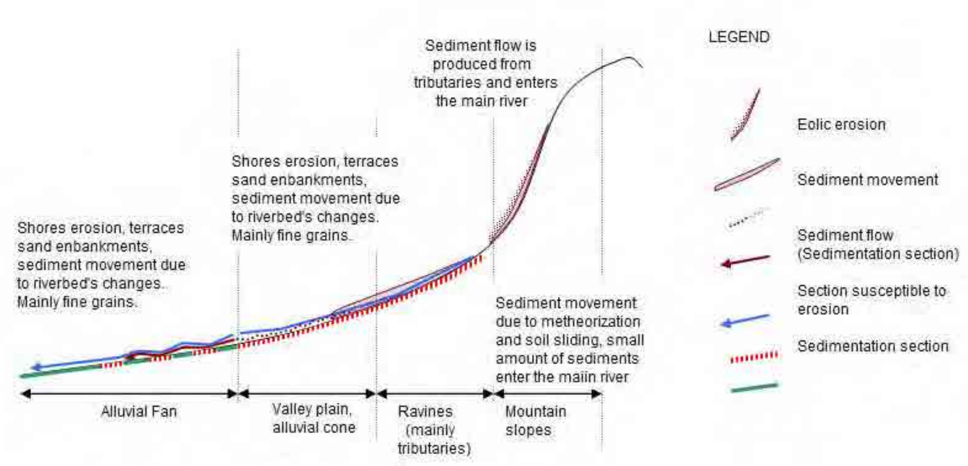


Figure 3.1.8-13 Production and entrainment of sediments during the torrential rainfall of magnitude similar to that of El Niño (1:50 year return period)

iii) Large magnitude overflows (which may cause the formation of terraces similar to those existing now), with once a few thousands year

In the coast, daily rainfall with 100 years of probability are approximately 50 mm, so land slides entrained by water scarcely occur currently. However, precisely since there are few rains, when torrential rainfall occurs, there is a high potential of water sediment entrainment.

If we suppose that rainfall occurs with extremely low possibilities, for example, 1:10.000 years, we estimate that the following situation would happen (see Figure 3.1.8-14).

- Sediment entrainment from hillsides, by the amount congruent with water amount
- Exceeding sediment entrainment from the bank and bottom of hillsides by the amount congruent with the water amount, provoking landslides which may close streams or beds
- Destruction of the natural embankments of beds closed by the sediments, sediment flow by the destruction of sand banks
- Formation of terraces and increase of sediments in the beds of lower watershed due to the large amount of sediments
- Overflowing in section between alluvial cone and critical sections, which may change the bed.

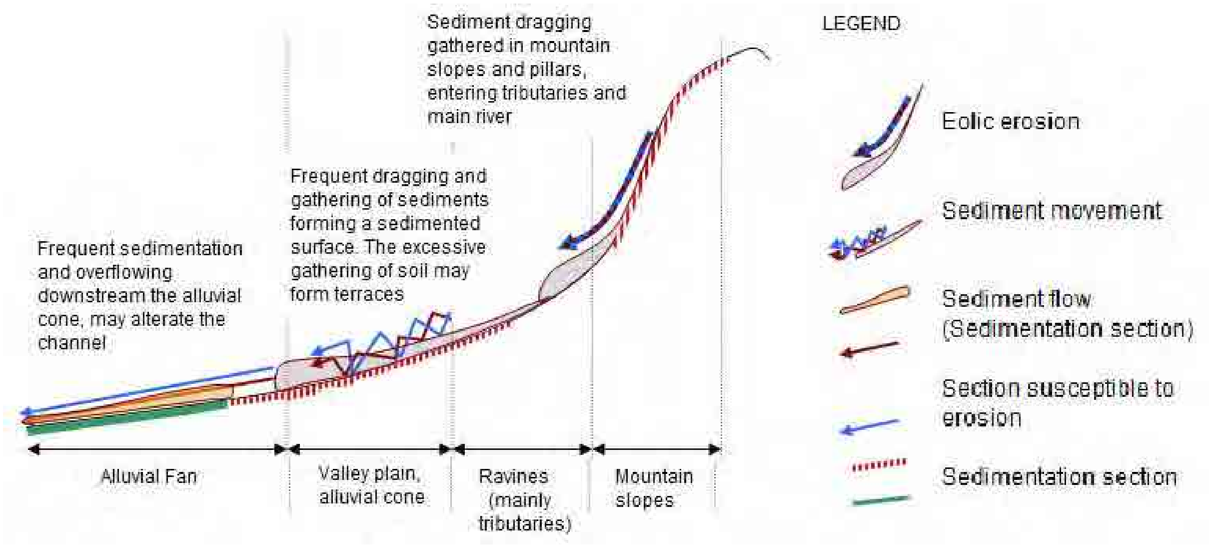


Figure 3.1.8-21 Production of sediments in large overflowing (once a few thousands years)

3.1.9 Run-Off Analysis

The run-off study in the study area is described as follows. For further detail of Meteorology/Hydrology and Run-off study, refer to the Annex-1 Meteorology/Hydrology and Run-off Study.

3.1.9.1 Rainfall

The rainfall data is collected and processed in order to obtain the observation conditions of rainfall data in the study area, which are to be used in the run-off study. The rainfall data is collected mainly from SENAMHI which is the observation agency of the most of the stations. The observation method is not automatic but manual at regular time of a day for all of the stations in the study area so that there is no hourly data but only daily data (24 hour -rainfall data).

(1) Conditions of rainfall observation

The rainfall observation stations and their observation period in Cañete basin are as shown in the Table-3.1.9.1-1 and the Table-3.1.9.1-2.

In Cañete basin, the rainfall has been observed in 13 stations, and the longest observation period is 47 years from 1964 to 2010.

Table-3.1.9.1-1 Rainfall observation station (Cañete river)

Code No.	Observation Station	Region	Longitude	Latitude	Responsible Agency
636	**YAUYOS**	**LIMA**	**75° 54'38.2**	**12° 29'31.4**	SENAMHI
155450	**YAURICOCHA**	**LIMA**	**75° 43'22.5**	**12° 19'0**	
155169	**TOMAS**	**LIMA**	**75° 45'1**	**12° 14'1**	
156106	**TANTA**	**LIMA**	**76° 01'1**	**12° 07'1**	
6230	**SOCSI CAÑETE**	**LIMA**	**76° 11'40**	**13° 01'42**	
638	**PACARAN**	**LIMA**	**76° 03'18.3**	**12° 51'43.4**	
6641	**NICOLAS FRANCO SILVERA**	**LIMA**	**76° 05'17**	**12° 53'57**	
156112	**HUANTAN**	**LIMA**	**75° 49'1**	**12° 27'1**	
156110	**HUANGASCAR**	**LIMA**	**75° 50'2.2**	**12° 53'55.8**	
156107	**COLONIA**	**LIMA**	**75° 53'1**	**12° 38'1**	
156109	**CARANIA**	**LIMA**	**75° 52'20.7**	**12° 20'40.8**	
156104	**AYAVIRI**	**LIMA**	**76° 08'1**	**12° 23'1**	
489	**COSMOS**	**JUNIN**	**75° 34'1**	**12° 09'1**	

Table-3.1.9.1-2 Observation period of rainfall data (Cañete river)

Figure-3.1.9.1-1 Location of rainfall and discharge observation station (Cañete river)

(2) Monthly rainfall

The average monthly rainfall and its distribution of each station in Cañete basin are as shown in Table-3.1.9.1-3 and the Figure-3.1.9.1-2.

According to the Table and the Figure, the monthly rainfall is large from October to April and extremely small from May to September. And the yearly rainfall varies from 1.47mm in Socsi to 1,016mm in Yauricocha.

Table - 3.1.9.1-3 Average monthly rainfall in Cañete basin and adjacent basin (mm）

STATION	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
YAUYOS	71.36	83.70	83.26	20.35	3.36	0.52	0.15	0.92	3.10	12.94	19.68	44.46	343.80
YAURICOCHA	178.17	168.19	169.94	92.76	20.76	9.40	10.52	20.85	37.28	88.02	81.24	138.64	1,015.78
TOMAS	128.45	119.02	100.86	67.50	21.93	17.36	11.13	14.36	35.34	44.19	55.36	86.90	702.39
TANTA	151.80	157.83	162.22	91.07	25.07	7.23	5.52	11.23	29.59	60.70	78.74	110.98	891.99
SOCSI CAÑETE	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.00	1.47
PACARAN	4.21	4.70	3.83	0.29	0.10	0.04	0.01	0.07	0.09	0.41	0.41	1.93	16.09
NICOLAS FRANCO SILVERA	1.80	4.57	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.33	11.50
HUANTAN	195.68	236.82	196.02	72.60	7.82	1.09	1.77	2.17	2.61	50.73	62.07	98.77	928.15
HUANGASCAR	59.94	72.77	85.06	9.93	0.63	0.20	0.03	0.25	0.43	2.23	6.45	24.95	262.87
COLONIA	84.62	109.69	127.22	27.47	3.15	0.35	0.79	0.56	3.81	15.23	21.41	64.96	459.25
CARANIA	118.12	118.97	126.34	43.37	12.69	3.80	3.19	4.98	11.01	27.60	32.47	79.56	582.10
AYAVIRI	119.80	137.90	151.32	46.06	5.25	0.02	0.28	0.83	1.93	10.36	17.37	56.67	547.80
COSMOS	110.38	99.85	110.09	53.48	24.93	4.10	7.03	13.01	32.87	49.44	52.59	95.53	653.29

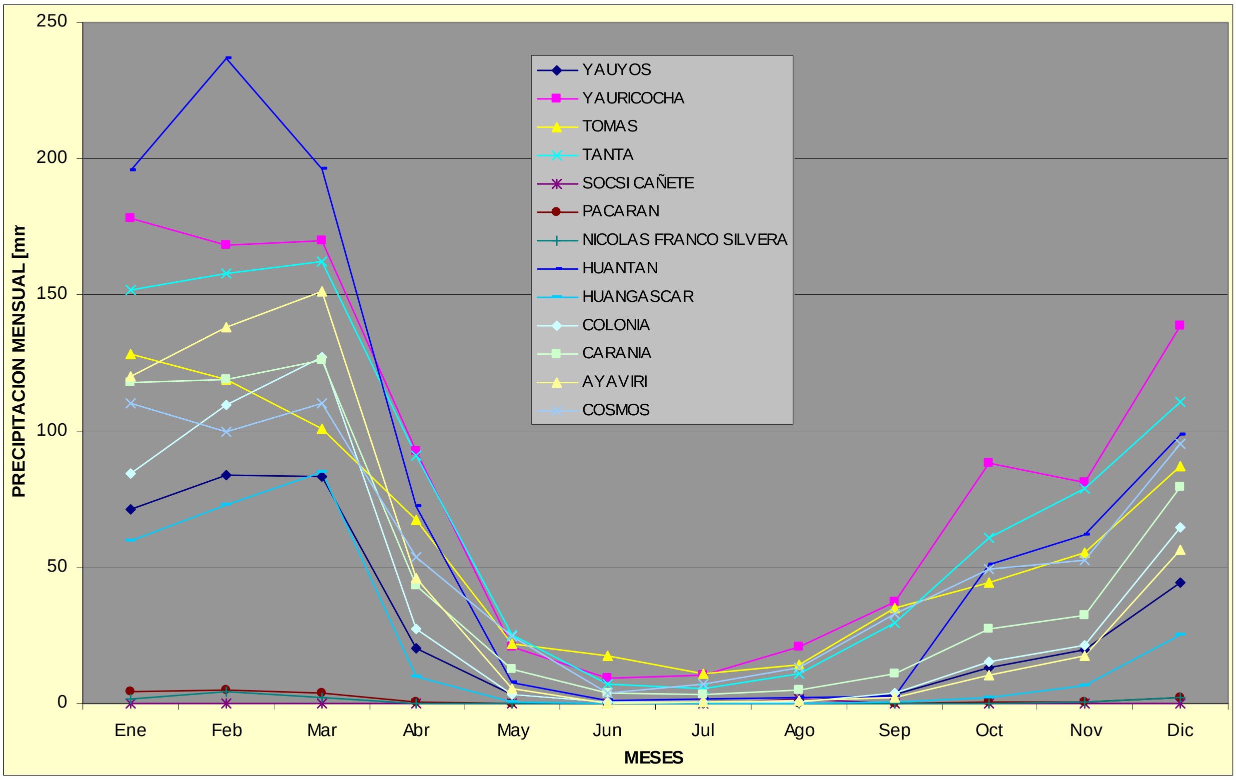


Figure - 3.1.9.1-2 Distribution of average monthly rainfall in cañete basin and adjacent basin (mm）

(3) Yearly maximum of 24-hour rainfall

The yearly maximum of 24-hour rainfall (daily rainfall) of each observation station in Cañete basin is as shown in the Table-3.1.9.1-4.

Table-3.1.9.1-4 Yearly maximum of 24-hour rainfall (daily rainfall) in Cañete basin (mm)

Year	YAUYOS	YAURICOCHA	TOMAS	TANTA	SOCSI CAÑETE	PACARAN	NICOLAS FRANCO SILVERA	HUANTAN	HUANGASCAR	COLONIA	CARANIA	AYAVIRI	COSMOS
1964	19.5			25.4						14.2	28.4	12.0	
1965	31.4			34.5		2.1		41.6	15.0	43.5	44.3	13.0	
1966	23.3			26.6		2.5		20.0	25.1	34.4	25.0	28.5	
1967	23.6			28.0		8.8			35.3	62.8	18.6		
1968				23.7				17.7	12.9	18.1		19.7	
1969	17.4			33.0					21.3	17.2	29.3	33.5	
1970	26.8			37.9		20.3		21.2	28.0	24.2	16.6	29.9	
1971	33.0			24.5		6.3		18.5	19.6	31.5	18.0	22.7	
1972				26.1		4.8		29.3	70.5	16.3	20.1	33.0	
1973	28.2			18.2		6.0		30.2	27.2	15.8	22.6	37.6	
1974	21.5			19.3		2.4		20.0	12.7	15.7	16.8	30.5	
1975	19.0			15.1		3.3		40.1	34.6	14.1	16.0	34.8	
1976	20.0			17.5		0.4		32.4		23.2	19.3	16.1	
1977	14.8			16.4		0.8			29.4	24.9	17.4	34.4	
1978	20.1			16.3		0.2		22.0	49.8	25.2	16.1	33.4	
1979	16.9			11.7					18.1		15.1	11.2	
1980	15.5			14.4					8.5		17.1		
1981	22.8			13.1					21.0	17.6	17.5		
1982			16.8	13.3				61.2	17.2		15.6		19.3
1983			9.8					33.6	9.7	21.5	16.6		15.5
1984	10.0			11.3				53.4	14.9		14.2		27.0
1985				12.4					13.8	8.0	12.9		
1986			17.5	18.0		3.5		36.2	19.0	26.5	20.0	32.7	33.7
1987		37.6	13.1	16.8		4.8		35.5	13.1	12.5	20.9	31.9	29.3
1988		28.8	13.6	13.8		3.3			20.4		33.1	23.8	
1989		26.1		13.9		6.0		27.7	20.0		24.4	39.4	
1990		30.8		15.8		1.2			20.0		26.0	25.6	
1991		24.0		11.5		1.5			19.0		12.4	27.4	
1992	6.3	21.5		16.0		1.2			5.0		15.1	29.9	
1993	17.3	40.5		41.6		3.0			20.0		16.0	29.7	
1994	31.5	21.8		26.4		9.0			24.0		14.1	30.2	
1995	12.2	20.2		27.0		6.2			30.0		13.5	30.2	
1996	24.3	16.6		31.7		2.6			23.0		16.1	24.6	
1997	18.8	28.2		27.4		3.6			25.3		14.6	46.2	
1998	14.7	27.6		41.8		5.5			33.8		14.1	32.4	
1999	19.9	24.4		24.5		11.2			24.3		15.6	23.1	
2000	12.9	58.6		28.9		3.8			30.6		27.0	35.4	
2001	13.3	20.6		22.7		5.6			12.8		14.9	24.0	
2002	11.6	25.8		28.2					24.8		17.7	28.7	
2003	14.4	60.4		28.0		4.4			15.0		18.9	18.2	
2004	14.2	41.3		32.9					17.7		21.4	29.2	
2005	13.6	30.4		22.0	0.0		6.4		13.0		20.5	21.0	
2006	20.6	26.2		29.5	0.0		3.0		25.1		30.1	26.5	
2007	19.8	29.0		33.6	0.0	2.3			14.6		23.4	34.2	
2008	19.9	15.4			0.0	2.6			24.0		21.9	30.4	
2009	15.1	26.9		69.2	8.0	6.0			14.8		20.5	27.3	
2010													

3.1.9.2 Discharge

The discharge observation method is not automatic but manual at regular time of a day, once a day at 7 a.m. or twice a day at 7a.m. and 7p.m. for all of the stations in the study area so that there is no hourly data but only daily data (24 hour -discharge data). Therefore instantaneous maximum discharge such as the flood peak discharge is not observed.

The water level is observed by staff gauge, and the discharge is estimated applying the water level to the relation curve between the water level and discharge which is prepared beforehand by actual measurement of flow area and velocity.

The rivers originate at high land connected with Andes Mountains and flow down through alluvial fan to the coast. The discharge observation stations are generally located at the middle stream or downstream of the alluvial fan (refer to the location map of rainfall observation stations). Since there is hardly rainfall in the coastal area, the discharge will not enter from residual area of downstream basin so that the discharge observation shows the total discharge from the whole basin. Therefore it is desirable to select the reference point for run-off analysis at such observation station.

(1) Discharge observation station

The discharge observation station in Cañete River is as shown in the Table-3.1.9.2-1. The observation is performed by SENAMHI and the water users committee.

Table-3.1.9.2-1 Discharge observation station(Cañete river)

Observation Station	Latitude	Longitude	Elevation (m.a.s.l.)
SOCSI CAÑETE	13° 01'42	76° 11'40	330

(2) Yearly maximum daily discharge

The yearly maximum daily discharge of each year is as shown in the Table-3.1.9.2-2.

Table-3.1.9.2-2 Yearly maximum daily discharge(Cañete river) (m³/s)

Year	Yearly Maximum Daily Discharge	
	SENAMHI	water userS committee
1926	-	455.00
1927	-	120.00
1928	-	198.00
1929	-	342.00
1930	-	263.00
1931	-	148.60
1932	-	850.00
1933	-	176.00
1934	-	305.00
1935	-	386.00
1936	-	265.00
1937	-	283.76
1938	-	401.99
1939	-	308.53
1940	-	141.28
1941	-	301.13
1942	-	319.22
1943	-	324.13
1944	-	396.65
1945	-	350.00
1946	-	354.00
1947	-	353.00
1948	-	279.00
1949	-	198.00

1950	-	244.74
1951	-	485.00
1952	-	360.00
1953	-	555.00
1954	-	657.00
1955	-	700.00
1956	-	470.00
1957	-	228.32
1958	-	270.40
1959	-	700.00
1960	-	488.75
1961	-	597.62
1962	-	566.24
1963	-	242.37
1964	-	153.06
1965	214.70	214.70
1966	207.00	201.00
1967	343.00	343.00
1968	154.00	154.00
1969	316.00	316.00
1970	408.00	408.00
1971	430.00	430.00
1972	900.00	900.00
1973	484.20	450.10
1974	-	326.00
1975	-	298.00
1976	294.92	332.00
1977	-	249.00
1978	-	216.00
1979	-	182.80
1980	-	100.10
1981	-	257.10
1982	-	120.00
1983	-	228.00
1984	-	425.50
1985	-	165.60
1986	-	370.50
1987	-	487.30
1988	206.00	420.30
1989	-	377.00
1990	-	189.00
1991	-	372.00
1992	-	164.30
1993	-	390.00
1994	-	550.00
1995	-	500.00
1996	-	310.00
1997	-	350.00
1998	-	348.00
1999	-	420.00
2000	-	350.00
2001	-	255.00
2002	-	204.00
2003	-	215.00
2004	-	196.00
2005	-	167.00
2006	-	250.00

3.1.9.3 Probable Flood Discharge Based on Observation Data

The reference point for run-off analysis was selected at the observation station in Cañete basin, and where the flood discharge with return period from 2years to 100 years are calculated based on the observation data of yearly maximum daily discharge by statistical processing. The results of calculation are as shown in the Table-3.1.9.3-1.

The following probable distribution models are used for hydrological statistic calculation, and the most adaptable value among models is adopted for each basin, for further details refer to the Appendix attached at end of this report.

- Distribution Normal or Gaussiana
- Log - Normal 3 parameters
- Log - Normal 2 parameters
- Gamma 2 or 3 parameters
- Log - Pearson III)
- Gumbel Distribution
- Generalized Extreme Values

Table-3.1.9.3-1 Probable discharge at reference point

(m^3/s)

Riiver/Reference Point	Return Period of 2years	Return Period of 5years	Return Period of 10years	Return Period of 25 years	Return Period of 50 years	Return Period of 100 years
Cañete/ Socsi	313	454	547	665	753	840

The maximum observation discharge is 900m3/sec in Socsi station in Cañete river in1972, therefore the values of the above table are calculated including this discharge. As described later in the clause 3.1.9.5, the maximum discharge which can be observed in this station is estimated about 900m3/sec, therefore the values shown in the above table seem to be less than the actual discharge with high possibility.

3.1.9.4 Run-off Analysis Based on Rainfall Data (HEC-HMS Method)

There is only daily discharge data in the objective study area, and the probable discharges calculated in the previous close 3.1.9.3 show the peak discharge. In order to perform the inundation analysis described later clause, the hourly distribution of flood discharge (flood hydrograph) is required. Therefore the run-off study based on rainfall data is performed in this clause.

The run-off analysis method is to be HEC-HMS (Hydrologic Engineering Center- Hydrologic Modeling System） which is developed by US Army Corps of Engineer. This system is the run-off analysis program for general purpose which is widely used in the north America and other areas in the world, and one of the most popular program in Peru.

(1) Summary of HEC-HMS system

HEC-HMS is designed to simulate the precipitation-runoff processes of dendritic watershed system. The basin model can be composed of sub-basin, reach, junction, diversion, reservoir etc. To simulate infiltration loss options for event modeling include SCS curve number, Initial Constant, Exponential, Green Ampt etc.

Several methods are included for transforming excess precipitation into surface runoff such as unit hydrograph methods including Clark, Snyder, SCS technique. Several methods including Muskingum, kinematic wave can be applied for flood routing in channel. And several methods can be applied for representing base flow contribution to sub-basin outflow.

Six different historical and synthetic precipitation methods are included. Four different methods for analyzing historical precipitation are included. The gage weights method uses an limited number of recording and no-recording gages and Thiessen technique is one possibility for determining the weights.

The frequency storm method uses statistical data to produce balanced storms with a specific exceeding probability. The SCS hypothetical storm method implements the primary distribution for design analysis using Natural Resources Conservation Service Criteria (NRCS). Most parameters for methods included in sub-basin and reach elements can be estimated automatically using optimization trials. Six different objective functions are available to estimate goodness-of-fit between the computed results and observed discharge.

The procedure of applying HEC-HMS in this analysis is as shown below. According to this procedure the summary of run-off analysis on Majes-Camana basin is described below. As to detail of run-off study for each basin refer to Annex-1 Meteorology/Hydrology and Run-off Study, Appendix.

1) Preparation of Basin Model
2) Rainfall Analysis
    i) Calculation of Probable 24-hour Rainfall in Each Station
    ii) Calculation of 24-hour Rainfall in Each Sub-basin
    iii) Selection of Type of 24-hour Rainfall Curve
3) Calculation of Infiltration Loss by SSC Method
    i) Selection of Initial Curve Number in Each Sub-basin
    ii) Selection of Final Curve Number in Each Sub-basin
    iii) Verification of Model
4) Calculation of Probable Flood Discharges and their Flood Hydrograph

(2) Preparation of basin model

1) Division of basin

Cañete basin is divided into many sub-basins each of which has similar hydraulic characteristics, such as topography, distribution pattern of river channel, forestation conditions, surface soil conditions etc. The division of the basin is as shown in the Figure -3.1.9.4-1.

2) Preparation of basin model

The sub-basin, reach and junction are represented schematically as shown in the Figure-3.1.9.4-2 in HEC-HMS. In accordance with these, the whole basin model of Cañete basin is prepared.

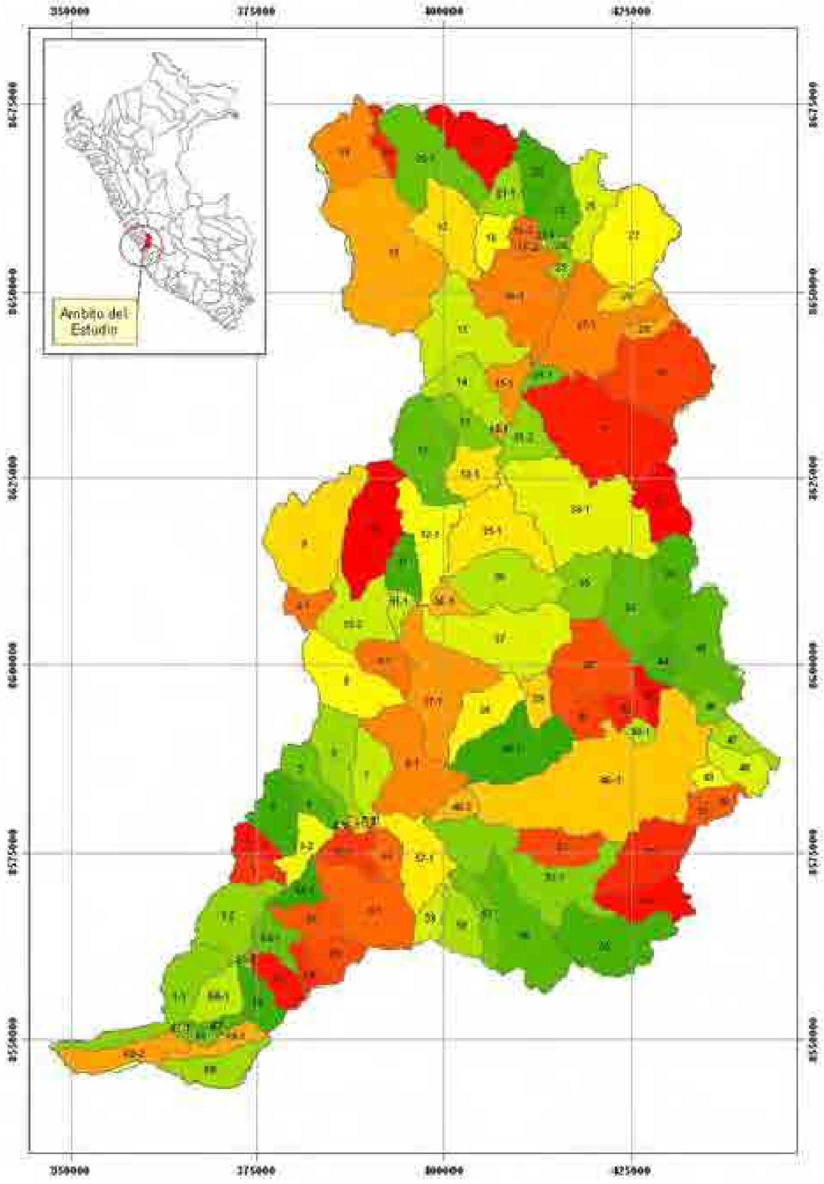


Figure-3.1.9.4-1 Division of Cañete basin

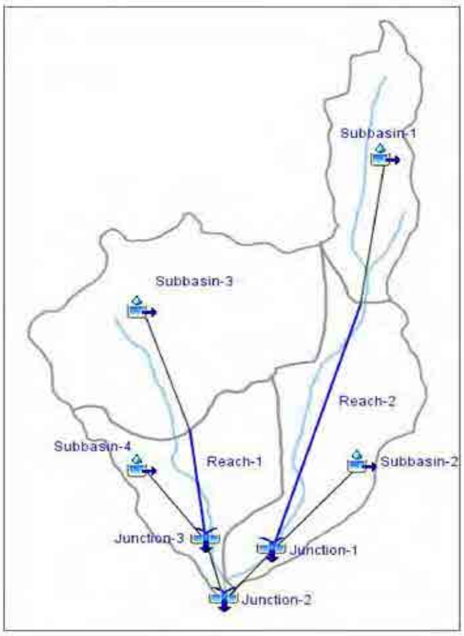


Figure-3.1.9.4-2 Schematic diagrams in HEC-HMS

(1) Rainfall analysis

Information was collected on hourly rainfall of Chivay station located in the middle basin for the period February 2011 to February 2012. Using this information, a Depth-Duration Analysis was performed for 3 different periods of flood. Of the 3 cases of floods, the longest storm duration was measured in the period of February 2012 (Qp = 1.400 m3/sec.) and the duration was 17 hours. Thus in the discharge analysis the used storm duration was 24 hours. Furthermore, according to interviews with representatives of SENAMHI and Peruvian universities, on the Peruvian coast storm duration range is from 6 to 12 hours and for calculations for discharge analysis the usually used storm duration is 24 hours.

1) Probable 24-hour dayly rainfall

The probable 24-hourrainfall in each observation station is calculated by statistical processing of yearly maximum rainfall of 24-hour as shown in the Table-3.1.9.4-1. Based on the table the isohyetal map of 24h-hour rainfall with return period of 50-year is as shown in the Figure-3.1.9.4-3.

2) 24-hour rainfall in sub-basin

24-hour rainfall in sub-basin is calculated based on 24-hour rainfall of observation stations by Inverse Distance Weighted method as shown in the Table-3.1.9.4-2. The table is for some sub-basin among many sub-basins in Cañete basin.

It is usually required to determine for each sub-basin the probabilistic rainfall using the maximum values of precipitation for each year calculated from the average precipitation. However, since the rainfall information is incomplete, it is difficult to calculate average rainfall, this is the reason why there was no choice but to use probabilistic rainfall average of each sub-basin calculated from probabilistic rainfall information from each of the rainfall stations. The results of this calculation are presented in the Table -3.1.9.4-2. Same methodology is used for other basins.

Inverse Distance Weighted method is included in HEC-HMS for calculation of average rainfall over basin, and which is calculated by the following equation using the observation data surrounding the objective sub-basin (refer to HEC-HMS, Technical Reference Manual, p-23)..

wc = (1/dc2)/(1//da2)+ (1//db2)+ (1/dc2)

P = waPa+ wbPb+wcPc

where; wc：weight of station c, d: distance from the center of sub-basin to each station

P：average rainfall in sub-basin, Pa,b,c: rainfall in each station

3) Selection of type of 24-hour rainfall curve

There is not hourly rainfall observation data but 24-hour rainfall observation data (daily rainfall data) so that the hourly data cannot but being estimated by 24-hour rainfall data. SCS (Soil Conservation Service) hypothetical storm which is generally used in HEC-HMS is used for 24-hour rainfall curve.

This method is developed through the analysis of rainfall data in USA, which is expressed 4 types of rainfall curve with non-dimension as shown in the Table-3.1.9.4-3 and the Figure-3.1.9.4-4. The distribution of rainfall is as shown in the Figure-3.1.9.4-5 assuming time interval. And the applied area of 4 types in USA is as shown in the Figure-3.1.9.4-6, according to which the type II is recommended to be applied to major part of USA. In addition to this it is said that 24-hour rainfall can be applicable for most of basins.

Since there is no hourly rainfall data in the study area, it is difficult to judge the type of rainfall, however the type is determined actually based on a few study examples in Peru. Miplo Mining Company analyzed the hourly rainfall data which was obtained from Chavin station installed western slope of Peru (between Cañete basin and highland of Chincha basin), and judged the rainfall type of this area belongs to type II and that the type II can be applied the central and south of coastal area. Based on these study results, type II is applied for Cañete basin.

Table-3.1.9.4-1 Probable 24-hour rainfall in each station (Cañete basin)

Station	**Return Period**						
	PT_2	**PT_5**	**PT_10**	**PT_25**	**PT_50**	**PT_100**	**PT_200**
AYAVIRI	29.0	35.0	37.0	39.0	40.0	41.0	42.0
CARANIA	18.0	23.0	27.0	33.0	39.0	45.0	52.0
COLONIA	21.0	30.0	37.0	48.0	56.0	66.0	77.0
COSMOS	23.0	31.0	35.0	40.0	43.0	45.0	47.0
HUANGASCAR	20.0	29.0	35.0	44.0	51.0	59.0	67.0
HUANTAN	30.0	40.0	48.0	58.0	66.0	75.0	84.0
PACARAN	4.0	7.0	9.0	12.0	15.0	18.0	21.0
SOCSI CAÑETE	0.0	1.0	2.0	4.0	7.0	12.0	21.0
TANTA	23.0	32.0	38.0	46.0	52.0	58.0	65.0
TOMAS	14.0	18.0	20.0	21.0	22.0	23.0	24.0
YAURICOCHA	27.0	36.0	43.0	54.0	64.0	75.0	88.0
YAUYOS	18.0	23.0	27.0	31.0	34.0	37.0	40.0

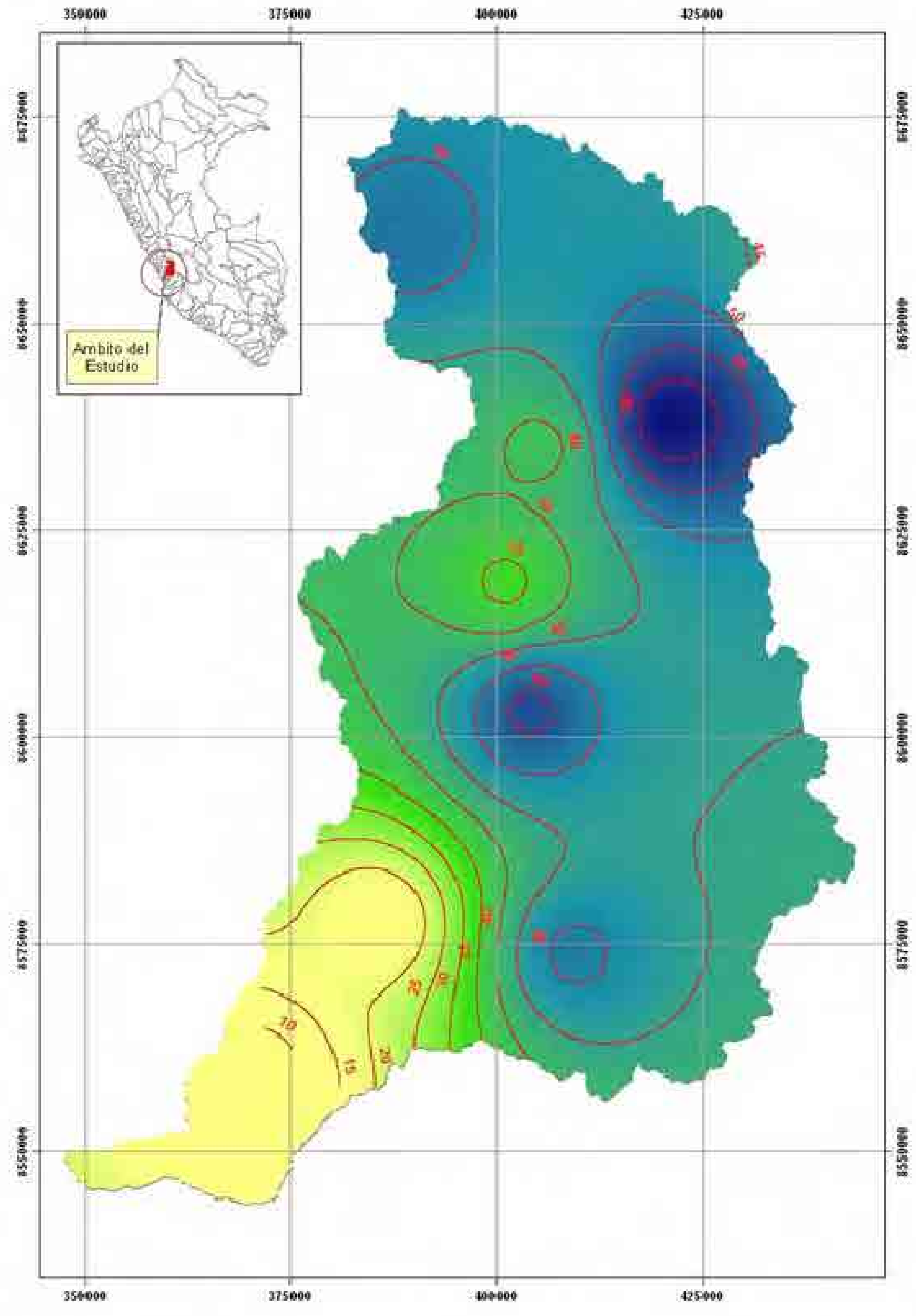


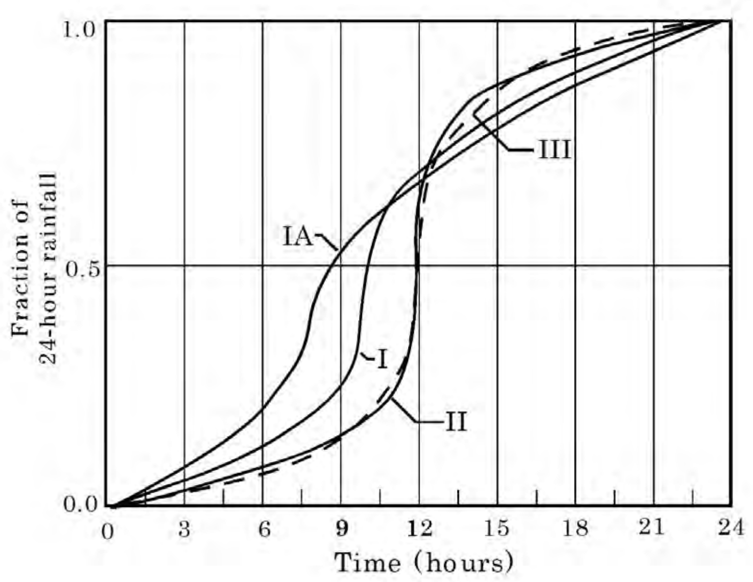
Figure-3.1.9.4-3 Isohyetal map of 24-hour rainfall with return period of 50-year (Cañete basin)

Table-3.1.9.4-2 Probable 24-hour rainfall in sub-basin(Cañete basin)

Sub basin	Area [m^2]	Return Period					
		PT_2	PT_5	PT_10	PT_25	PT_50	PT_100
1	23,147,500	5.6	8.8	11.0	14.5	18.0	22.3
10	99,153,800	20.1	26.1	30.3	35.6	39.8	44.3
10-2	70,237,800	18.9	25.4	30.1	36.6	41.7	47.5
11	31,142,000	19.2	25.4	30.0	35.9	40.5	45.6
1-1	78,972,200	2.3	4.1	5.5	8.1	11.4	16.4
11-1	13,827,500	19.4	26.3	31.5	38.8	44.4	50.9
12	89,313,800	19.5	25.2	29.3	34.8	39.4	44.2
1-2	72,163,700	2.6	4.6	6.1	8.8	12.1	16.9
12-1	70,463,200	18.7	24.3	28.6	33.6	37.4	41.5
13	31,367,400	18.7	24.1	28.3	34.3	40.1	45.9
13-1	42,137,500	19.0	24.6	28.9	34.3	39.0	43.9
14	54,650,700	18.7	24.0	28.2	34.3	40.2	46.1
14-1	2,579,850	18.8	24.3	28.5	34.7	40.6	46.7
15	110,794,000	20.6	27.0	31.7	38.3	44.2	50.3
15-1	29,864,500	19.3	25.0	29.4	35.9	42.1	48.5
16	28,933,500	22.1	29.6	34.7	41.8	47.7	53.8
16-1	115,763,000	22.1	29.2	34.4	41.8	48.3	55.1
16-2	5,852,460	22.3	29.7	34.8	42.0	48.1	54.4
16-3	11,163,600	22.3	29.7	34.8	42.0	47.9	54.1
17	76,294,400	22.3	30.2	35.6	42.9	48.7	54.6
18	211,788,000	22.5	30.7	36.1	43.5	49.2	54.9
19	64,858,300	22.7	31.2	36.9	44.4	50.2	56.0
2	21,011,000	6.5	9.9	12.3	16.0	19.5	23.7
20	14,588,700	22.6	31.1	36.7	44.2	50.0	55.8
20-1	104,300,000	22.5	30.7	36.2	43.6	49.3	55.1
21	67,786,400	22.3	30.1	35.3	42.4	48.0	53.8
21-1	30,166,600	22.2	29.9	35.0	42.1	47.8	53.7
22	43,677,300	22.3	29.8	34.9	41.9	47.5	53.2
23	35,324,400	22.4	30.0	35.0	42.1	47.9	53.8
23-1	893,202	22.4	29.9	35.0	42.3	48.4	54.6
24	7,548,340	22.6	30.1	35.2	42.6	48.7	55.1
25	8,179,220	22.8	30.3	35.5	43.2	49.7	56.4
26	47,884,700	22.6	30.2	35.2	42.2	47.8	53.5

Table-3.1.9.4-3 Accumulated curve of 24-hour rainfall in SCS hypothetical storm

		24 hr precipitation temporal distribution			
Time (hr)	**t/24**	**Type I**	**Type IA**	**Type II**	**Type III**
0.00	0.000	0.000	0.000	0.000	0.000
2.00	0.083	0.035	0.050	0.022	0.020
4.00	0.167	0.076	0.116	0.048	0.043
6.00	0.250	0.125	0.206	0.080	0.072
7.00	0.292	0.156	0.268	0.098	0.089
8.00	0.333	0.194	0.425	0.120	0.115
8.50	0.354	0.219	0.480	0.133	0.130
9.00	0.375	0.254	0.520	0.147	0.148
9.50	0.396	0.303	0.550	0.163	0.167
9.75	0.406	0.362	0.564	0.172	0.178
10.00	0.417	0.515	0.577	0.181	0.189
10.50	0.438	0.583	0.601	0.204	0.216
11.00	0.458	0.624	0.624	0.235	0.250
11.50	0.479	0.654	0.645	0.283	0.298
11.75	0.490	0.669	0.655	0.357	0.339
12.00	0.500	0.682	0.664	0.663	0.500
12.50	0.521	0.706	0.683	0.735	0.702
13.00	0.542	0.727	0.701	0.772	0.751
13.50	0.563	0.748	0.719	0.799	0.785
14.00	0.583	0.767	0.736	0.820	0.811
16.00	0.667	0.830	0.800	0.880	0.886
20.00	0.833	0.926	0.906	0.952	0.957
24.00	1.000	1.000	1.000	1.000	1.000



Source :Urban water hydrology for small watersheds(TR-55) Appendix B

Figure-3.1.9.4-4 Distribution of 24hour rainfall in each type

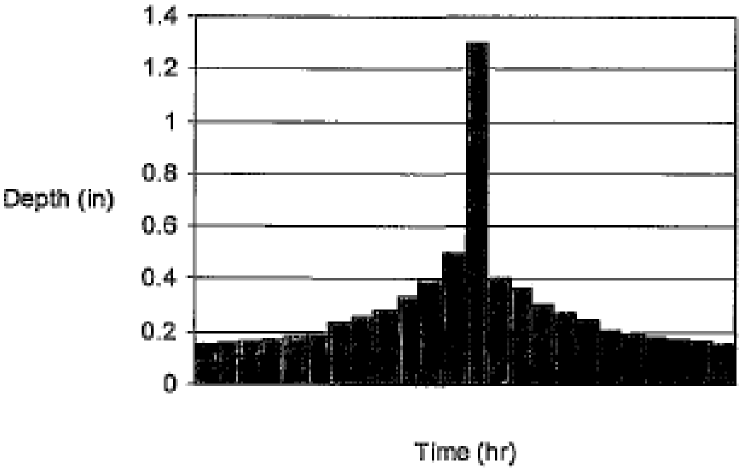
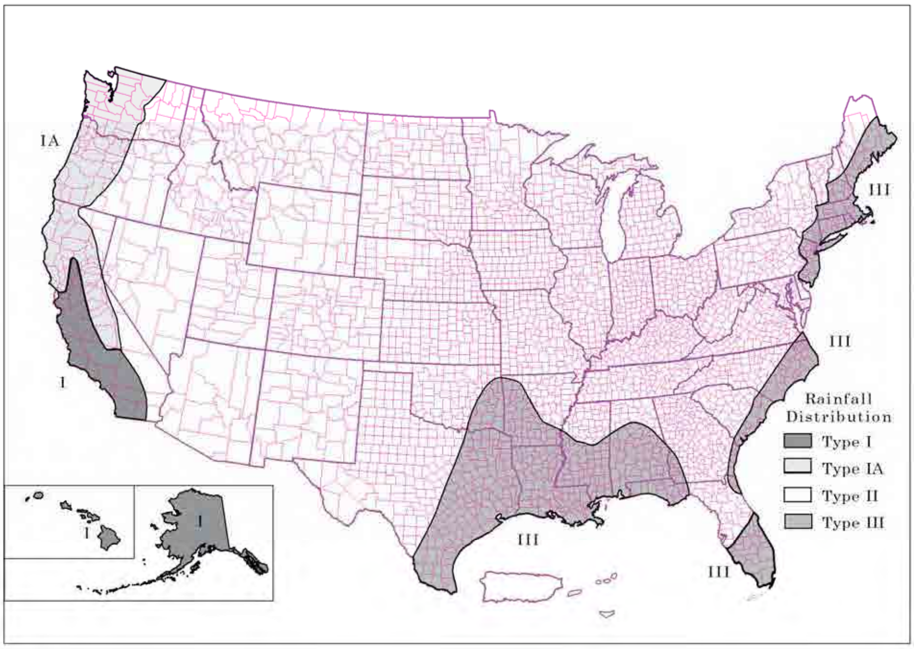


Figure-3.1.9.4-5 Division of 24-hour rainfall



Source :Urban water hydrology for small watersheds(TR-55) Appendix B

Figure-3.1.9.4-6 Type of 24-hour rainfall and applied area

(2) Excess rainfall by SSC method

1) Basic formula

SSC Curve Number (CN) Loss Model is to estimate the excess rainfall based on the function of accumulated rainfall, soil conditions, land use, initial rainfall loss etc. in the following formula.

$$P_e = \frac{(P - I_a)^2}{P - I_a + S}$$

where; Pe :Excess rainfall at time t ; P : Accumulated rainfall at time t ; Ia :Initial loss ; S : Possible storage volume

Assuming Ia = 0.2 S

$$P_e = \frac{(P_e - 0.2S)^2}{P + 0.8S}$$

Relation S and CN representing basin characteristics is as shown below.

$$S = \frac{1000}{CN} - 10$$

Assuming CN, the relation Pe and P is calculated as shown the Figure-3.1.9.4-7.

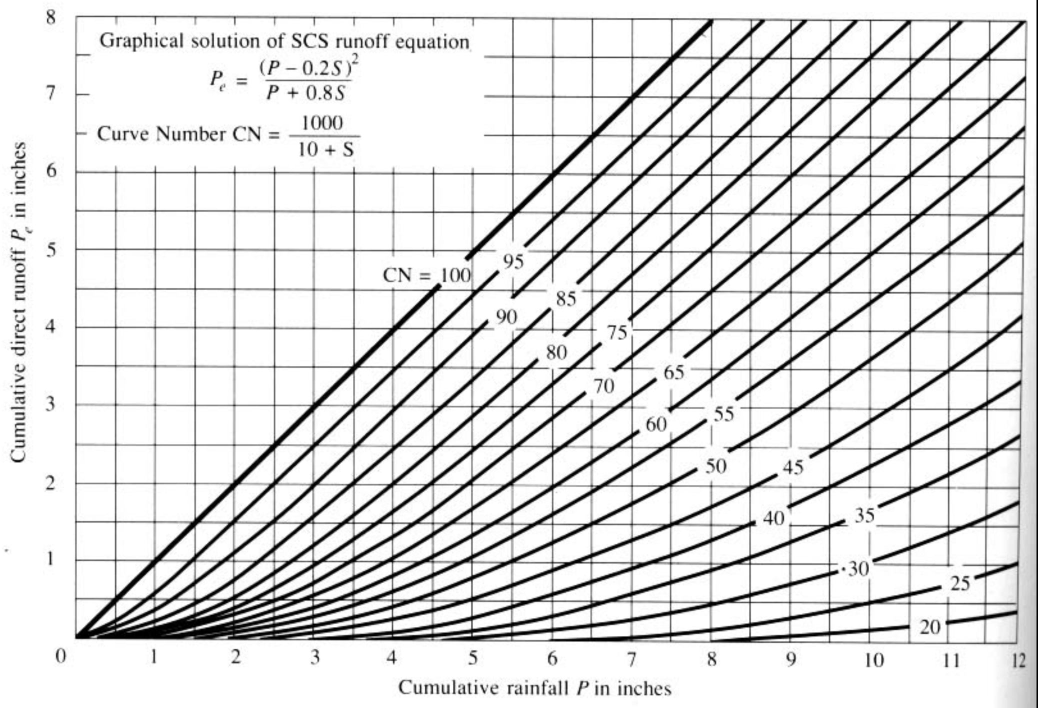


FIGURE 5.5.2
Solution of the SCS runoff equations. (*Source:* Soil Conservation Service, 1972, Fig. 10.1, p. 10.21)

Figure-3.1.9.4-7 Relation among CN, P and P_e

2) Selection of CN in sub-basin

Referring to the Table-3.1.9.4-4 and based on the land use and soil conditions, CN of each sub-division is determined.

The initial CN value in Cañete Basin is determined from 75 to 78 considering the basin characteristics and the past experiences and so on.

The run-off analysis carried out based on the initial value of CN, and the each probable flood peak and flood hydrograph are calculated for various values of CN. And examining the calculation results, the final CN value is determined as 80.

Since there is no hourly discharge data but only daily data, it is difficult to verify the study results strictly; however the verification is carried out as shown in the clause 3.1.9.5.

Table-3.1.9.4-4(1) CN Value depending on land use and soil conditions (1/3)

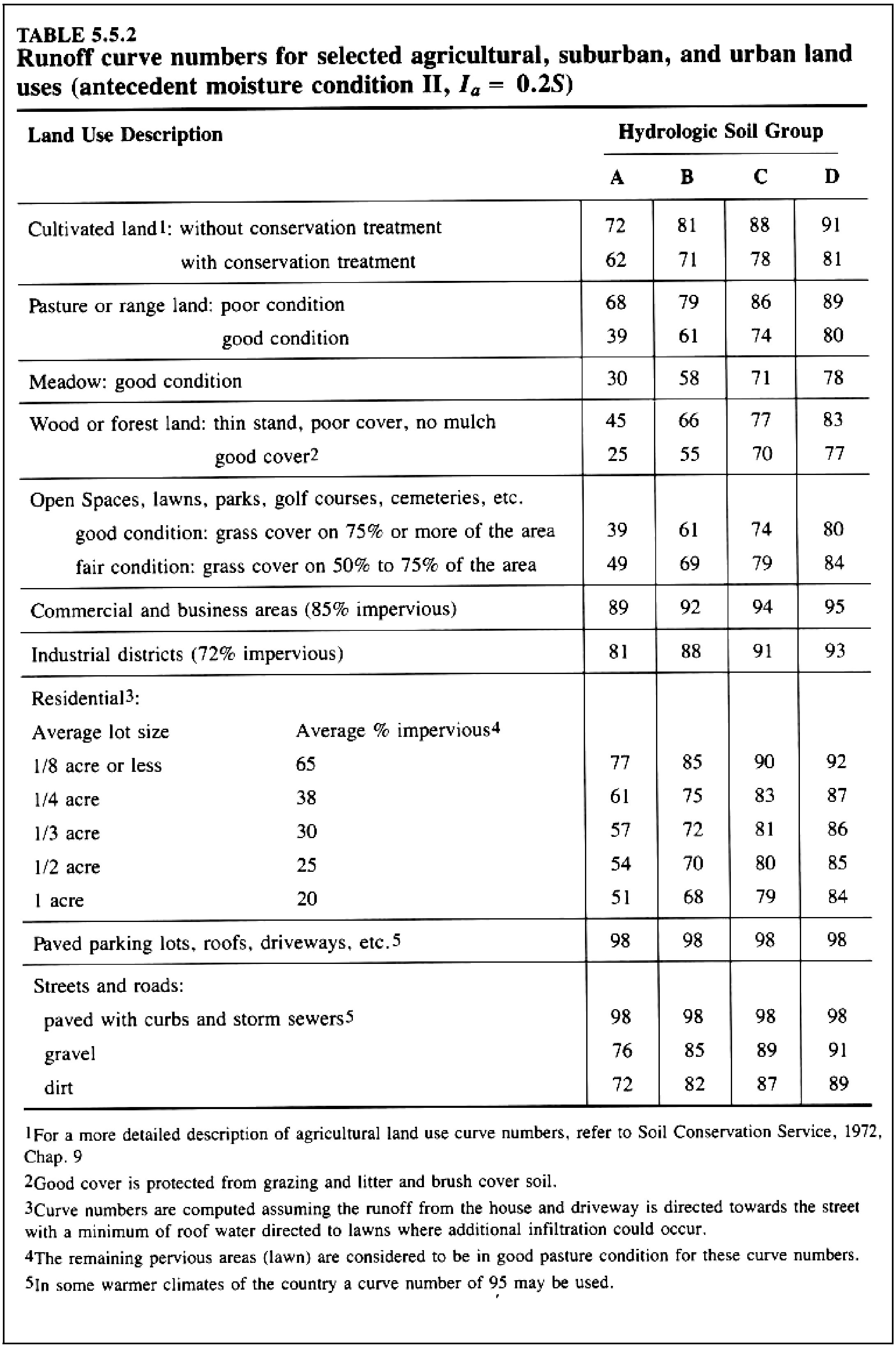


TABLE 5.5.2

Runoff curve numbers for selected agricultural, suburban, and urban land uses (antecedent moisture condition II, $I_a = 0.2S$)

Land Use Description		Hydrologic Soil Group			
		A	B	C	D
Cultivated land[1]: without conservation treatment		72	81	88	91
with conservation treatment		62	71	78	81
Pasture or range land: poor condition		68	79	86	89
good condition		39	61	74	80
Meadow: good condition		30	58	71	78
Wood or forest land: thin stand, poor cover, no mulch		45	66	77	83
good cover[2]		25	55	70	77
Open Spaces, lawns, parks, golf courses, cemeteries, etc.					
good condition: grass cover on 75% or more of the area		39	61	74	80
fair condition: grass cover on 50% to 75% of the area		49	69	79	84
Commercial and business areas (85% impervious)		89	92	94	95
Industrial districts (72% impervious)		81	88	91	93
Residential[3]:					
Average lot size	Average % impervious[4]				
1/8 acre or less	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
Paved parking lots, roofs, driveways, etc.[5]		98	98	98	98
Streets and roads:					
paved with curbs and storm sewers[5]		98	98	98	98
gravel		76	85	89	91
dirt		72	82	87	89

[1] For a more detailed description of agricultural land use curve numbers, refer to Soil Conservation Service, 1972, Chap. 9

[2] Good cover is protected from grazing and litter and brush cover soil.

[3] Curve numbers are computed assuming the runoff from the house and driveway is directed towards the street with a minimum of roof water directed to lawns where additional infiltration could occur.

[4] The remaining pervious areas (lawn) are considered to be in good pasture condition for these curve numbers.

[5] In some warmer climates of the country a curve number of 95 may be used.

Table3.1.9.4-4(2) CN value depending on land use and soil conditions (2/3)

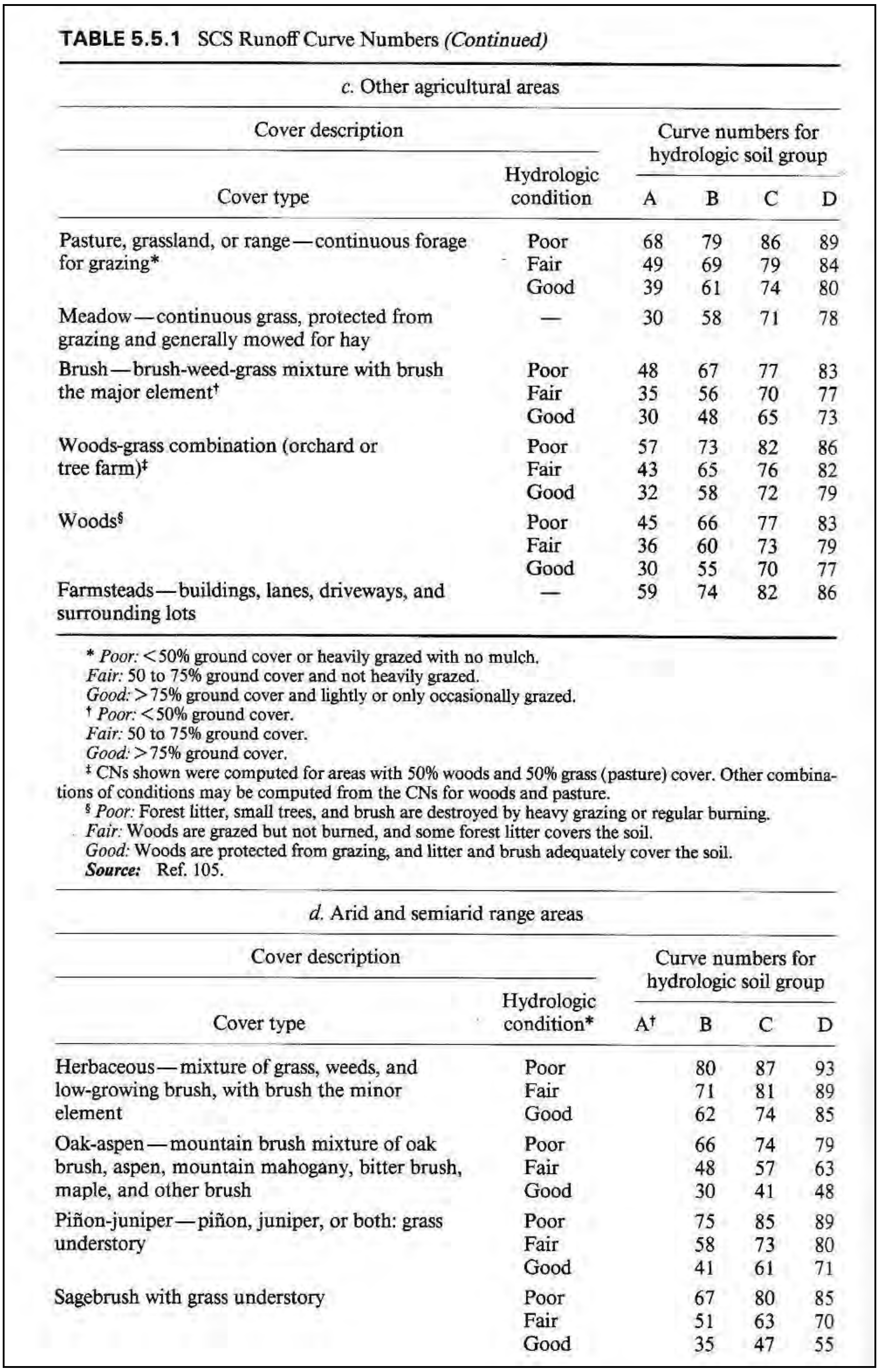


TABLE 5.5.1 SCS Runoff Curve Numbers *(Continued)*

c. Other agricultural areas

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing*	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element†	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods-grass combination (orchard or tree farm)‡	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods§	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots	—	59	74	82	86

* *Poor:* <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: >75% ground cover and lightly or only occasionally grazed.
† *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
‡ CNs shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CNs for woods and pasture.
§ *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.
Source: Ref. 105.

d. Arid and semiarid range areas

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition*	A†	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Piñon-juniper—piñon, juniper, or both: grass understory	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55

Table-3.1.9.4-4(3) CN value depending on land use and soil conditions (3/3)

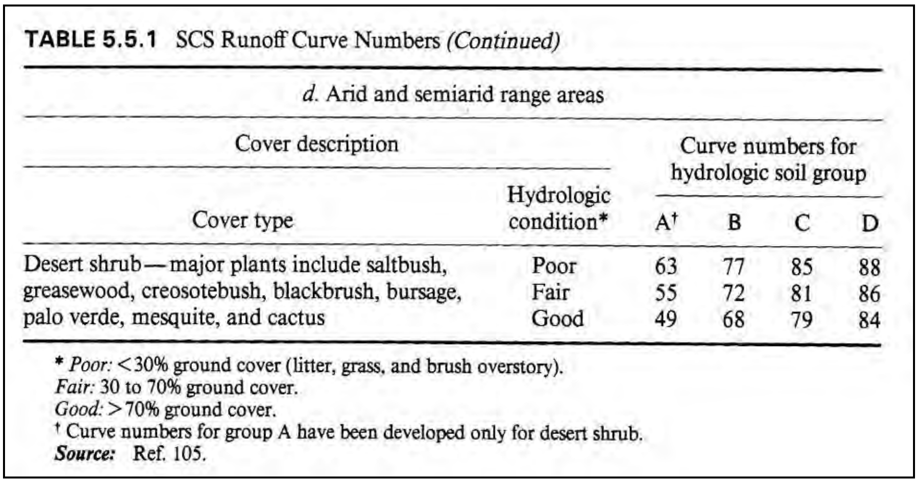


TABLE 5.5.1 SCS Runoff Curve Numbers *(Continued)*

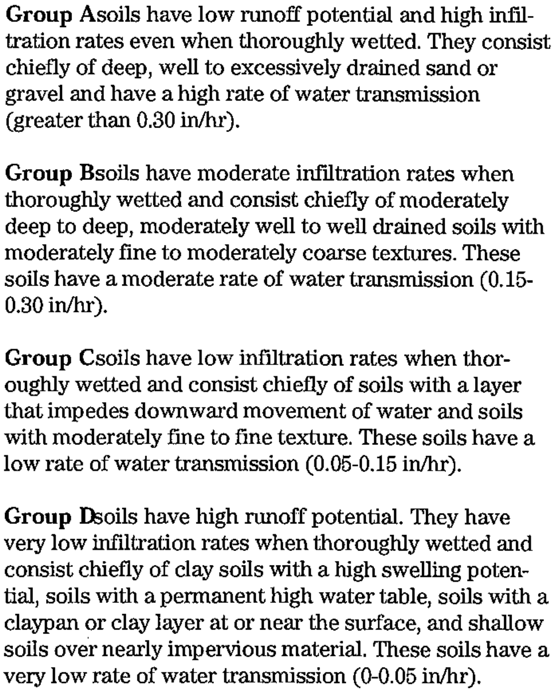
d. Arid and semiarid range areas

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition*	A†	B	C	D
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

* *Poor:* <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: >70% ground cover.
† Curve numbers for group A have been developed only for desert shrub.
Source: Ref. 105.

Source: Maidment (1993).

Note: Hydrological Soil Group



Group Asoils have low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sand or gravel and have a high rate of water transmission (greater than 0.30 in/hr).

Group Bsoils have moderate infiltration rates when thoroughly wetted and consist chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission (0.15-0.30 in/hr).

Group Csoils have low infiltration rates when thoroughly wetted and consist chiefly of soils with a layer that impedes downward movement of water and soils with moderately fine to fine texture. These soils have a low rate of water transmission (0.05-0.15 in/hr).

Group Dsoils have high runoff potential. They have very low infiltration rates when thoroughly wetted and consist chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a claypan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very low rate of water transmission (0-0.05 in/hr).

(3) Probable flood discharge and hydrograph

The probable flood discharge and hydrograph are calculated by HEC-HMS. The beginning of rainfall and flood hydrograph is assumed to be same hour. The kinematic wave method is applied for the flood routing of river channel.

The calculation results are as shown in the Table-3.1.9.4-5～3.1.9.4-7 and the Fgure-3.1.9.4, and which are to be used for discharge capacity analysis of river channel, inundation analysis and flood protection planning.

Table-3.1.9.4-5 Probable flood discharge

(m^3/s)

River/Reference Point	ReturnPeriod of 2-year	ReturnPeriod of 5-year	ReturnPeriod of 10-year	ReturnPeriod of 25-year	ReturnPeriod of 50-year	ReturnPeriod of 100-year
Cañete/ Socsi	331	408	822	1,496	2,175	2,751

Table-3.1.9.4-6 Probable specific flood discharge

(m^3/s/km^2)

River/Reference Point	ReturnPeriod of 2-year	ReturnPeriod of 5-year	ReturnPeriod of 10-year	ReturnPeriod of 25-year	ReturnPeriod of 50-year	ReturnPeriod of 2-year	BasinArea Km2
Cañete/ Socsi	0.058	0.072	0.145	0.264	0.383	0.485	5,676

Table-3.1.9.4-7 Past maximum discharge and 50-year probable discharge (m3/sec)

Rive/Reference Point	Past Maximum Discharge	Observation Period(year)	Probabe Discharge of 50 year
Cañete/ Socsi	900	81	2,175

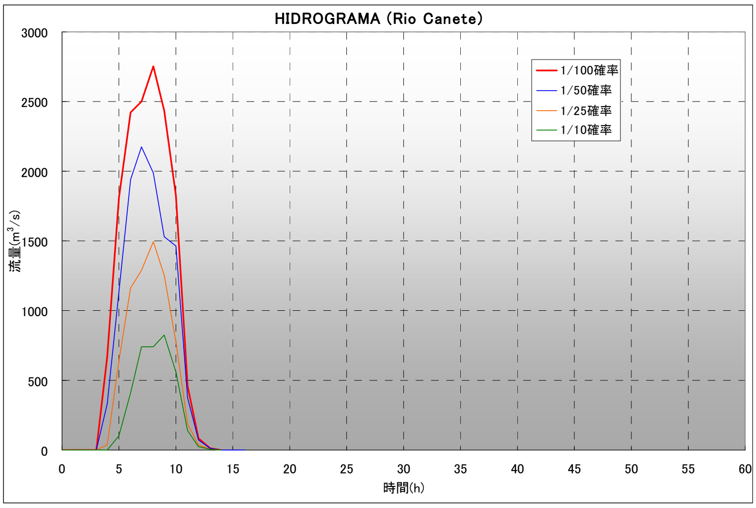


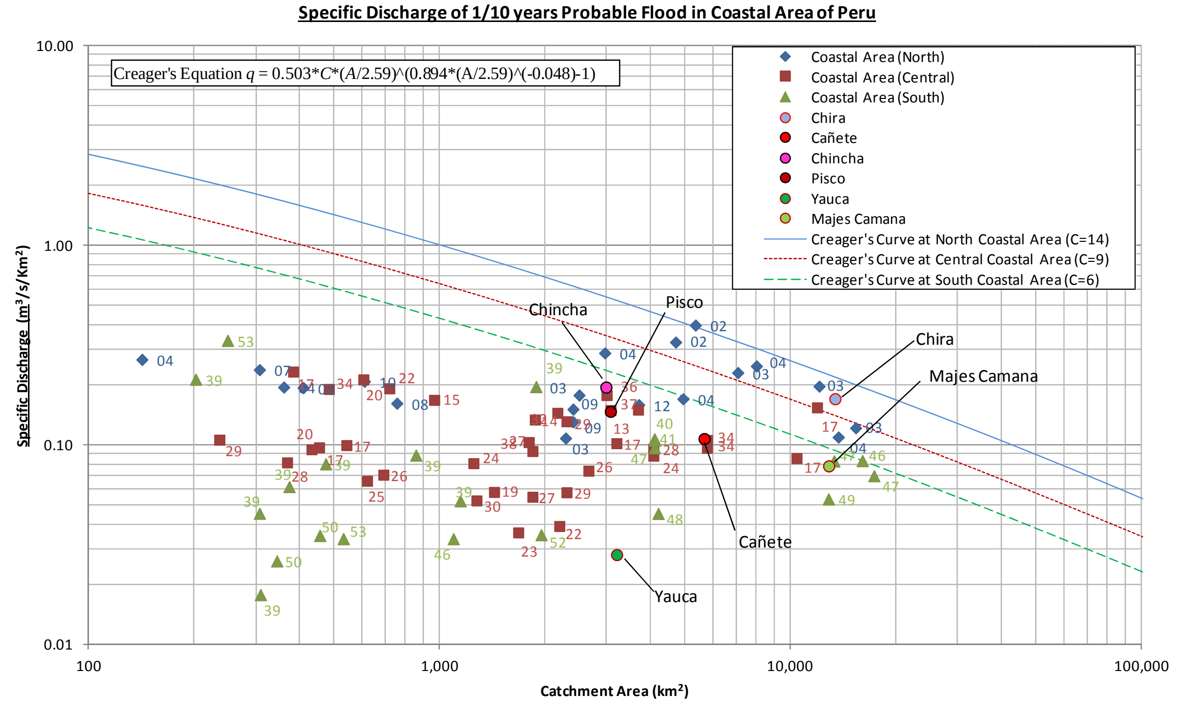
Figure-3.1.9.4-10 Flood hydrograph in Cañete basin

3.1.9.5 Consideration on results of analysis

(1) Verification of peak discharge

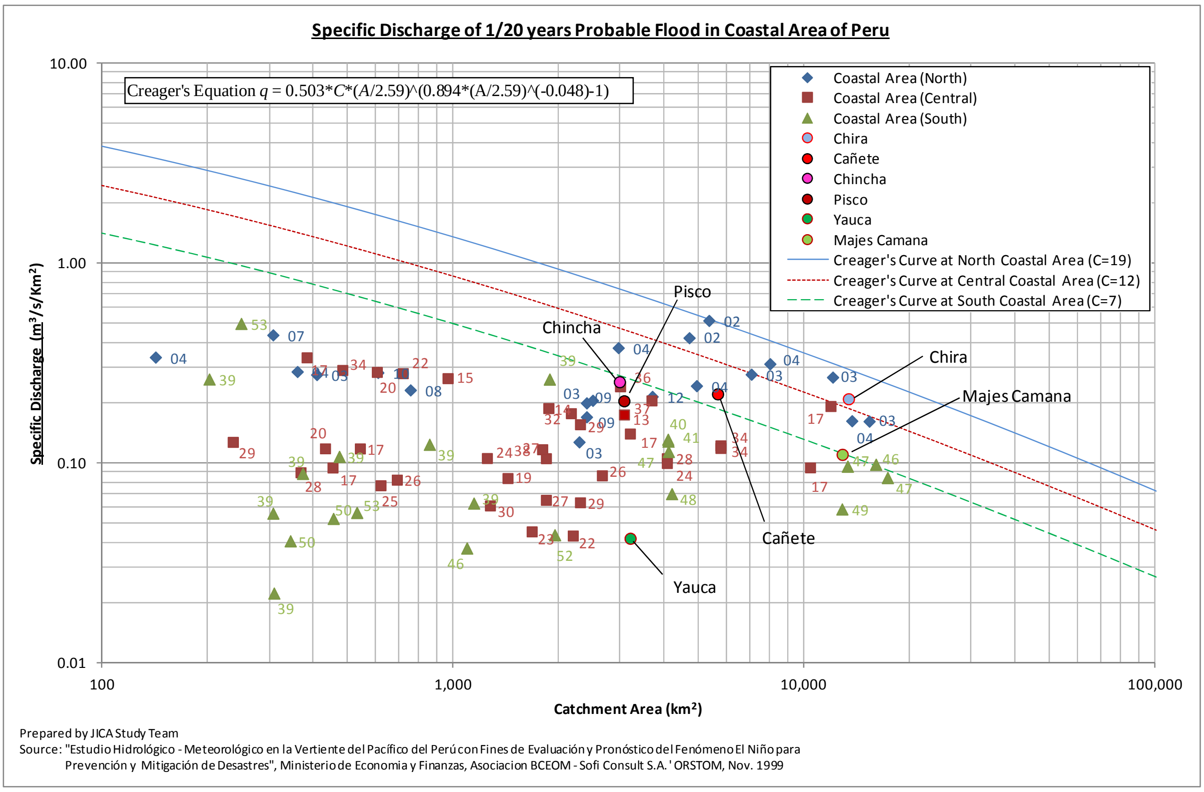
In Figure-3.1.9.5-1 to 3.1.9.5-4 is plotted the specific probabilistic return flow and the results of discharges analyzes conducted for each river in coastal area of Peru. (Source: "Estudio Hidrológico - Meteorológico en la Vertiente del Pacífico del Perú con Fines de Evaluación y Pronóstico del Fenómeno El Niño para Prevención y Mitigación de Desastres", Ministerio de Economía y Finanzas, Asociación BCEOM - Sofi Consult S.A. ORSTOM, Nov. 1999.)

Comparing the Creager envelopes curves and the calculated specific flows for each of the basins we can conclude that calculated probabilistic discharges are within the acceptable range.



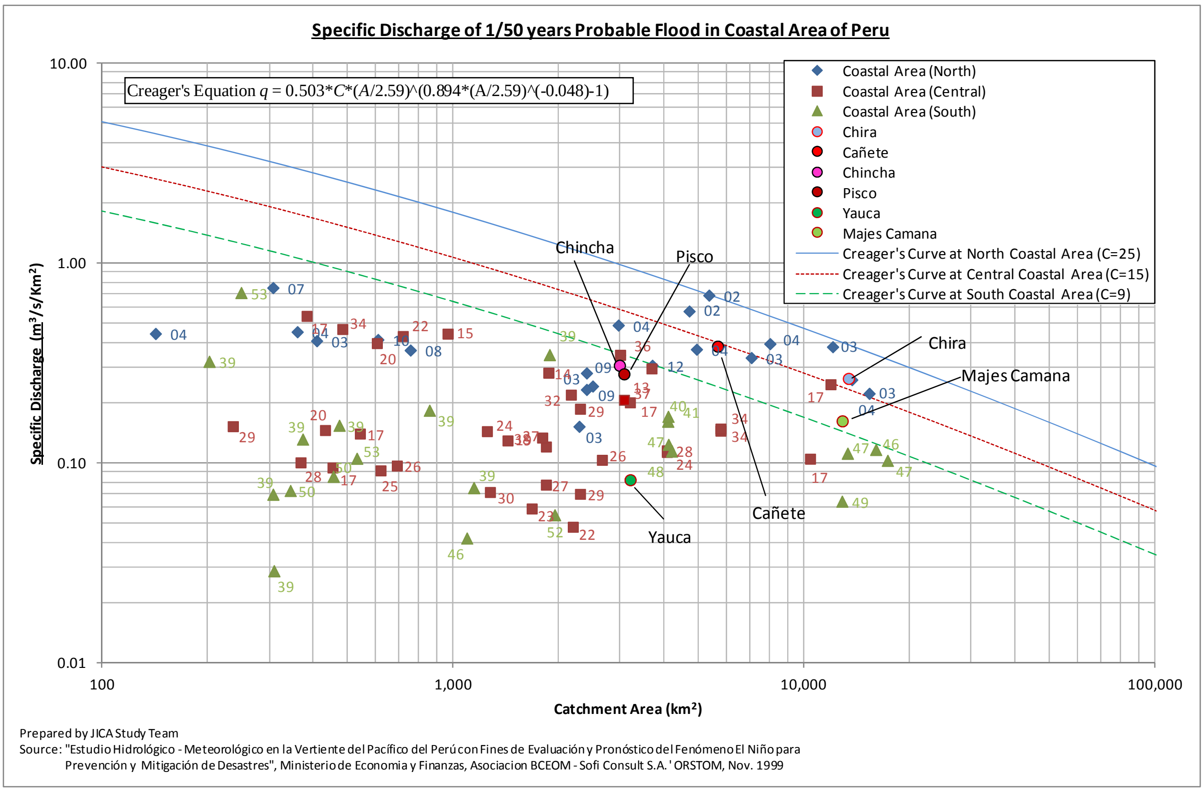
Prepared by JICA Study Team
Source: "Estudio Hidrológico - Meteorológico en la Vertiente del Pacifico del Perú con Fines de Evaluación y Pronóstico del Fenómeno El Niño para Prevención y Mitigación de Desastres", Ministerio de Economia y Finanzas, Asociacion BCEOM - Sofi Consult S.A. ' ORSTOM, Nov. 1999

Figure 3.1.9.5-1 Probabilistic specific discharges and calculated peak discharges (t=1/10)



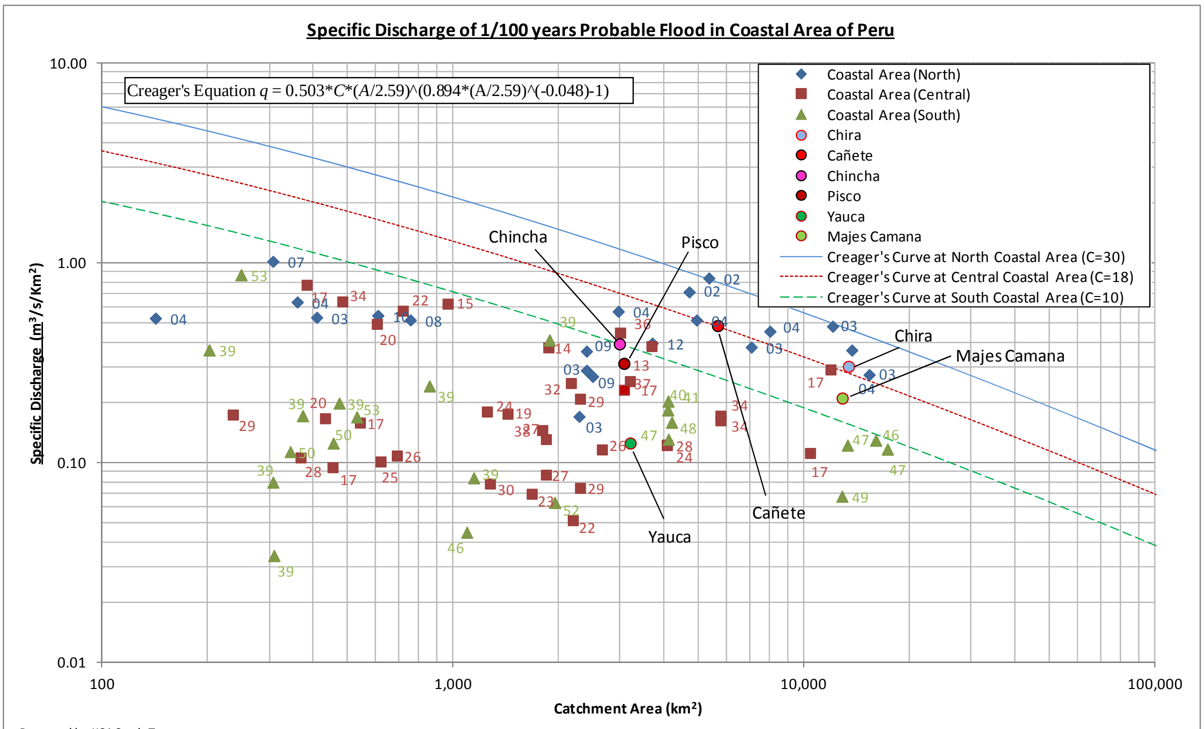
Prepared by JICA Study Team
Source: "Estudio Hidrológico - Meteorológico en la Vertiente del Pacífico del Perú con Fines de Evaluación y Pronóstico del Fenómeno El Niño para Prevención y Mitigación de Desastres", Ministerio de Economia y Finanzas, Asociacion BCEOM - Sofi Consult S.A. ' ORSTOM, Nov. 1999

Figure 3.1.9.5-2 Probabilistic specific discharges and calculated peak discharges (t=1/20)



Prepared by JICA Study Team
Source: "Estudio Hidrológico - Meteorológico en la Vertiente del Pacífico del Perú con Fines de Evaluación y Pronóstico del Fenómeno El Niño para Prevención y Mitigación de Desastres", Ministerio de Economia y Finanzas, Asociacion BCEOM - Sofi Consult S.A. ' ORSTOM, Nov. 1999

Figure 3.1.9.5-3 Probabilistic specific discharges and calculated peak discharges (t=1/50)



Prepared by JICA Study Team
Source: "Estudio Hidrológico - Meteorológico en la Vertiente del Pacífico del Perú con Fines de Evaluación y Pronóstico del Fenómeno El Niño para Prevención y Mitigación de Desastres", Ministerio de Economia y Finanzas, Asociacion BCEOM - Sofi Consult S.A. ' ORSTOM, Nov. 1999

Figure 3.1.9.5-4 Probabilistic specific discharges and calculated peak discharges (t=1/100)

(2)Flood discharge with return period of 50-year in Cañete basin

1) Upper Limit of discharge observation in Socsi station

The cross section of river channel at Socsi discharge observation station is as shown in the Figure-3.1.9.5-5, in which the area at maximum water level (water depth:2.77m) is as follows:

A = (28.17+37.92)*1.0/2+(55.50+66.28)*0.70/2+(66.28+70.88)*1.07/2) = 149.0m2

The flood discharge velocity at Socsi station is estimated 5～6 m/sec as the station is located at upstream of the objective study area.

Assuming the velocity is 6 m/sec, the discharge will be as follows:

Q = AV= 149.0x6.0 = 894m3/sec

The maximum observation record in the past is 900 m3/sec, and which is almost equal to the above discharge, that is to say, the discharge more than this value is difficult to measure in this station.

The Socsi observation station seems to have the upper limit of measurable discharge as shown above, therefore the observation station is to be removed to the appropriate place as soon as possible.

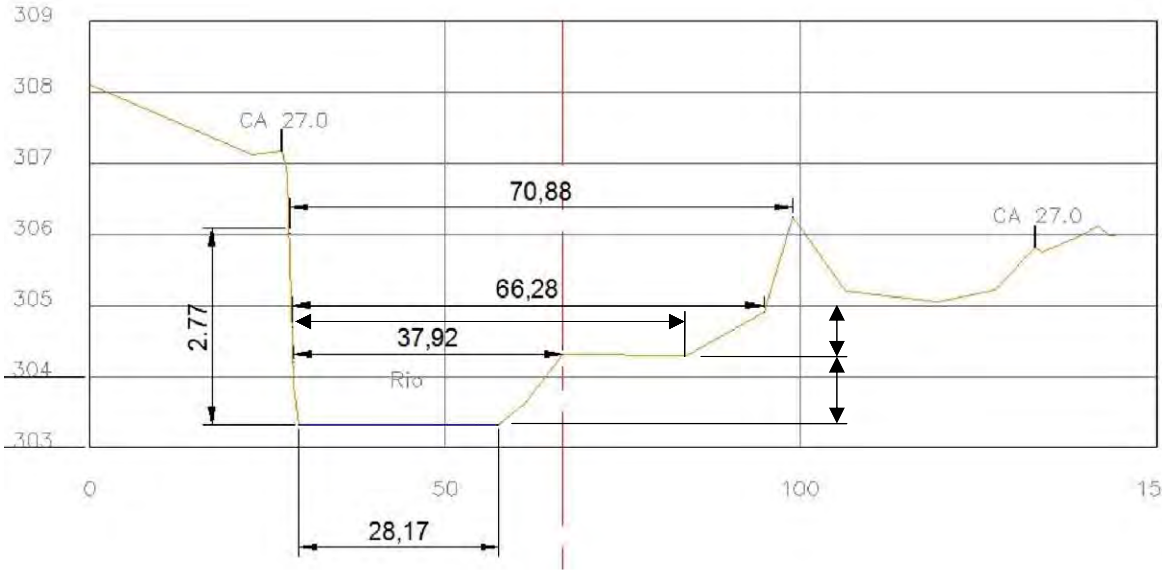


Figure-3.1.9.5-5 Cross section at Socsi station

2) Comparison with adjacent basin for probable flood discharge

The appropriateness of the discharge obtained from two methods (based on observation data and HEC-HMS analysis) is verified comparing Cañete with the adjacent basins such as Chincha and Pisco which have similar basin characteristics such as topography, surface geology etc.

Cañete basin is located nearest to the capital Lima, and south to which Chincha basin and Pisco basin in this order, therefore the Chincha basin is the most similar to Cañete basin.

i) Run-off characteristics

The run-off characteristics based on the observation data is as shown in the Table-3.1.9.5-1, and the Maximum discharge in Cañete basin is observed extremely small compared with the other basins.

Table-3.1.9.5-1 Run-off characteristics of each basin

Item	Cañete Socsi	Chincha Conta	Pisco Letrayoc
Basin Area（km^2）①	5,676	2,981	3,096
Max. Discharge（m^3/s）②	900.0	1,268.8	956.0
Ave. discharge（m^3/s）③	338.8	240.3	296.6
②／①	0.159	0.426	0.306
③／①	0.060	0.081	0.096
②／③	2.657	5.280	3.223

The probable discharges calculated from yearly maximum observation data and their ratio to the value of Chincha basin are as shown in the Table-3.1.9.5-2 together with specific discharge. Those values of Cañete basin are also extremely small compared with the other basins.

Table-3.1.9.5-2 Comparison of probable flood discharge and specific discharge

Items	Cañete		Chincha		Pisco	
Basin Area/Ratio	Basin Area	Ratio	Basin Area	Ratio	Basin Area	Ratio
Basin Area(km2)	5,676	1.904	2,981	1.000	3,096	1.039
Discharge(m3/sec) /Ratio	Discharge	Ratio	Discharge	Ratio	Discharge	Ratio
Probability:1/5year	454	1.201	378	1.000	398	1.053
Probability:1/10year	547	1.021	536	1.000	500	0.933
Probability:1/25year	665	0.872	763	1.000	648	0.849
Probability:1/50year	753	0.792	951	1.000	774	0.814
Probability:1/100year	840	0.727	1156	1.000	914	0.791
Specific Discharge(m3/sec/km2)/Ratio	Specific Discharge	Ratio	Specific Discharge	Ratio	Specific Discharge	Ratio
Probability:1/5year	0.080	0.631	0.127	1.000	0.129	1.014
Probability:1/10year	0.096	0.563	0.180	1.000	0.161	0.898
Probability:1/25year	0.117	0.458	0.256	1.000	0.209	0.818
Probability:1/50year	0.133	0.416	0.319	1.000	0.250	0.784
Probability:1/100year	0.148	0.382	0.388	1.000	0.295	0.761

ii）Rainfall Characteristics

The probable 24-hour rainfall at the reference point of each basin is as shown in the Table- Table-3.1.9.5-3. The rainfall amount in Cañete basin is larger than in the other basins.

Table-3.1.9.5-3 Probable 24-hour rainfall at reference point（mm）

Probable Year	Cañete	Chincha	Pisco
1/5 year	25.5	23.4	28.9
1/10 year	30.3	27.4	33.2
1/25 year	37.3	32.2	38.8
1/50 year	43.1	35.6	42.6
1/100 year	49.4	39.1	46.9

In order to estimate the total rainfall amount which affects the flood discharge, the total rainfall amount in the basin is calculated by multiplying the probable 24-hour rainfall amount with total basin area, of which result is as shown in the Table-3.1.9.5-4.

Table-3.1.9.5-4 Probable total 24-hour rainfall amount at reference point (1,000m3)

Probable Year	Cañete	Chincha	Pisco
1/5 year	144,738	69,755	89,474
1/10 year	171,983	81,679	102,787
1/25 year	211,715	95,988	120,125
1/50 year	244,636	106,124	131,890
1/100 year	280,394	116,557	145,202

3) Evaluation of probable observation discharge in Cañete basin

a) Probable Specific Discharge at Reference Point

The probable specific discharge is as shown in the Table-3.1.9.5-5, in which the probable specific discharge in Cañete basin is extremely small compared with the other basins so that it can be concluded that the probable discharge calculated based on the observation data in Cañete basin is questionable.

Table-3.1.9.5-5 Probable specific discharge at reference point (m3/sec/km2)

Probable Year	Cañete	Chincha	Pisco
1/5 year	0.080	0.127	0.129
1/10 year	0.096	0.180	0.161
1/25 year	0.117	0.256	0.209
1/50 year	0.133	0.319	0.250
1/100 year	0.148	0.388	0.295

b) Ratio between Probable Observation Discharge and Probable Total Rainfall Amount

The ratio between the probable observation discharge and the probable total rainfall amount in the basin is as shown in the Table-3.1.9.5-6, in which the ratio in Cañete basin does not increase in spite of increase of probability. Generally the more probability increases, the more the ratio increases as shown in the other basins. Therefore, the probable observation discharge in Cañete basin is questionable at this point.

Table-3.1.9.5-6 Ratio between probable observation discharge and total rainfall amount

Probable Year	Cañete	Chincha	Pisco	Average of 3Basin	Average of Chincha and Pisco
1/5 year	0.0031	0.0054	0.0044	0.0043	0.0049
1/10 year	0.0032	0.0066	0.0049	0.0049	0.0057
1/25 year	0.0031	0.0079	0.0054	0.0055	0.0067
1/50 year	0.0031	0.0090	0.0059	0.0060	0.0074
1/100 year	0.0030	0.0099	0.0063	0.0064	0.0081

c) Estimation of discharge in cañete basin from data of other basins

The probable discharges in Cañete basin are estimated with the ratio between the probable discharge and the total rainfall amount in the other basins.

The estimation is performed in case of using the ratio in Chincha basin which is the nearest basin and the average ratio of Chincha and Pisco basins. However the application of Chincha data seems to be more appropriate as the Chincha basin is just adjacent basin.

Table-3.1.9.5-7 Estimation of probable discharges in cañete basin based on data of other basin

(ratio, m3/sec)

	Chincha	**Pisco**	**Average**	**Discharge in Cañete**	
				Ratio of Chincha	**Ratio of Average**
1/5 year	0.0054	0.0044	0.0049	784.3	714.1
1/10 year	0.0066	0.0049	0.0057	1128.6	982.6
1/25 year	0.0079	0.0054	0.0067	1682.9	1412.5
1/50 year	0.0090	0.0059	0.0074	2192.2	1813.9
1/100 year	0.0099	0.0063	0.0081	2780.9	2273.0

Note: Ratio: between probable discharge and total 24-hour rainfall in the basin.

Discharge: ratio x total 24-hour rainfall in Cañete basin

(Conclusion)

The comparison among the probable observation discharge in Cañete basin①, the estimated discharge based on the ratio between probable discharge and the probable total 24-hour rainfall amount in Chincha basin ② and the probable discharge obtained from HEC-HMS run-off analysis using 24-hour rainfall data③ is as shown in the Table-3.1.9.5-8.

According to the Table ② is generally larger than ①, and in the high probability discharge ② is extremely same as ③.

In accordance with the above, it is difficult to adopt the probable discharge based on observation data, and it is appropriate that the probable discharge obtained based on HEC-HMS analysis using 24-hour rainfall data should be used in the further study of this Project.

Table-3.1.9.5-8 Comparison of probable discharge in Cañete basin

Occurrence Probaility	Observation Discharge①		Estimated Dicharge by Data of Chincha②		Discharge by HEC-HMS ③	
	Discharge(m3/sec)	Ratio to Rainfall	Discharge(m3/sec)	Ratio to Rainfall	Discharge(m3/sec)	Ratio to Rainfall
1/5year	454	0.0031	784.3	0.0052	408	0.0028
1/10year	547	0.0032	1128.6	0.0073	822	0.0048
1/25year	665	0.0031	1682.9	0.0089	1496	0.0071
1/50year	753	0.0031	2192.2	0.0099	2175	0.0089
1/100year	840	0.0030	2780.9	0.0099	2751	0.0098

3.1.10 Analysis of Inundation

(1) River surveys

Prior to the flood analysis, the transversal survey or Cañete river was performed as well as the longitudinal survey of dikes. Table 3.1.10-1 shows the results of the surveys in the five rivers subject of this Study.

In order to obtain the topographic data for the analysis of the flooding zones, the results of the true measurement results indicated in Table 3.1.10-1 were used as a complement, using the satellite figures data.

Table 3.1.10-1 Basic data of the river surveys

Survey	Unit	Quantity	Notes
1. Control points survey			
Cañete river	No.	4	
2. Dikes transversal survey			250m Interval, only one bank
Cañete river	km	33	
3. River transversal survey			500m Interval
Cañete river	km	46.9	67 lines x 0.7km
4. Benchmarks			
Type A	No.	30	Every control point
Type B	No.	273	33km x one point/km

(2) Inundation analysis method

Since the DGIH carried out the flood analysis of the profile study at a program level using the HEC-RAS model, for this Study, we decided to used this method, and review and modify it, if necessary.

1）Analysis basis

Normally, for the flooding analysis the following three methods are used.

① Varied flow unidimensional model
② Tank model
③ Varied flow horizontal bidimensional model

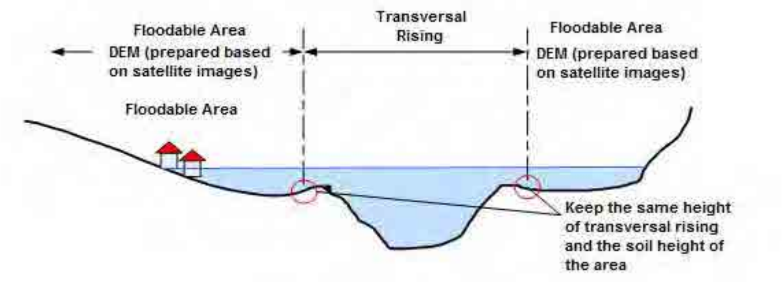
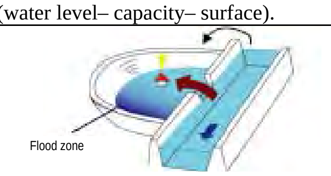
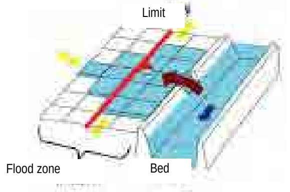


Figure 3.1.10-1 Idea of unidimensional model

The time and cost required by each method vary considerably, so only the most efficient method will be chosen, which guarantees the necessary accurateness degree for the preparation of the floodable zone maps.

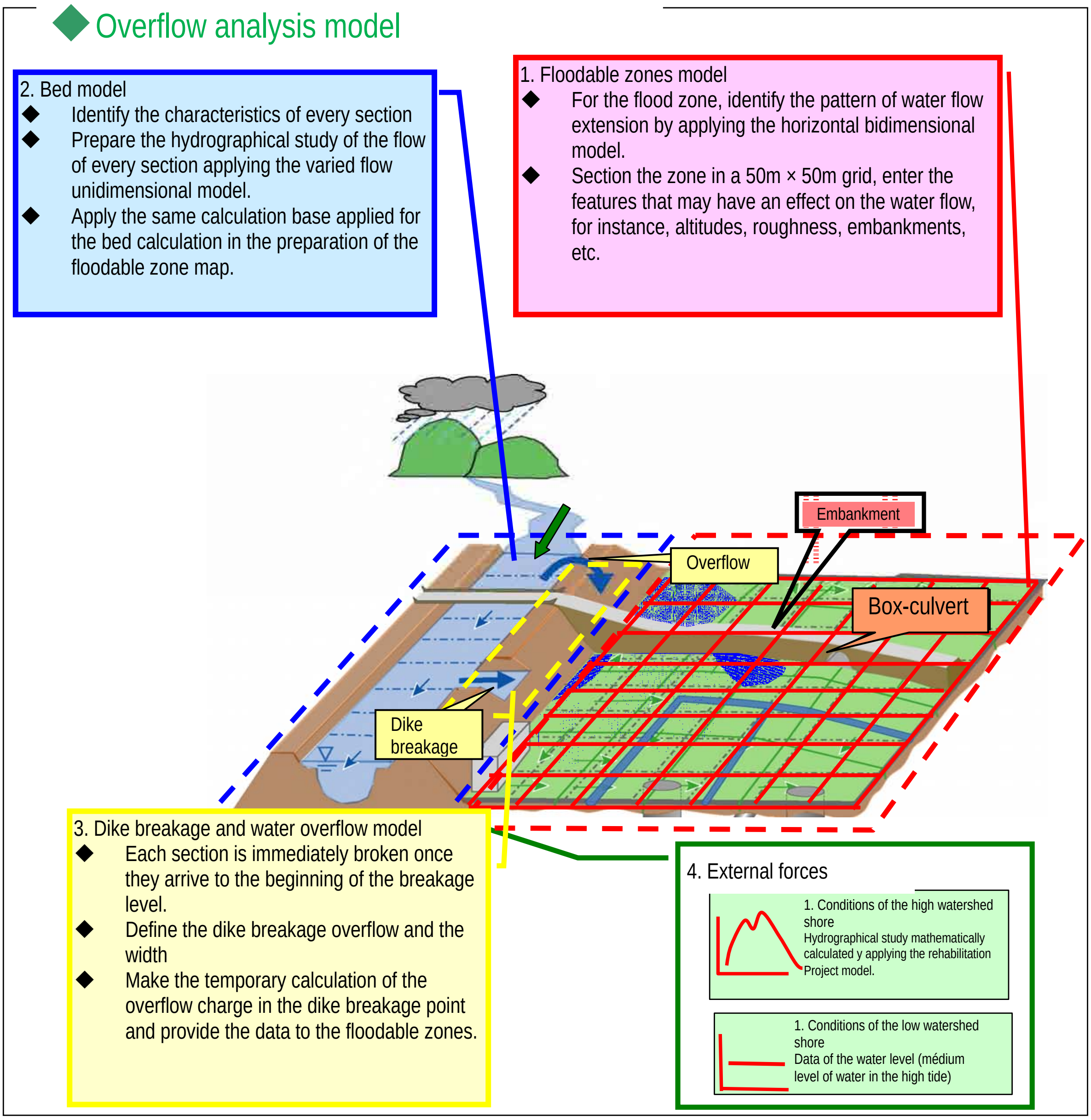
Table 3.1.10-2 shows the characteristics of each analysis method. From the results of the simulation performed by DGIH, it is known that the rivers have a slope between 1/100 and 1/300, so initially the varied flow one-dimensional model was chosen assuming that the floods were serious. However, we considered the possibility that the overflowed water extends within the watershed in the lower watershed, so for this study the variable regimen horizontal bi-dimensional model was used to obtain more accurate results

Table 3.1.10-2 Methodology of flooding analysis

Analysis methods	Vary flow unidimensional model	Tank model	Varied flow bi-dimensional horizontal model
Basic concept of the flood zone definition	In this method, the flood zone is considered to be included in the river bed, and the flood zone is determined by calculating the water level of the bed in relation to the maximum flooding flow	This method manages the flood zone and bed separately, and considers the flooding zone as a closed body. This closed water body is called *pond* where the water level is uniform. The flood zone is determined in relation to the relationship between the overflowed water from the river and entered to the flood zone, and the topographic characteristics of such zone (water level– capacity– surface).	This method manages the flood zones and the bed separately, and the flood zone is determined by analyzing the bidimensional flow of the behaviour of water entered to the flood zone.
Approach			
Characteristics	It is applicable to the floods where the overflowed water runs by the flood zone by gravity; that means, current type floods. This method must manage the analysis area as a protected area (without dikes).	Applicable to blocked type floods where the overflowed water does not extend due to the presence of mountains, hills, embankments, etc. The water level within this closed body is uniform, without flow slope or speed. In case there are several embankments within the same flood zone, it may be necessary to apply the pond model in series distinguishing the internal region.	Basically, it is applicable to any kina of flood. Reside the flood maximum area and the water level, this method allows reproducing the flow speed and its temporary variation. It is considered as an accurate method compared with other methods, and as such, it is frequently applied in the preparation of flood irrigation maps. However, due to its nature, the analysis precision is subject to the size of the analysis model grids.

2） Overflow analysis method

Figure 3.1.10-2 shows the conceptual scheme of the variable regimen horizontal bi-dimensional model.



◆ Overflow analysis model

2. Bed model
- ◆ Identify the characteristics of every section
- ◆ Prepare the hydrographical study of the flow of every section applying the varied flow unidimensional model.
- ◆ Apply the same calculation base applied for the bed calculation in the preparation of the floodable zone map.

1. Floodable zones model
- ◆ For the flood zone, identify the pattern of water flow extension by applying the horizontal bidimensional model.
- ◆ Section the zone in a 50m × 50m grid, enter the features that may have an effect on the water flow, for instance, altitudes, roughness, embankments, etc.

3. Dike breakage and water overflow model
- ◆ Each section is immediately broken once they arrive to the beginning of the breakage level.
- ◆ Define the dike breakage overflow and the width
- ◆ Make the temporary calculation of the overflow charge in the dike breakage point and provide the data to the floodable zones.

4. External forces

1. Conditions of the high watershed shore
Hydrographical study mathematically calculated y applying the rehabilitation Project model.

1. Conditions of the low watershed shore
Data of the water level (médium level of water in the high tide)

Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge capacity analysis

The current discharge capacity of the river was estimated based on the results of the river survey and applying the HEC-RAS method, which results appear in Figure 3.1.10-3. This Figure also shows the flooding flows of different return periods obtained by run-off analysis,, which allow evaluating in what points of the Cañete river watershed the inundation may happen and what magnitude of flood flow may they have.

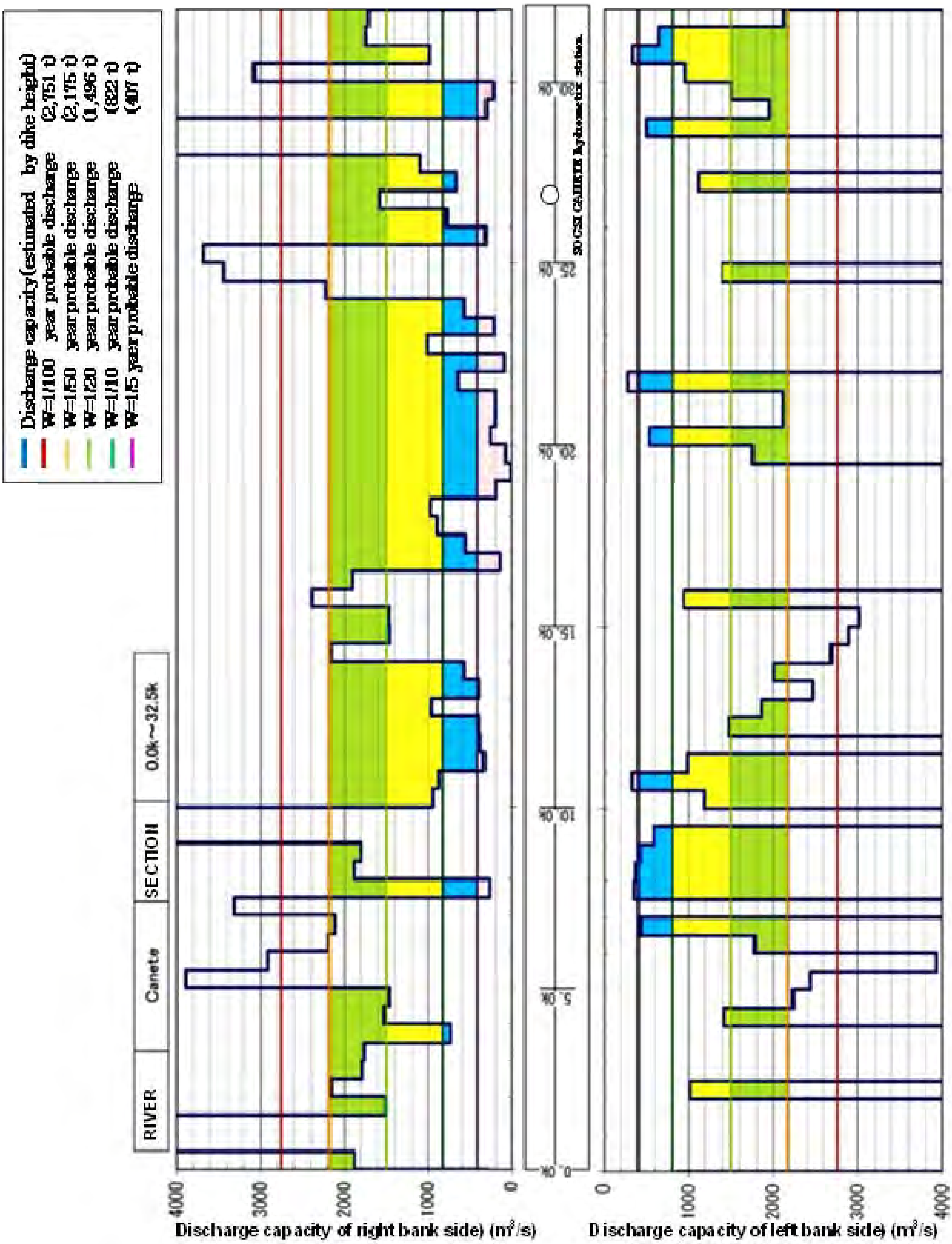


Figure 3.1.10-3 Current discharge capacity of cañete river

(4) Inundation area

As a reference, Figures 3.1.10-4 show the results of the inundation area calculation in the Cañete river watershed compared to the flooding flow with a 50 year return period.

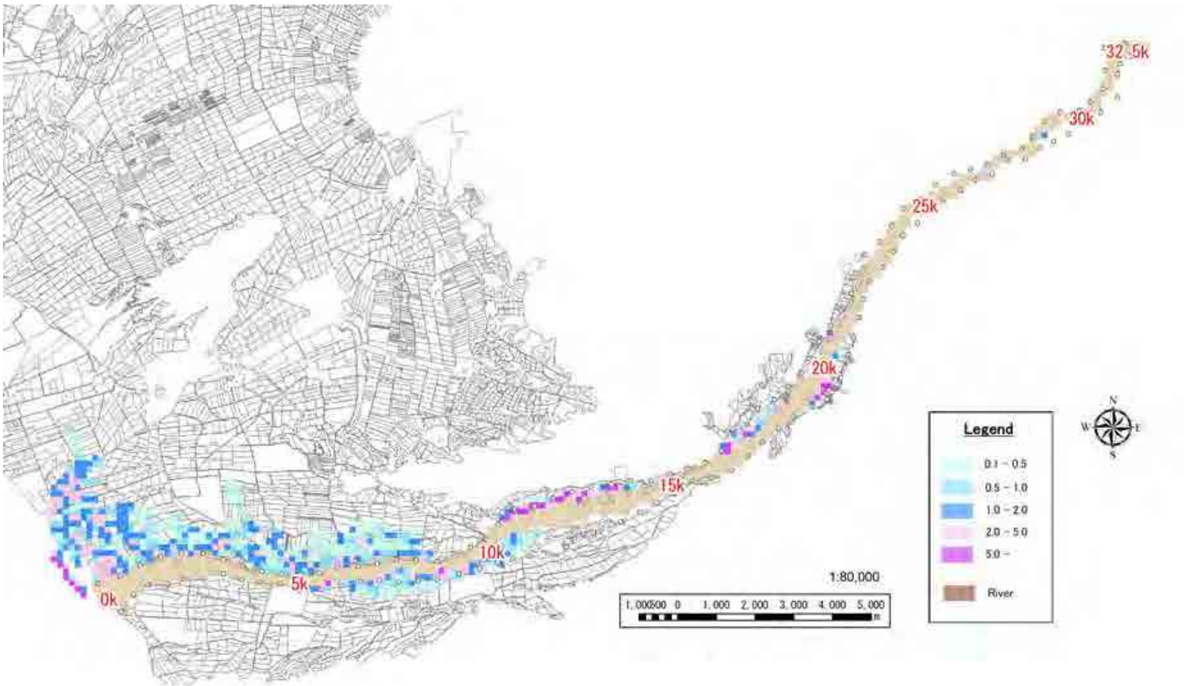


Figure 3.1.10-4 Inundation area of Cañete river (50 year period floods)

3.2 Definition of Problem and Causes

3.2.1 Problems of Flood Control Measures in the Study Area

Based on the results of the Cañete River, the main problem on flood control was identified, as well as the structures to be protected, which results are summarized in Table 3.2.1-1.

Table 3.2.1-1 Problems and conservation measures of flood control works

Problems		Overflowing			Dike erosion	Margins erosion	Non-working intake	Non-working derivation works
		Without dikes	Sediment in bed	Lack of width				
Structures to be protected	Agricultural lands	○	○	○	○	○	○	○
	Irrigation channels					○	○	
	Urban area	○		○				○
	Roads					○		
	Bridges		○					

3.2.2 Problem Causes

Next, the main problem and its direct and indirect causes for flood control in the Study Area are described:

(1) Main problem

Valleys and local communities highly vulnerable to floods

(2) Direct and indirect causes

Table 3.2.2-2 shows the direct and indirect causes of the main problem

Table 3.2.2-2 Direct and indirect causes of the main problem

Direct cause	1. Excessive flood flow	2. Overflowing	3.Insufficient maintenance of control works	4. Insufficient communitarian activities for flood control
Indirect causes	1.1 Frequent occurrence of extraordinary weather (El Niño, etc..)	2. Lack of flood control works	3.1 Lack of maintenance knowledge and skills	4.1 Lack of knowledge and flood prevention techniques
	1.2 Extraordinary rains in the middle and upper basins	2.2 Lack of resources for the construction of works	3.2 Lack of training in maintenance	4.2 Lack of training in flood prevention
	1.3 Vegetation cover almost zero in the middle and upper basins	2.3 Lack of plans for flood control in basins	3.3 Lack of dikes and margins repair	4.3 Lack of early warning system
	1.4 Excessive sediment dragging from the upper and middle river levee	2.4 Lack of dikes	3.4 Lack of repair works and referral making	4.4 Lack of monitoring and collection of hydrological data
	1.5 Reduction of hydraulic capacity of rivers by altering slopes, etc.	2.5 Lack of bed channel width	3.5 Use of illegal bed for agricultural purposes	

		2.6 Accumulation of sediments in beds	3.6 Lack of maintenance budget	
		2.7 Lack of width at the point of the bridge construction		
		2.8 Elevation of the bed at the point of the bridge construction		
		2.9 Erosion of dikes and margins		
		2.10 Lack of capacity for the design of the works		

3.2.3 Problem Effects

(1) Main problem

Valleys and local communities highly vulnerable to floods

(2) Direct and indirect effects

Table 3.2.3-1 shows the direct and indirect effects of the main problem

Table 3.2.3-1 Direct and indirect effects of the main problem

Direct Effects	1. Agriculture Damages	2. Direct damages to the community	3. Social infrastructure damages	4. Other economical damages
Indirect Effects	1.1 Agriculture and livestock damage	2.1 Private property and housing loss	3.1 Roads destruction	4.1 Traffic interruption
	1.2 Agricultural lands loss	2.2 Industries and facilities loss	3.2 Bridges loss	4.2 Flood and evacuations prevention costs
	1.3 Irrigation channels destruction	2.3 Human life loss and accidents	3.3 Running water, electricity, gas and communication infrastructures' damages	4.3 Reconstruction costs and emergency measures
	1.4 Work destruction and derivation	2.4 Commercial loss		4.4 Work loss by local inhabitants
	1.5 Dikes and margins erosion			4.5 Communities income reduction
				4.6 Life quality degradation
				4.7 Loss of economical dynamism

(3) Final effect

The main problem final effect is the community socio-economic impediment development of the affected area.

3.2.4 Causes and Effects Diagram

Figure 3.2.4-1 shows the causes and effects diagram done based on the above analysis results.

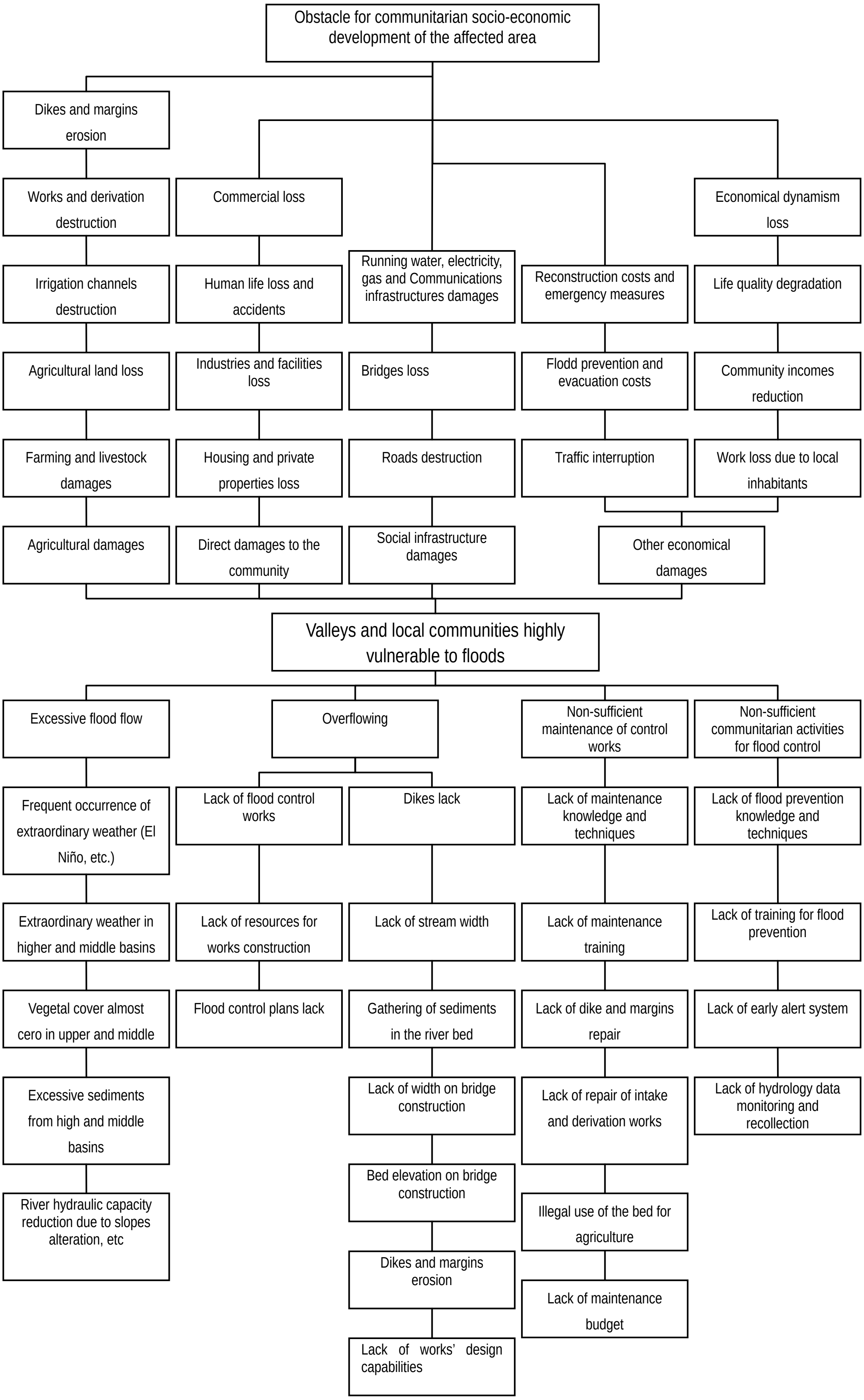


Figure 3.2.4-1 Causes and effects diagram

3.3 Objective of the Project

The final impact that the Project wants to achieve is to alleviate the vulnerability of valleys and local community to flooding and promote local economic development.

3.3.1 Solving Measures for the Main Problem

(1) Main objective

Soothe the valleys and local community to flooding vulnerability.

(2) Direct and indirect measures

In table 3.3.1-1, direct and indirect solutions measures for the problem are shown.

Table 3.3.1-1 Direct and indirect solution measures to the problem

Direct measures	1. Analyze and relieve excessive flood flow	2. Prevent overflow	3. Full compliance with maintenance of flood control works	4. Encourage community flood prevention
Indirect measures	1.1 Analyze extraordinary weather (El Niño, etc..)	2.1 Construct flood control works	3.1 Strengthen maintenance knowledge and skills	4.1 Strengthen knowledge and skills to prevent flooding
	1.2 Analyze extraordinary rainfall in the upper and middle basins	2.2 Provide resources for the works construction	3.2 Reinforce training maintenance	4.2 Running flood prevention training
	1.3 Planting vegetation on the upper and middle basins	2.3 Develop plans for flood control basins	3.3 Maintain and repair dikes and margins	4.3 Creating early warning system
	1.4 Relieve Excessive sediment entrainment from the upper and middle river dikes	2.4 Build dikes	3.4 Repair intake and derivation works	4.4 Strengthen monitoring and water data collection
	1.5 Take steps to alleviate the reduction in hydraulic capacity of rivers by altering slopes, etc.	2.5 Extends the width of the channel	3.5 Control the illegal use of bed for agricultural purposes	
		2.6 Excavation of bed	3.6 Increase the maintenance budget	
		2.7 Extending the river at the bridge's construction		
		2.8 Dredging at the point of the bridge construction		
		2.9 Control dikes and margins erosion		
		2.10 Strengthen the capacity for works design		

3.3.2 Expected Impacts for the Main's Objective Fulfillment

(1) Final impact

The final impact that the Project wants to achieve is to alleviate the vulnerability of the valleys and the local community to floods and promoting local socio-economic development.

(2) Direct and indirect impacts

In table 3.3.2-1 direct and indirect impacts expected to fulfill the main objective to achieve the final impact are shown.

Table 3.3.2-1 direct and indirect impacts

Direct Impacts	1. Agricultural damage relief	2. Relief of direct harm to the community	3. Relief of social infrastructure damage	4. Relief of other economic damage
Indirect Impacts	1.1 Relief to crops and livestock damage	2.1 Housing and private properties loss prevention	3.1 Road destruction prevention	4.1 Traffic interruption prevention
	1.2 Relief for farmland loss	2.2 Prevention of Industries and facilities establishments	3.2 Prevention of bridges loss	4.2 Reducing costs of flood prevention and evacuation
	1.3 Prevention of the destruction of irrigation channels	2.3 Prevention of accidents and human life loss	3.3 Running water, electricity, gas and communication infrastructures' relief	4.3 Cost reduction of the reconstruction and emergency measures
	1.4 Prevention of destruction works of intake and derivation	2.4 Commercial loss relief		4.4 Increase of local community hiring
	1.5 Dikes and margins erosion relief			4.5 Community income increase
				4.6 Life quality improvement
				4.7 Economic activities development

3.3.3 Measures - Objectives – Impacts Diagram

In Figure 3.3.3-1 the measures - objectives – impacts diagram is shown.

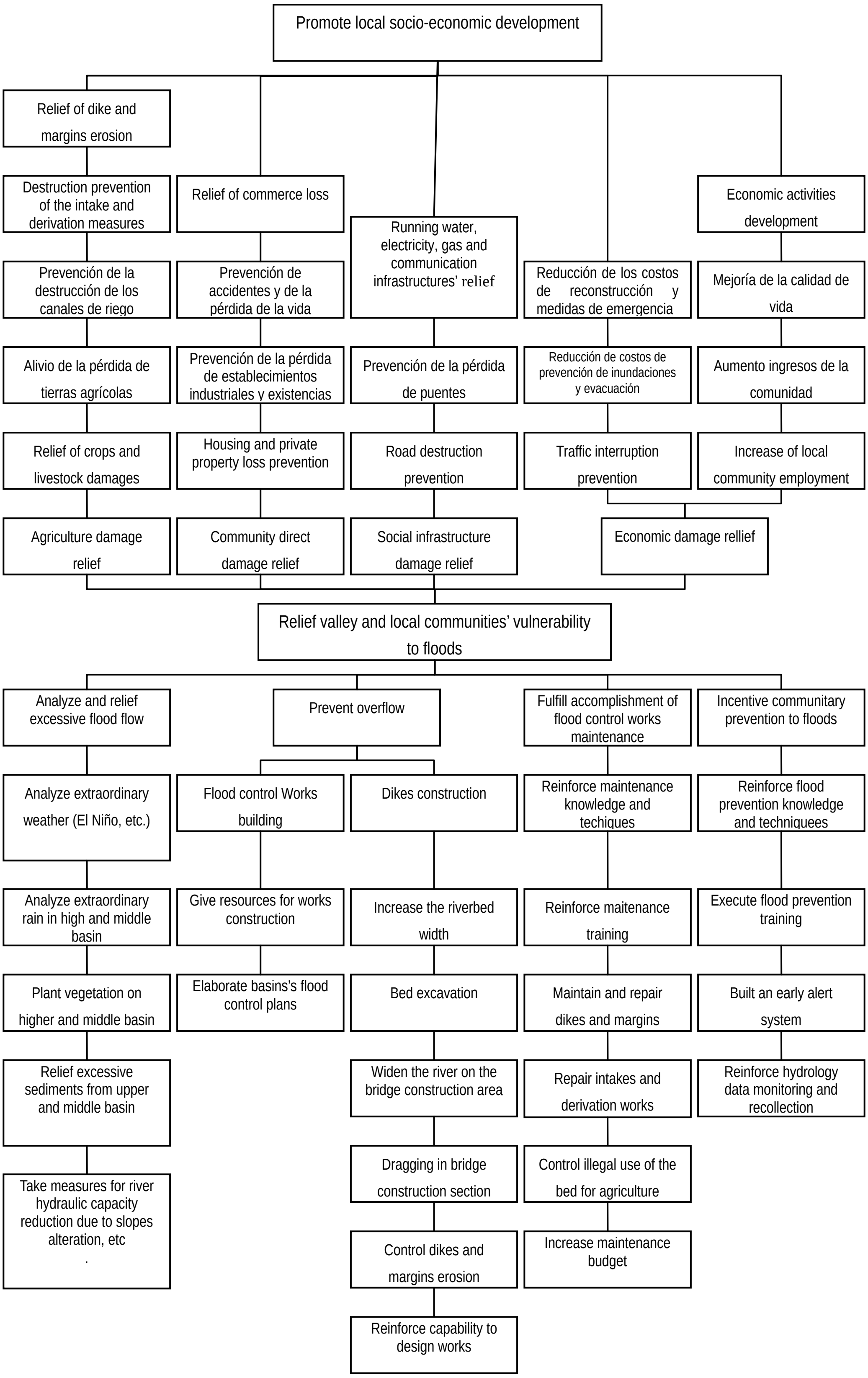


Figure 3.3.3-1 Measures - objectives – impacts diagram

4. FORMULATION AND EVALUATION

4.1 Definition of the Assessment Horizon of the Project

The Project’s assessment horizon will be of 15 years, same as the one applied on the Program Profile Report. The Annex-10 of SNIP regulation stipulates that the assessment horizon should be basically 10 years; however the period can be changed in case that the project formulator (DGIH in this Project) admits the necessity of change. DGIH adopted 15 years in the Program Profile Report and OPI and DGPM approved it in March 19, 2010. In JICA’s development study it should be generally 50 years, so the JICA Study Team inquired on the appropriate period to DGIH and OPI, they directed JICA Study Team to adopt 15 years. And the social evaluation in case of 50 years assessment horizon is described in Annex-14 Implementation Program of Japanese Yen Loan Project.

4.2 Supply and Demand Analysis

The theoretical water level was calculated considering flowing design flood discharge based on river cross sectional survey executed with a 500m interval, in each Watershed, considering a flood discharge with a return period of 50 years. Afterwards, the dike height was determined as the sum of the design water level plus the freeboard of dike.

This is the dike height required to prevent damages caused by design floods and represents the local community demand indicator.

The height of the existing dike or the height of the present ground is that required to prevent present flood damages, and represents the present supply indicator.

The difference between the design dike (demand) and the height of the present dike or ground represents the difference or gap between demand and supply.

Table 4.2-1 shows the averages of flood water level calculated with a return period of 50 years in “3.1.9 Run-off Analysis”; of the required dike height (demand) to control the discharge adding the design water level plus the freeboard dike; the dike height or that of the present ground (supply), and the difference between these last two (difference between demand-supply) of the river. Then, Table 4.2-2 shows the values of each point in Cañete river. The dike height or that of the present ground is greater than the required dike height, at certain points. In these, the difference between supply and demand was considered null.

Table 4.2-1 Watershed demand and supply

Watershed	Present Height of Embankment or Ground (supply)		Flood Water Level of 1/50 year Probability	Freeboard of Embankment	Required Height of Embankment (demand)	Supply and Demand Gap	
	Left Bank	Right Bank				Left Bank	Right Bank
	①	②	③	④	⑤=③+④	⑥=⑤-①	⑦=⑤-②
Cañete	188.40	184.10	184.77	1.20	185.97	1.18	2.03

Table 4.2-2 Demand and supply according to the calculation (Cañete river)

Watershed	Dike Height / current land (supply)		Water level with return period of 50 years	Dike Freeboard	Required dike's heigth (demand)	Diff. demand/supply	
	Left margin	Right margin				Left margin	Right margin
	①	②	③	④	⑤=③+④	⑥=⑤-①	⑦=⑤-②
0.0	3.04	2.42	3.88	1.20	5.08	2.04	2.66
0.5	10.85	6.43	6.69	1.20	7.89	0.00	1.46
1.0	19.26	15.46	11.66	1.20	12.86	0.00	0.00
1.5	23.14	22.02	18.55	1.20	19.75	0.00	0.00
2.0	28.54	24.14	24.47	1.20	25.67	0.00	1.53
2.5	29.77	30.43	30.42	1.20	31.62	1.85	1.19
3.0	39.57	36.32	36.54	1.20	37.74	0.00	1.42
3.5	44.29	41.17	41.52	1.20	42.72	0.00	1.55
4.0	50.87	44.51	45.90	1.20	47.10	0.00	2.59
4.5	50.77	50.90	51.48	1.20	52.68	1.91	1.78
5.0	56.72	55.97	56.70	1.20	57.90	1.18	1.93
5.5	61.60	62.63	61.30	1.20	62.50	0.90	0.00
6.0	67.94	67.29	66.75	1.20	67.95	0.01	0.66
6.5	71.98	72.26	72.21	1.20	73.41	1.43	1.15
7.0	75.91	77.89	77.87	1.20	79.07	3.16	1.18
7.5	84.54	83.93	83.14	1.20	84.34	0.00	0.41
8.0	87.14	86.94	89.24	1.20	90.44	3.30	3.50
8.5	92.88	94.92	95.12	1.20	96.32	3.44	1.40
9.0	97.59	99.58	99.95	1.20	101.15	3.55	1.57
9.5	103.52	106.09	104.87	1.20	106.07	2.55	0.00
10.0	113.17	112.15	110.18	1.20	111.38	0.00	0.00
10.5	115.92	115.66	116.69	1.20	117.89	1.97	2.23
11.0	120.02	120.74	121.86	1.20	123.06	3.04	2.32
11.5	126.04	125.46	126.55	1.20	127.75	1.71	2.29
12.0	133.58	131.61	132.64	1.20	133.84	0.26	2.23
12.5	138.25	137.29	138.65	1.20	139.85	1.60	2.56
13.0	144.87	144.19	145.04	1.20	146.24	1.37	2.05
13.5	151.37	149.50	151.14	1.20	152.34	0.97	2.84
14.0	157.25	155.68	157.32	1.20	158.52	1.27	2.84
14.5	163.04	162.65	162.70	1.20	163.90	0.85	1.24
15.0	169.07	168.02	168.53	1.20	169.73	0.66	1.71
15.5	174.33	173.29	173.80	1.20	175.00	0.67	1.71
16.0	178.76	179.67	179.56	1.20	180.76	2.00	1.09
16.5	189.69	184.90	185.00	1.20	186.20	0.00	1.30
17.0	198.92	190.23	192.31	1.20	193.51	0.00	3.28
17.5	204.00	196.35	198.05	1.20	199.25	0.00	2.90
18.0	208.64	202.64	203.68	1.20	204.88	0.00	2.24
18.5	216.02	208.07	208.90	1.20	210.10	0.00	2.03
19.0	231.58	214.00	215.17	1.20	216.37	0.00	2.37
19.5	234.50	219.81	221.58	1.20	222.78	0.00	2.97
20.0	227.59	225.71	227.83	1.20	229.03	1.44	3.32
20.5	232.17	231.84	233.16	1.20	234.36	2.19	2.51
21.0	239.69	238.14	239.70	1.20	240.90	1.21	2.76
21.5	243.75	244.32	245.70	1.20	246.90	3.15	2.58

22.0	258.48	248.71	251.12	1.20	252.32	0.00	3.61
22.5	261.54	255.90	256.70	1.20	257.90	0.00	2.00
23.0	277.79	260.72	263.17	1.20	264.37	0.00	3.65
23.5	286.32	266.55	268.34	1.20	269.54	0.00	2.99
24.0	293.96	274.25	274.19	1.20	275.39	0.00	1.14
24.5	279.29	280.51	279.73	1.20	280.93	1.64	0.42
25.0	305.10	286.83	285.94	1.20	287.14	0.00	0.31
25.5	310.22	289.46	291.96	1.20	293.16	0.00	3.70
26.0	317.26	295.71	297.32	1.20	298.52	0.00	2.81
26.5	307.24	302.64	303.34	1.20	304.54	0.00	1.90
27.0	307.18	306.25	308.61	1.20	309.81	2.64	3.56
27.5	335.69	311.92	313.47	1.20	314.67	0.00	2.75
28.0	342.51	321.75	317.21	1.20	318.41	0.00	0.00
28.5	323.24	329.22	326.63	1.20	327.83	4.59	0.00
29.0	331.04	327.61	331.31	1.20	332.51	1.47	4.90
29.5	335.86	332.81	336.85	1.20	338.05	2.19	5.25
30.0	340.36	343.00	341.99	1.20	343.19	2.83	0.19
30.5	346.28	347.78	349.42	1.20	350.62	4.33	2.84
31.0	352.37	355.00	355.54	1.20	356.74	4.38	1.74
31.5	363.03	362.32	363.14	1.20	364.34	1.31	2.02
32.0	372.35	365.18	368.39	1.20	369.59	0.00	4.41
32.5	375.30	373.38	376.70	1.20	377.90	2.60	4.52
Average	188.40	184.10	184.77	1.20	185.97	1.18	2.03

4.3 Technical Planning

4.3.1 Structural Measures

As structural measures it was necessary to prepare a flood control plan for the whole Watershed. The later section 4.15 “Medium and Long Term Plan” and 4.15.1 “General Flood Control Plan” details results on the analysis. This plan proposes the construction of dikes for flood control in the entire Watershed. However, in the case of the Watershed of Cañete river, a big project needs to be set up investing very high costs, far beyond those considered in the budget of the present Project, what makes it difficult to take this proposal. Therefore, supposing the flood control dikes in the whole Watershed are built progressively within a medium and long term plan, they would be focused on the study of more urgent and priority works for flood control.

(1) Design flood discharge

1) Guideline for flood control in Peru

The Methodological Guide for Projects on Protection and/or Flood Control in Agricultural or Urban Areas prepared by the Public Sector Multiannual Programming General Direction (DGPM) (present DGPI) of the Economy and Finance Ministry (MEF) recommends to carry out the comparative analysis of different return periods: 25 years, 50 years and 100 years for the urban area, and 10 years, 25 years and 50 years for rural area and agricultural lands.

Considering that the present Project is focused on the protection of rural and agricultural areas, the design flood discharge should be the discharge with return period of 10year to 50-year.

2) Maximum discharge in the past and design flood discharge

The yearly maximum discharge in Cañete river is as shown in Figure-4.3.1. Based on the figure, the maximum discharge in the past can be extracted as shown in the Table- 4.3.1-1 together with the flood discharges with different return periods.

The maximum discharge in the past in Cañete river is 900 m3/sec, which seems to be the maximum possible observation data in Socsi station as described in 3.1.9.5(2) and less than probable flood of 2,175 m3/sec with return period of 50 years, the latter is to be adopted design as the design discharge according to the guideline described in the above 1).

Table - 4.3.1-1 Flood discharge with different return period (m^3/sec)

Watershed	2-year	10-year	25-year	50-year	100-year	Max. in the Past
Cañete	331	822	1,496	2,175	2,751	900

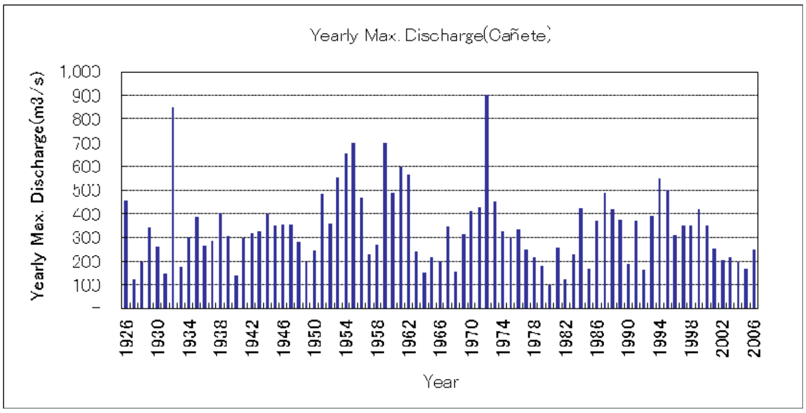


Figure- 4.3.1-1 Yearly max. discharge (Cañete)

3) Relation among probable flood, damage and inundation area

The relation among probable flood, Damage and inundation area in Cañete river are shown in the Figure-4.3.1-2. Based on the figures the following facts can be expressed.

① The more increase probable flood discharge, the more increase inundation area (green line in the figure).

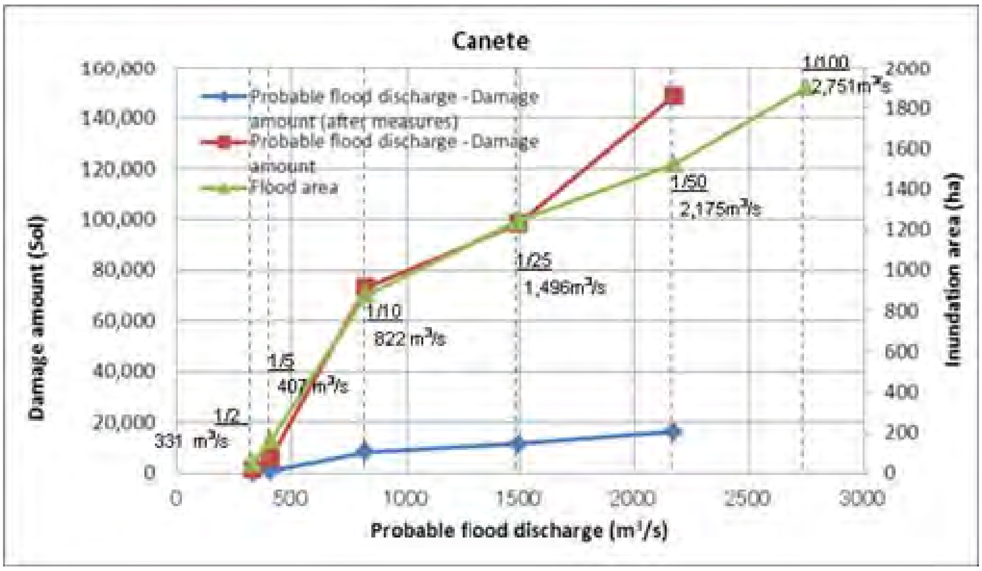
② The more increase probable flood discharge, the more increase damage (red line in the figure).

③ According to increase of probable flood discharge, the damage with project increase gently (blue line in the figure).

④ According to increase of probable flood discharge, damage reduction (difference between red line and blue line) increase steadily, and it reaches maximum at the probable flood of 50- year within the scope of study.

The damage reduction amount in the design discharge is largest among the probable flood discharge less than with return period of 50-year, and economic viability of the design flood is confirmed.

Although the design discharge is the flood with return period of 50-year, the inundation area of the flood with return period of 100-year is described in the figures.



Figure－4.3.1-2 Probable flood discharge, damage amount and inundation area (Cañete river)

(2) Topographical survey

The topographical survey was carried out in selected places for the execution of structural measurements (Table 4.3.1-2). The preliminary design of control works was based on these topographical survey results.

Table 4.3.1-2 Summary of topographical survey

River	Location (No.)	Installations	Topo lift.	Transversal Lifting (S=1/200)		
			(ha)	Line No.	Middle length (m)	Total length (m)
Cañete	Ca-1	Dike & excavation	20.0	11	200.0	2,200
	Ca-2	Dike	6.0	13	50.0	650
	Ca-3	Dike & excavation	50.0	11	500.0	5,500
	Ca-4	Reservoir	15.0	6	300.0	1,800
	Ca-5	Dike	3.8	9	50.0	450
Total			94.8	50		10,600

(3) Selection of flood protection works with high priority

1) Basic guidelines

For the selection of priority flood control works, the following elements were considered:

- Local community demand (based on historic flood damages)
- Lack of hydraulic capacity (including stretches affected by undermining)
- Conditions of adjacent areas (conditions of the urban area, arable lands, etc.)

- Flood conditions (overflow extension according to flood analysis results)
- Social and environmental conditions (important local installations, etc.)

An overall assessment was carried on of the five before mentioned elements taking into consideration the results on the river uplift, land study, assessment of the hydraulic capacity, overflow analysis, interviews (to irrigator commissions, local authorities, historic data on flood damages, etc.) and they selected those places where priority flood control works should be executed (spots with greater score as a result of the overall assessment).

Specifically, given that the river survey, the discharge capacity assessment and the overflow analysis have been carried out within of 500 meters intervals (section), the overall assessment was also carried out within 500 meter stretches. These stretches were evaluated at scales of 1 to 3 (0 point, 1 point, 2 points), and those stretches whose sum surpassed 6 points were selected as priority ones. The inner limit (6 points) has been established taking also into account the general Project available budget. Table 4.3.1-3 details evaluated aspects and assessment criteria.

Table 4.3.1-3 Assessment aspects and criteria

Assessment Aspects	Description	AssessmentCriteria
Demand of local population	● Flood damages in the past ● Demand of local population and producers	・Stretches with big floods in the past and with great demand from local community (2 points) ・Demand of local population (1 point)
Lack of river hydraulic capacity (undermined stretches)	● Chance of river overflow given the lack of hydraulic capacity ● Chance of dike collapse due to undermining	・Stretches with hydraulic capacity particularly reduced (that overflow with rise with return period of 10 years or less) (2 points) ・Stretches with reduced hydraulic capacity (return period of less than 25 years) (1 point)
Conditions of surrounding areas	● Large arable lands, etc. ● Urban area, etc. ● Assessment of lands and infrastructure close to the river.	・Stretches with large arable lands (2 points) ・Stretches with arable lands mixed with towns, or big urban area (2 points) ・ Same configuration as the previous one, with shorter scale (1 point)
Overflow conditions	● Overflow magnitude	・Where overflow extends on vast surfaces (2 points) ・Where overflow is limited to a determined area (1 point)
Socio-environmental conditions (important structures)	● Intake of the irrigation system, drinking water, etc. ● Bridges and main roads (Carretera Panamericana, etc.)	・Where there are important infrastructures for the area (2 points) Where there are important infrastructures (but less than the first ones) for the area (regional roads, little intakes, etc.) (1 point)

2) Selection results

Figure 4.3.1-3 details assessment results of each stretch of the river, as well as the selection results of flood control priority works.

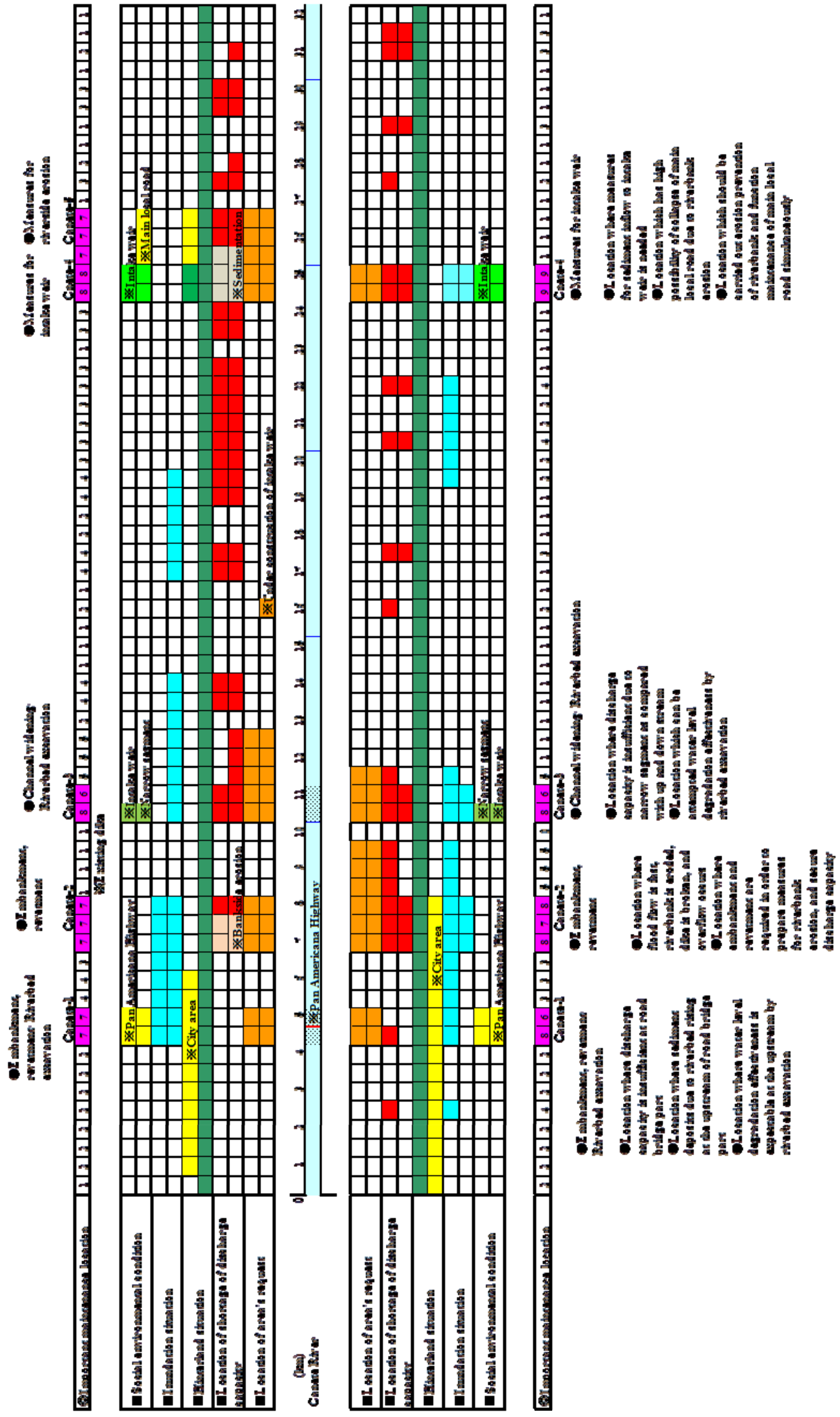


Figure 4.3.1-3 Selection results of prioritized flood protection works in Cañete river

3) Basis of selection

Cañete river has narrow sections at the main bridges and intake at the downstream of 10 km from the river mouth, and upstream of which the inundation is apt to occur. The inundation spreads widely to the right bank side causing big damage, although the inundation upstream of 10 km is limited to nearby crop areas. Therefore the embankment and bank protection in the lower section of 10 km, which has large damage potential, is to be implemented with priority securing the discharge capacity at narrow sections.

And upstream of Cañete river there is tourist area due to rich water flow and short access from Lima. In order to keep short access to the area, the conservation of principal regional road are important from view point of regional economic activities, so that the bank protection work for scouring is also selected as flood prevention work.

At the Pan-American road the river width is narrowed, so that the widening the river width with building new bridge is considered, however taking account of the large traffic volume, necessity of access road to the bridge causing large cost, and that DGIH judged that the construction of new bridge is difficult for demarcation of administrative responsibility among Ministries, the construction of new bridge is not adopted in this Project.

Table-4.3.1-4 Basis of Selection for flood protection work (Cañete river）

No	Location	Basis of Selection
①	km4,0-km5,0 (right bank) + (riverbed partial excavation)	This section is one of the sections with less discharge capacity of the Cañete River lower watershed, where the Pan American Road's Bridge is built. In the flood caused by El niño phenomena, daming up of flow occurred and inundated in this section. Since it is impossible to rebuilt the bridge, the dike's height is required to be elevated on the right bank and dredge part of the riverbed crossing the bridge to increase discharge capacity [Characteristics of the section] ●Narrow section (where the bridge is) in which the discharge capacity is reduced ●Section in which damming up of flow occurs and sediments deposited due to the narrowness ●Section in which the water level can be reduced by the riverbed excavation [Elements to be protected] ○ Great agricultural lands that are downstream [Method of Protection] ▼Inundation occurs at the flood with return period of 10-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼In order to secure discharge capacity, the embankment and bank protection work in the section in which the embankment height is insufficient are built utilizing existing embankment as well as riverbed excavation.
②	km6,5-km8,1 (both banks)	Erosion of the right bank caused by former flooding has provoked dike's destruction, leaving great damage. Likewise, due to the reduced discharge capacity, it is considered as a section in which a dike and bank protection must be built to protect banks erosion and maintain the necessary discharge capacity On the lower reach (between the mouth and km 10) the inundation extends to the right bank side causing more damage, inundation extends to the left bank side also, flooding agricultural land, but in less magnitude that on the right

		bank. The flooded area is bigger than the upper section. [Characteristics of the section] ●Section where the discharge capacity is lowest in the lower reach of Cañete river ●Section where flood flow is fast, causing banks erosion, dike's destruction and inundation ●Section where a dike has to be built to prevent bank erosion and keep the necessary discharge capacity [Elements to be protected] ○Agricultural lands of both banks [Method of Protection] ▼Inundation occurs at the flood with return period of 10-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼In order to secure discharge capacity, the embankment and bank protection work in the section in which the embankment height is insufficient are built utilizing existing embankment as well as riverbed excavation (effective use of existing dike at right bank side).
③	km10.0-km11.0 (widening river width on left bank)	The intake weir formulates the narrow section at this section, which causes the rise of water level and inundation at the upstream of this section. The most damage occurs to the crop land in this section among the sections from 10km towards upstream, therefore widening river and excavation of riverbed is required. And the upstream discharge capacity can be increased by lowering water level. [Characteristics of the section] ●Section where the intake has to be protected ●Narrow section with insufficient discharge capacity compared to the upstream and downstream sections ●Section where scouring performance will reduce the water level of the superior section [Elements to be protected] ○Intake ○Left bank agricultural lands [Method of Protection] ▼This intake is the most important in the river. If the intake function is damaged, the influence to the region is very heavy, therefore the intake is to be safe in case of El niño flood (equal to flood with return period of 50-year) ▼Widening river width so that the flood dose not concentrate to the intake.
④	km24.25-km24.75 (widening river width on left bank)	In this section, the intake is constructed. In the past flood in El niño phenomena the water could not take for more than one month. At present the sediment deposits in every flooding so that the maintenance works such as excavation etc. are required to maintain the function of intake. In future if the big flood occurs, the function of the intake will be lost and the large influence will be given to the crop land. The diversion work is required to distribute water adequately.

		[Characteristics of the section] ●Section where sediment inflow control to the entrance of the intake is required. [Elements to be protected] ○Intake [Method of Protection] ▼This intake is the most important in the river. If the intake function is damaged, the influence to the region is very heavy, therefore the intake is to be safe in case of El niño flood (equal to flood with return period of 50-year) ▼Protection work utilizing present river characteristics.
⑤	km24.75-km26.5 (right bank)	The banks have been eroded due to former flooding and their impact has reached the regional roads. It is urgent to take adequate measures, if not, the road will be destroyed and this will affect local economy [Characteristics of the section] ●Section where the bank's erosion may cause regional road destruction ●Section in which banks erosion control works and regional roads functioning conservation works have to be done simultaneously [Elements to be protected] ○Right bank regional road [Method of Protection] ▼Since the destruction of regional road affects regional economy, very much,the road is to be safe in case of El niño flood (equal to flood with return period of 50-year) ▼The protection of road only is one solution, however together with that, the protection work for smooth flowing down of flood is required because the agricultural land at right bank is low and feared to be eroded and affect the road.

(4) **Location of prioritized flood control works**

Figure 4.3.1-4 shows the location of priority works on flood control in the Cañete Watershed, and The Table 4.3.1-5 shows the summary of the priority works.

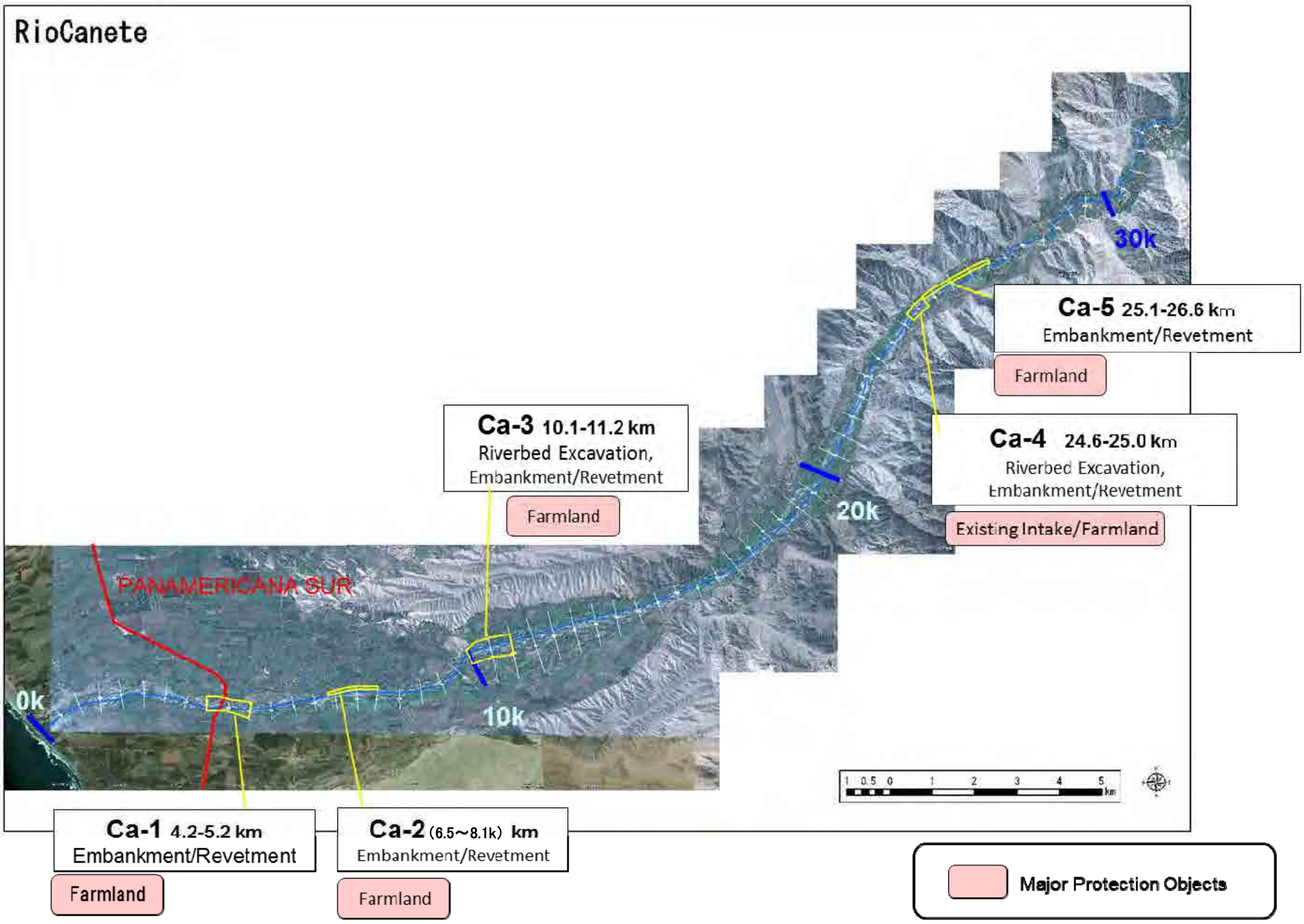


Figure 4.3.1-4 Priority Works on flood control in the Cañete river

Table 4.3.1-5 Summary of priority works

River	Location		Critical Point	Main Protection Objects	Measure	Feature of Work	
Rio Canete	Ca-1	4..2-5.2 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length Bank Protection Large Boulder Riplap	1,100 m 5,430 m3 9,230 m3
	Ca-2	6.7～8.3 km	Innnuded Point		Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	3,200 m 113,700 m3 28,200 m3
	Ca-3	10.1-11.2 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=700 m, V=80,270m3 1,630 m 16,730 m3
	Ca-4	24.6-25.0 km	Existing Intake Weir (w:150m, i: 1:2, crest w:2.0m)	Intake Weir, Agricultural Lands	Riverbed excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=370 m, V=34,400 m3 L=710m, V=20,150 m3 7,300 m3
	Ca-5	25.1-26.6 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	1,520 m 95,125 m3 14,000 m3

(5) Standard section of the dike

1) Width of the crown

The width of the dike crown was defined in 4 meters, considering the dike stability when facing design overflows, width of the existing dike, and width of the access road or that of local communication.

2) Dike structure

The dike structure has been designed empirically, taking into account historic disasters, soil condition, condition of surrounding areas, etc.

Dikes are made of soil in all the Watersheds. Although there is a difference in its structure varying from area to area, this can be summarized as follows, based on the information given by the administrators interviewed:

① The gradient of the slope is mainly 1:2 (vertical: horizontal relationship); the form may vary depending on rivers and areas.

② Dike materials are obtained from the river bed in the area. Generally these are made of sand/gravel ～sandy soil with gravel, of reduced plasticity. As to the resistance of the materials, we cannot expect cohesiveness.

③ The Watershed of the Cañete River is made of loamy soil with varied pebble, relatively compacted.

④ The lower stretch of the Sullana weir of the Chira River is made of sandy soil mixed with silt. Dikes have been designed with a "zonal-type" structure where material with low permeability is placed on the riverside of the dike and the river; material with high permeability is placed on landside of the dike. However, given the difficulty to obtain material with low permeability, it has been noticed that there is lack of rigorous control of grain size distribution in supervision of construction.

⑤ When studying the damaged sections, significant differences were not found in dike material or in the soil between broken and unbroken dike. Therefore, the main cause of destruction has been water overflow.

⑥ There are groins in the Chira and Cañete rivers, and many of them are destroyed. These are made of big rocks, with filler material of sand and soil in some cases, what may suggest that destruction must been caused by loss of filler material.

⑦ There are protection works of banks made of big rocks in the mouth of the Pisco River. This structure is extremely resistant according to the administrator. Material has been obtained from quarries, 10 km. away from the site.

Therefore, the dike should have the following structure.

① Dikes will be made of material available in the zone (river bed or banks). In this case, the material would be sand and gravel or sandy soil with gravel, of high permeability. The stability problems forecasted in this case are as follows.

i) Infiltrate destruction caused by piping due to washing away fine material

ii) Sliding destruction of slope due to infiltrate pressure

In order to secure the stability of dike the appropriate standard section should be determined by infiltration analysis and stability analysis for sliding based on unit weight, strength and permeability of embankment material.

② The gradient of the slope of the dike will be between 30º ～35º (angle of internal friction) if the material to be used is sandy soil with low cohesiveness. The stable gradient of the slope of an embankment executed with material with low cohesiveness is determined as: tanθ=tanφ/n (where “θ” is gradient of the slope; “φ” is angle of internal friction and “n” is 1.5 ,safety factor).

The stable slope required for an angle of internal friction of 30° is determined as: V:H=1:2.6 (tanθ=0.385).

Taking into consideration this theoretical value, a gradient of the slope of 1:3.0 was considered, with more gentle inclination than the existing dikes, considering the results of the discharge analysis, the prolonged time of the design flood discharge (more than 24 hours), the fact that most of the dikes with slope of 1:2 have been destroyed, and the relative resistance in case of overflow due to unusual flooding.

The infiltration analysis and stability analysis of dike based on the soil investigation and martial tests are not performed in this Study so that the slope is determined by simple stability analysis assuming the strength factors of dike material estimated by field survey of material and by adding some safety allowance.

And the slope of dike in Japan is generally 1:2.0 in minimum, however the average slope will be more than 1:3.0 because the dike has several steps in every interval of 2m~3m of height.

③ The dike slope by the riverside must be protected for it must support a fast water flow given the quite steep slope of the riverbed. This protection will be executed using big stones or big rocks easily to get in the area, given that it is difficult to get connected concrete blocks .

The size of the material was determined between 30cm and 1m of diameter, with a minimum protection thickness of 1m, although these values will be determined based on flow speed of each river.

④ The penetration depth to bank protection is to be i) difference height between the deepest riverbed in the past and present riverbed or ii) empirical depth (0.5m~1.5m in Japan), the former is u certain without chronological riverbed fluctuation data, therefore according to the latter the depth is to be 1.75m referring to the river channel improvement section in Ica river

⑤ Heightening Method of Dike

The heightening length of existing dike is 1.0 km among the total length of dike construction of 7.7 km in Cañete.

The heightening method of dike is basically an overall enlargement type due to the following reasons and the alignment of dike accords with the one of exiting dike.

i) The heightening method of widening dike in riverside decreases river width so that the discharge capacity is reduced resulting in raising height of dike more than the other methods.

ii) The heightening method of widening dike in land side requires more land acquisition. It is desirable that the land acquisition is to be reduced as much as possible because the land is mainly important agricultural land of expensive.

iii) Although the workmanship of dike construction such as the compaction condition and material characteristics are unknown, the existing dike is to be utilized because the dike has been functioned in the past flooding, and the heightening method of overall enlargement type is to be applied, in which the existing dike is covered by the new dike with high strength, and can secure the safety and be economical with less land acquisition.

On the other hand, in the section with the narrow river width and river channel near to the dike, the heightening method of widening dike in land side is applied, in this case the riverside slope is protected with revetment.

3) Freeboard of the dike

The dike is made of soil material, and as such, it generally turns to be an weak structure when facing overflow. Therefore, it is necessary to prevent water overflow, to a lower water rise than the design discharge. So it is necessary to keep a determined freeboard when facing a possible increase in water level caused by the waves by the wind during water rise, tidal, hydraulic jump, etc. Likewise, it is necessary that the dikes have sufficient height to guarantee safety in surveillance activities and flood protection work , removal of logs and other carryback material, etc.

Table 4.3.1-6 shows guidelines applied in Japan regarding freeboard. Although in Peru there is a norm on freeboard, it has been decided to apply the norms applied in Japan, considering that rivers in both countries are alike.

Table-4.3.1-6 Design discharge and freeboard

Design discharge	Freeboard
Less than 200 m^3/s	0.6m
More than 200 m^3/s, less than500 m^3/s	0.8m
More than 500 m^3/s, less than 2,000 m^3/s	1.0 m
More than 2,000 m^3/s, less than 5,000 m^3/s	1.2 m
More than 5,000 m^3/s, less than10,000 m^3/s	1.5 m
More than 10,000 m^3/s	2.0 m

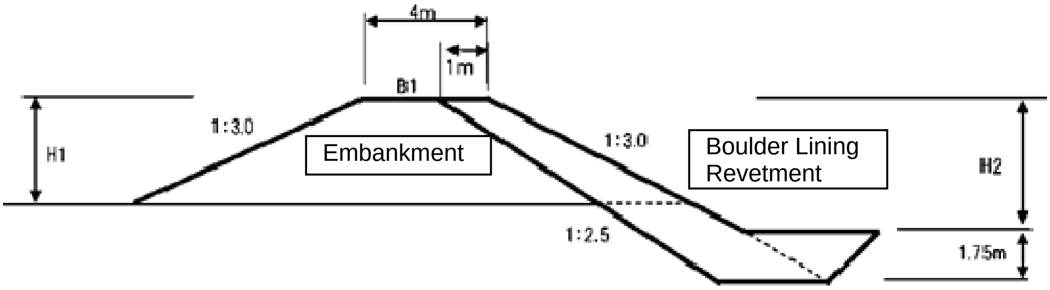


Figure 4.3.1-5 Standard dike section

4) Importance in Construction Work

The importance in dike construction is sufficient compaction of dike material. The cost estimate standard in Peru the compaction is to be made by tractor; however for the sufficient compaction it is desirable to use compaction equipment such as vibration roller etc.

And in order to supervise the compaction of material, the density test and grain size analysis are important, of which are specified in the technical specification of the tender document.

(6) Effect of flood prevention facilities

The discharge capacity of each river is enlarged up to the flood discharge with return period of 50-year by construction of the flood prevention facilities as shown in the Figure-4.3.1-6, and the inundation area is reduced remarkably.

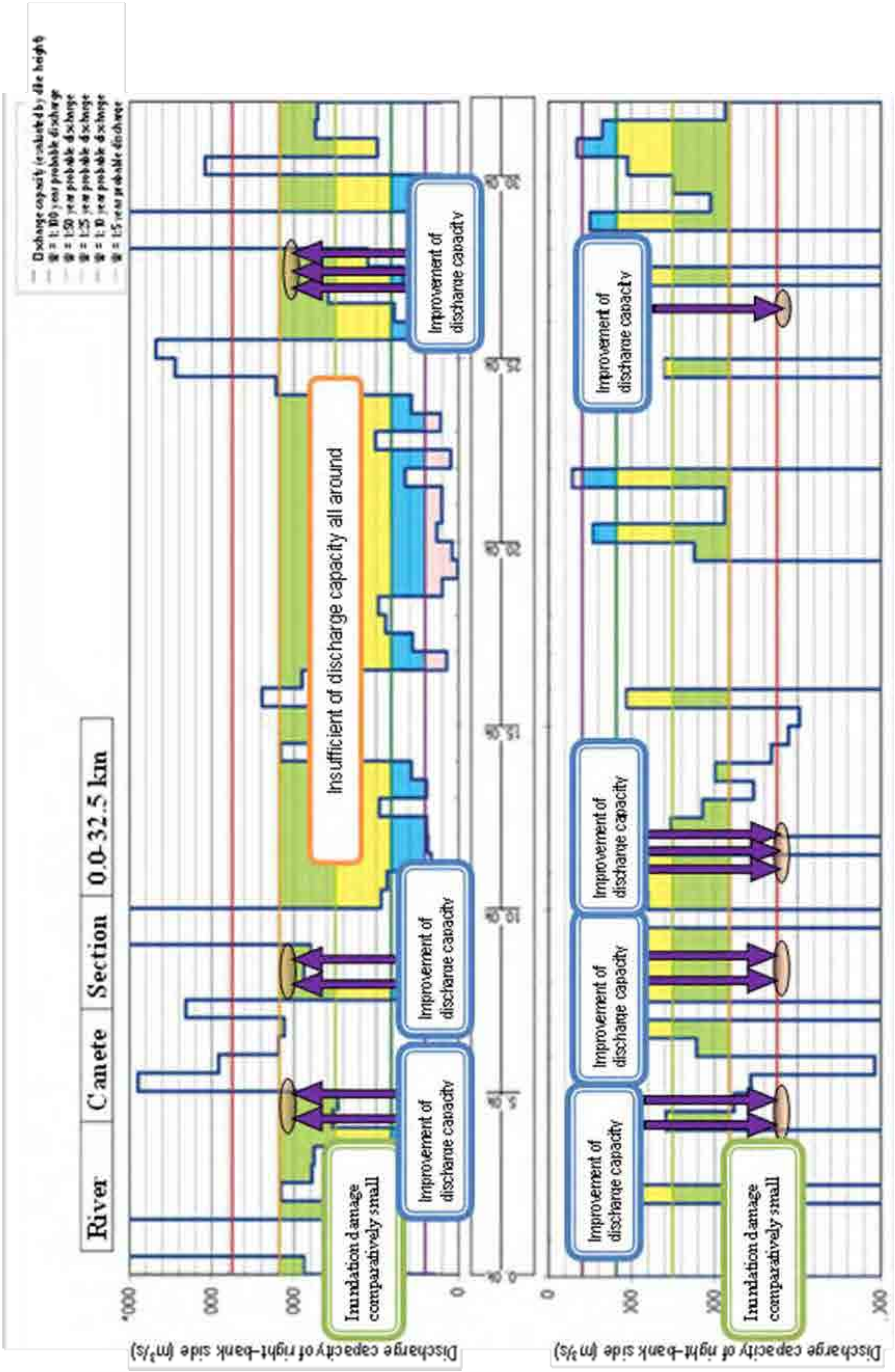


Figure-4.3.1-6 Effect of flood prevention facilities（Rio Cañete）

4.3.2 Nonstructural Measures

4.3.2.1 Reforestation and Vegetation Recovery

(1) Basic policies

The Reforestation and Vegetation Recovery Plan satisfying the goal of the present Project can be classified in: i) reforestation along fluvial works; and ii) reforestation in the high Watershed. The first one contributes directly to flood control and expresses its effect in short time. The second one demands a huge investment and an extended time, as detailed in the later section 4.15 "Medium and long term Plan", 4.15.2 "Reforestation Plan and Vegetation Recovery", what makes not feasible to implement it in the present Project. Therefore, the analysis is here focused only in option i).

(2) Reforestation plan along river structures

Policies for the afforestation plan along river structure is as shown below. The conceptual diagram of the afforestation scheme are shown in Figures 4.3.2.1-1.

a) Objective: Reduce impact of river overflow when water rise occurs or when river narrowing is produced by the presence of obstacles, by means of vegetation borders between the river and the elements to be protected.

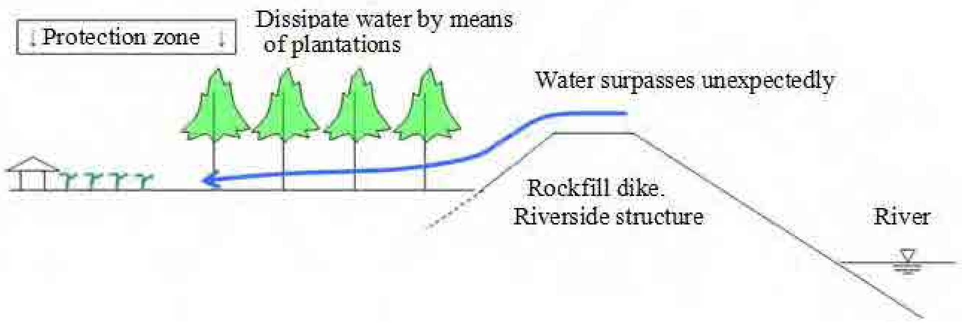
b) Methodology: Create vegetation borders of a certain width between river structures and the river.

c) Work execution: Plant vegetation at a side of the river structures (dikes, etc.) is to be a part of construction work of river structures, and which is carried out by the same contractor as for the river structures. The reasons are i) plant vegetation is to be certain for the withered damage just after plantation and ii) The same contractor for the river structures is appropriate due to the parallel work of plantation and structure construction.

d) Maintenance post reforestation: The maintenance will be assumed by irrigation commissions by own initiative. In the past project, it is usually performed that the agreement is made between the irrigation committee and DGIH on the following two items.
  i) The ownership of plantation belongs to the irrigation committee.
  ii) Operation and maintenance cost of the plantation is born by the committee

Therefore the plantation is not private property but public one in the committee.

e) Plantation section : Since the purpose of plantation is mitigation of damage in overflowing of flood, the plantation is to be made in the preventive side of dike. In case that the plantation is made in the section without dike, the trees are knocked down directly by flood water, and they flow down along river causing the choke in the bridges etc. resulting in secondary damage, and as the length without dike is long , the cost of construction and land acquisition increases.



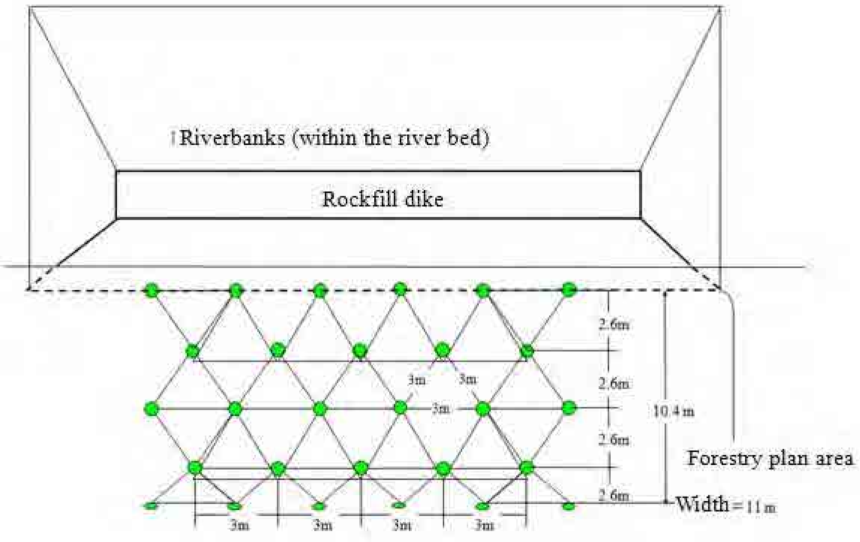
source: JICA Study Team)

Figure 4.3.2.1-1 Conceptual diagram afforestation in the riverside structures

(3) Reforestation plan measure

1) **Structure (plantation arrangement)**

In Peru the most common pattern for afforestation is with equilateral triangles. This project also uses this model by planting trees with 3-meter intervals (Figure 4.3.2.1-2). If this method is used, the interval of trees vertical to the dike will be 2.6m and in the case of zigzag arrangement, the width will be 1.3m of which interval can stop the bolder with diameter of 1m or dissipate the energy of the boulder. And 4 lines of trees can increase the effect. Thus the width of plantation zone will be 11 m adding the allowance to 10.4 m.



(Source: JICA Study Team)

Figure 4.3.2.1-2 Arrangement of plantation along river structure

2) Species to be forested

The following list of forestry species has been developed for selecting the species to be planted.

- Forestry species for production (information obtained by forest nursery companies): see Table

4.3.2.1-1

- Forestry species verified in situ: see Table 4.3.2.1-2.

The mentioned species are selected for afforestation in bank structures. For selecting them, an evaluation was conducted considering certain criteria. In Table 4.3.2.1-3 shows the details of the selection, in Table 4.3.2.1-4 you can find the Table with the selection criteria.

Evaluation criteria used for selection:

1. Species with adequate properties to grow and develop in the riverside (preferably native)
2. Possibility of growing in plant nurseries
3. Possibility of wood and fruit use
4. Demand of local population
5. Native species (preferably)

After making a field survey, a list of planted or indigenous species of each zone was firstly made. Then, a list of species whose plants would grow in seedbeds, according to interviews made to plant growers, was prepared.

Priority was given to the aptitude of local conditions and to plant production precedents, leaving as second priority its usefulness and demand or if they were native species or not. Table 4.3.2.1-1 shows the assessment criterion.

Table 4.3.2.1-1 List of seedlings that may be produced

Watershed	Producers	Seedlings production sites	Commonly produced species	Sporadic produced species
Cañete	AGRORURAL	Santa Eulalia	Pino, Molle, Eucalipto, Huarango (*Prosopis limensis*)	Ciprés, Tara
	Fomeco	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	
	Agrimex	Lima	Aliso, Algarrobo, Caña, Támarix, Bambú, Pino, Casuarina, Eucalipto	

(Source: Information gathered by the forestry seedlings producers)

Table 4.3.2.1-2 List of verified tree species in the field (for riparian forestation)

Location	Tree Species	Characteristics
Cañete	Eucalyptus	Common along the river, and its characteristics shows high adequateness.
	Casuarina	Common along the river, and its characteristics shows high adequateness.
	Sauce	Common along the river, and its characteristics shows high adequateness.
	Molle	Shrub species, its characteristics shows high adequateness.

(Source: JICA study team)

Table 4.3.2.1-3 Results of planting species selection (details)

River Basin	Tree Species	Adequateness to evaluation items*						Remarks
		1	2	3	4	5	Total**	
Cañete	Aliso	C	B	A	C	A	--	Adequate for high elevation areas rather as
	Algarrobo	B	A	C	B	A	--	Similar to Huarango (*Prosopis limensis*), Prosopis is selected in the southern areas
	Canya (Cariso)	A	C	B	B	A	--	Grass
	Quinual	C	C	B	C	A	--	Adequate for high elevation areas rather as
	Colle	C	D	D	B	A	--	Adequate for high elevation areas rather as
	Tamalix	B	A	B	B	B	--	Its characteristics shows high adequateness in the Northern areas, but unknown in the southern areas
	Tara	D	A	A	B	A	-	Recently, fruit was found as effectiveness, becomes popular for plantation
	Bamboo	A	A	B	B	A	+	Unknown for forestation record
	Pine	B	D	B	B	B	-	Adequate for high elevation areas rather as
	Molle	B	A	B	B	A	+	It is said as its root grows in deep
	Casuarina	A	B	C	B	B	+	Adequate for high elevation areas rather as
	Eucalyptus	A	B	B	A	B	++	Adequate for high elevation areas rather as
	Huarango (*Prosopis limensis*)	A	A	D	A	A	++	Its characteristics shows high adequateness in the area near to the sea or dry area

* Evaluation criteria are shown above, ** ++: Selected, +: second, -: nominated but not so good,--: not be selected

(Source: JICA Study Team based on hearing from the seedling providers)

Table 4.3.2.1-4 Assessment criterion for forest species selection

		Assessment Criterion				
		1	2	3	4	5
Assessment points	A	In situ testing (natural or reforested growth)	Major production	Possible use as wood or for fruit production	Water demand by the Users Committee, among others	Local specie
	B	Growth has not been checked in situ, however it adapts in the zone	Sporadic production	Possible use as wood or for fruit production	There is NO water demand by the Users Committee	No local specie
	C	None of the above	Possible reproduction but not usual	No use as wood nor fruit	—	—
	D	Unknown	Not produced	Unknown	—	—

(Source: JICA Study Team)

Table-4.3.2.1-5 shows a list of selected species applying these assessment criterion. ◎ marks main species, are those species that would be planted with a proportion of 30% to 50%. This proportion is considered to avoid irreversible damages such as plagues that can kill all the trees.

Table 4.3.2.1-5 Selection of forest species

Watershed	Forest species
Cañete:	Eucalipto (◎), Huarango (○), Casuarina (○)

In the Cañete Watershed the main forestry specie is Eucalyptus. This specie adapts very well in this area, it adapts to the zone and has high demand by the Water User’s Committees. Huarango (*Prosopis limensis*: is how this plant is known in the northern region of Peru, comes from another seed) is a native specie form the southern region of Peru. It is planted along the Panamericana Highway. Casuarina specie has been planted in this area to protect from wind and sand, moreover for the lands near farms.

3) Quantity of reforestation plan

The forestry plan has been selected as it is mentioned in the location and type of species plan, in the bank protection and embankment along the riverside.

Following Table 4.3.2.1-3 shows the construction estimating for the Forestry and Recovery of Vegetation Cover Plan for Cañete Watershed.

Table 4.3.2.1-6 Forestry and vegetation recovery plan (Along the river)

N°	Location (bank)	Length (m)	Width (m)	Area (ha)	Distribution of species (unit)			
					Eucalipto	Huarango	Casuarina	total
Ca-1	-			0.0	—	—	—	—
Ca-2	Right bank	1,600	11	1.8	2,664	1,598	1,066	5,328
Ca-3	-			0.0	—	—	—	—
Ca-4	-			0,0	—	—	—	—
Ca-5	Right bank	1,750	11	1.9	2,812	1,687	1,125	5,624
Total		3,350		3.7	5,476	3,285	2,191	10,952

(Source: JICA Study Team)

4) Areas subject to the Reforestation and Vegetation Recovery Plan

In areas subject to the Reforestation/Vegetation Recovery Plan along fluvial works, the structure arrangement is similar everywhere. See section 4.3.2. 1(2)

5) Execution costs of the Reforestation and Vegetation Recovery Plan

Execution costs of works for the Reforestation and Vegetation Recovery Plan were estimated as follows:

- Planting unitary cost (planting unitary cost + transportation)
- Labor cost

Planting providers may include i) AGRORURAL or ii) private providers. For reforestation along rivers private providers will be requested.

For labor unitary cost estimation, common labor unitary cost is proposed to be applied for riverside reforestation.

i) Planting unitary cost

Planting unitary cost was defined as detailed in Table 4.3.2.1-7 based on information obtained through interviews to private providers. Given that planting prices and transportation cost varies per provider, an average Figure was applied.

Table 4.3.2.1-7Unitary cost of plants

ii) Labor cost

iii) Reforestation execution cost

Work costs for the forestry and vegetation cover recovery plan in the riverside structures are detailed in Table 4.3.2.1-8

表-4.3.2.1-8 Reforestation cost along river structure

6) Implementation plan

The Process Plan of afforestation works in riverbanks is part of the river structure, thus the same will be considered for the Construction Plan of the River Structure. Afforestation works should generally start at the beginning of the rainy season or just before, and must end approximately one month before the season finishes. However, there is scarce rain in the coastal area; therefore there is no effect of dry and rainy seasons. For the sake of afforestation, it is most convenient is to take advantage of water rise, but according to the Construction Schedule of the river structure there are no major afforestation issues in seasons where water level is low. The simple gravity irrigation system can be used to irrigate just planted plants during approximately the first 3 months until water level rises. This irrigation is performed using perforated horse which is a field technique actually carried out in Poechos dam area

4.3.2.2 Sediment Control Plan

(1) Importance of the sediment control plan

Below flood control issues in selected Watersheds are listed. Some of them relate to sediment control. In the present Project an overall flood control plan covering both the high and the low Watershed is prepared. The study for the preparation of the Sediment Control Plan comprised the whole Watershed.

- Water rise causes overflow and floods.
- Rivers have a steep slope of 1/30 to 1/300. The flow speed is high, as well as the sediment transport capacity.
- The accumulation of large quantities of dragged sediment and the consequent elevation of the river bed aggravate flood damages.
- There is a great quantity of sediment accumulated on the river bed forming a double sandbank. The water route and the spot of greater water impact are unstable, causing route change and consequently, change of spot of greater water impact.
- Riverside is highly erodible, causing a decrease of adjacent farming lands, destruction of regional roads, etc., for what they should be duly protected.
- Big stones and rocks cause damages and destruction of water intakes.

(2) Sediment control plan (structural measures)

The sediment control plan suitable for the present sediment movement pattern was analyzed. Table 4.3.2.2-1 details basic guidelines.

Table 4.3.2.2-1 Basic guidelines of the sediment control plan

Conditions	Typical year	Precipitations with 50-year return period
Sediment dragging	Margin erosion and river bed change	Margin erosion and river bed change Sediment flow from ravines
Measures	Erosion control → Margin protection Control of riverbed variation → compaction of ground, bands (compaction of ground in the alluvial cone, bands)	Erosion control → margin protection Riverbed variation control →compaction of ground, bands (compaction of ground in the alluvial cone, bands) Sediment flow → protection of slopes, sediment control dams

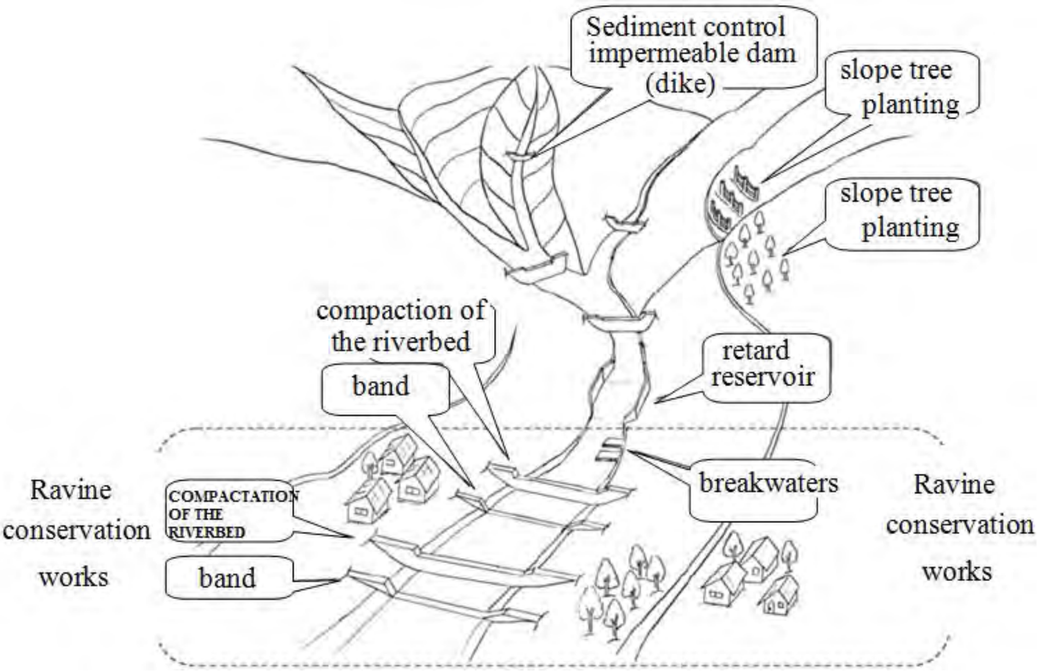


Figure 4.3.2.2-1 Sediment control works

1) Sediment control plan in the upper watershed

The next section 4.15 "Medium and long term Plan" 4.15.3 "Sediment Control Plan" details the sediment control plan covering the whole Upper Watershed. This plan will require an extremely long time with huge costs, what makes it quite not feasible. Therefore, it must be executed progressively within the medium and long term.

2）Sediment control plan in the low watershed

We observed that building sediment control dams covering the whole Watershed will demand huge costs. Therefore, the same calculation was done but reducing its scope to just the lower Watershed of the river. In this process, analysis results on riverbed variation were taken into consideration, also included in the present study.

The riverbed fluctuation in Cañete river is as shown below:

Total sediment inflow	3,000,000 m3
Average annual sediment inflow	60,000m3
Total riverbed fluctuation volume	673,000m3
Average Riverbed fluctuation height	0.2m/ 50 years

While the variation of the bed (volume of sediment) is not so much, looking at the average height of the bed, only 0.2 meters has changed in 50 years, and is therefore considered that the entry of sediments won't affect much the river downstream. Therefore, it is considered that it is not necessary to take a special sediment control measure at present.

However the sediment disaster will occur suddenly and locally so that the maintenance work of river channel will be studied by monitoring the riverbed fluctuation.

It is worth mentioning that in Cañete River watershed the Platanal dam was built last year, which is for hydropower generation and has small storage capacity so that it will be filled soon with sedimentation, however it can retain the function of sediment regulation, so it is expected that the volume of sediment for the lower basin will be reduced drastically in the future.

4.3.3 Technical Assistance

Based on the proposals on flood control measures, a component on technical assistance is proposed in order to strengthen risk management capabilities in the Program.

(4) Component objective

The component objective in the Program is the “Adequate capability of local population and professionals in risk management application to reduce flood damages in Watersheds”.

(5) Target area

The target area for the implementation of the present component is the Cañete watershed.

In the execution stage, the implementation has to be coordinated with local authorities in the watershed. However, each authority has to execute those activities related with the characteristics of the watershed to carry out an adequate implementation.

(6) Target population

Target populations will represent irrigator associations and other community groups, provincial, district and local community governments and local people in each watershed, considering the limited capacity to receive beneficiaries of this component.

Participants are those with skills to widespread technical assistance contents of local populations in the watershed.

Besides, the participation of women has to be considered because currently only few ones participate in technical assistance opportunities.

(7) Activities

In order to achieve the above purpose, the following 3 components of study and training is to be carried out.

Component 1: Knowledge on River Bank Protection Actions in consideration of Agriculture and Natural Enviornment

Course	a) River Bank Operation and Maintenance b) River Bank Plant Management c) Erosion Prevention and Mitigation Natural Resource Management

Objectives	a) In this project, local populations learn suitable technology to operate and give maintenance to constructions and works from prior projects. b) Local populations learn suitable technology on river bank plants and vegetation for flooding control purposes. c) Local populations learn suitable technology on erosion and natural resources for flooding control purposes.
Participants	a） Engineers and / or technicians from local Governments b-c) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives
Times	a） 12 times in all (every six (6) hours) b） 12 times in all (every five (5) hours) c） 26 times in all (every three (3) hours)
Lecturers	a） Contractors of constructions and works, Engineers from MINAG and / or the Regional Government b-c) Engineers from MINAG and / or the Regional Government, College professors (From universities, institutes, NGOs, etc.)
Contents	a-1) Suitable operation and maintenance technology for constructions and works from prior projects a-2) Suitable operation and maintenance technology for constructions and works in this project b-1) River bank protection with the use of plants b-2) The importance of river bank vegetation in flooding control b-3) Types of river bank plants and their characteristics c-1) Evaluation of the erosion conditions c-2) Evaluation of natural resource conditions c-3) Erosion approach for flooding control c-4) Natural resource approach for flooding control c-5) Environmental consideration approach c-6) Use of water resources c-7) Alternatives for suitable farming crops

Component 2: Preparation of Commnity Disaster Management Plan for Flood Control

Course	a) Risk management Plan Formulation b) Detailed Risk management Plan Formulation
Objectives	a) Local populations gain knowledge and learn technology to prepare a flooding control plan b) Ditto
Participants	a-c) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives
Times	a) 19 times in all (every four (4) hours) b) 34 times in all (every five (5) hours) c) 24 times in all (every five (5) hours)
Lecturers	a-c) Engineers from MINAG and / or the Regional Government, Community Development Expert, Facilitator (local participation)
Contents	a-1) Flooding control plan preparation manuals a-2) Current condition analyses for flooding control a-3) Community development alternatives by means of local participation a-4) Workshop for flooding control plan preparation b-1) Community activity planning in consideration of ecological zoning b-2) Risk management b-3) Resource management c-1) Preparation of community disaster management plan c-2) Joint activity with local governments, users’ association, etc.

Component 3: Basin Management for Anti – River Sedimentation Measures

Courses	a） Hillside Conservation Techniques b） Forest Seedling Production c) Forest Seedling Planting d) Forest Resource Management and Conservation
Objectives	a) Local populations learn suitable technology on hillside conservation for flooding control purposes b) Local populations learn suitable technology on forest seedling production c) Local populations learn suitable technology on forest seedling planting d) Local populations learn suitable technology on forest resource management and conservation
Participants	a-d) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives and Local People
Times	a） 12 times in all (every five (5) hours) b-d) 40 times in all for three (3) “Courses on Basin Management for Anti - River Sedimentation Measures” (every five (5) hours)
Lecturers	a-d) Engineers from MINAG and / or the Regional Government, College professors (From universities, institutes, NGOs, etc.)
Contents	a-1) Soil characteristics and conservation on hillsides a-2) Hillside agroforestry system a-3) Animal herding system on hillsides a-4) Reforestation with traditional vegetation and plants a-5) Hillside conservation and alleviation alternatives b-1) A selection of plants that are suitable to the local characteristics b-2) Forest seedling production technology b-3) Control carried out by the local population’s involvement c-1) Candidate areas for forestation c-2) Forest plantation control technology c-3) Forest plantation soil technology c-4) Control carried out by the local population’s involvement d-1) Forestation for flooding control purposes d-2) Forest plantation control technology d-3) Forest plantation output technology d-4) Control carried out by the local population’s involvement

(5) Direct cost and period

The direct cost for the above activities is as shown in the Table 4.3.3-1. The total cost for the objective basin is estimated as soles, and the brake down of the unit cost is as shown in the Annex-12, Appendix No.5. And the period required for study and training is assumed to be as same as the construction period of 2 years.

Table 4.3.3-1 Contents of technical assistance and direct cost

(6) Implementation plan

The Hydraulic Infrastructure General Direction (DGIH-MINAG) executes this component as the executing unity in cooperation with the Agriculture Regional Direction (DRA), the Board of Users and related Institutions. In order to execute the activities efficiently the following has to be considered:

- For the implementation of the present component, the DGIH-MINAG will coordinate actions with the Central Management Unit responsible for each Watershed, as well as with Regional Managements of Agriculture (DRA).
- For the Project administration and management, the DGIH-MINAG will coordinate actions with PSI-MINAG (Sub-sector Irrigation Program with extensive experience in similar projects).
- Considering there are some local governments that have initiated the preparation of a similar crisis management plan through the corresponding civil defense committee, under the advice of the National Institute of Civil Defense (INDECI) and local governments, the DGIH-MINAG must coordinate so that these plans be consistent with those existing in each Watershed.
- Training courses will be managed and administered by irrigator associations (particularly the unit of skills development and communications) with the support of local governments in each Watershed, to support timely development in each town.
- Experts in disaster management departments in each provincial government, ANA, AGRORURAL, INDECI, etc., as well as (international and local) consultants will be in charge of course instruction and facilitation.

4.4 Costs

4.4.1 Cost Estimate (at Private Prices)

(1) Project Costs Components

Project cost is composed of the following components:

1) Infrastructure cost
  i) Construction work cost
    ① Work direct costs (including plantation cost, environmental work cost, disaster prevention education/capacity development cost, infrastructure rehabilitation cost)
    ② Overhead cost＝① x 15%
    ③ Profit = ① x 10%
    ④ Work cost= ① + ② + ③
    ⑤ Tax =④ x 18% (IGV)
    ⑥ Construction cost = ④＋⑤
  ii) Consultant cost (for structure, plantation, environmental work and disaster prevention education/capacity development)
    ⑦ Detailed design cost
    ⑧ Construction supervision cost
    ⑨ Consultant cost=⑦＋⑧
  iii) Infrastructure cost=⑥＋⑨
2) Land acquisition cost
3) Management cost of implementation agency
4) Total project cost ＝1）＋2）＋3）

(2) Direct cost

The direct costs were calculated by multiplying the unit prices with the work quantities. And the unit price is estimated for each work item based on the labor cost, material cost and equipment cost,

1) Labor cost
The labor costs in Cañete river are as shown in the Table-4.4.1-1.

2) Material cost
The major material costs in Cañete river are as shown in the Table-4.4.1-2.

3) Equipment cost
The rental costs of equipment in Cañete river are as shown in the Table-4.4.1-3 .

4) Work quantities

The work quantity of each work item in each flood prevention facility is as shown in the Table-4.4.1-4. For further detail of work quantities refer to Annex-8 Plan and Design of Facility.

5) Unit price of work

Based on the above costs the unit price of each work is estimated, of which results in in Cañete river are as shown in the Table--4.4.1-5. For further detail refer to Annex-9 Construction Planning and Cost Estimate. Based on the work quantities and the unit price of work, the direct cost of construction work is calculated as shown in the Table-4.4.1-6

(3) Infrastructure cost

The infrastructure cost is as shown in the Table4.4.1-12, in which the breakdown of the detail design cost and construction supervision cost are as shown in the Table-4.4.1-7 and Table-4.4.1-8 respectively. The consultant cost was estimated based on the Terms of Reference attached to Annex-14 Implementation Program of Japanese Yen Loan Project as Appendix-1

(4) Land acquisition and infrastructure rehabilitation

The land acquisition coat and infrastructure rehabilitation cost are as shown in the Table-4.4.1-9 and the Table-4.4.1-10 respectively. For further detail refer to Annex-9 Construction Planning and Cost Estimate, 4. Compensation.

(5) Management cost of implementation agency

The management cost of implementation agency is as shown in the Table-4.4.1-11.

(6) Total project cost

The total project cost is calculated as shown in the Table-4.4.1-12.

(7) Operation and maintenance cost

The operation and maintenance cost after completion of the Project is estimated as shown in the Table-4.4.1-14 (refer to Annex-9 Constructoion Planning and Cost Estimation).

Table-4.4.1-1 Unit labor cost（1）（Cañete river）

Table-4.4.1-1 Unit labor cost（2）

Table-4.4.1-2 Unit price of main material

Table-4.4.1-3 Unit cost of main heavy equipment

Table-4.4.1-4 Work quantities

Table-4.4.1-5 Estimate of work unit cost（example of Cañete river: Ca-1）

Table-4.4.1-6 Direct cost(private price and social price）

Table 4.4.1-7 Consultant cost for detail design stage (for 4 basins)

Table 4.4.1-8 Consultant cost for construction supervision stage (for 4 basins)

Table 4.4.1-9 land acquisition cost (soles)

Table 4.4.1-10 Rehabilitation cost of existing facility (direct cost)

Table-4.4.1-11 Administration cost of implementation agency (for 4 basins)

Table-4.4.1-12 Total project cost (private price)

Table-4.4.1-13 Total project cost (social price)

Table-4.4.1-14 Annual operation and maintenance cost

4.4.2 Cost Estimate (at Social Price)

The direct cost at social price is as shown in the previous Table-4.4.1-6. The consultant cost, land acquisition cost and administration cost of the implementation agency are converted from the private price to the social price. The total project cost at social price is calculated as shown in the Table - 4.4.1-13.

The social price is calculated by multiplying the private price (labor cost, material cost and equipment cost) with the standard conversion factor(SCF). SCF is the ratio of the private price in domestic and the social price calculated at the border with respect to all goods of the country's economy,

In this study, economic evaluation is calculated based on the Guidelines which are available in Peru (Guideline of the National Public Investment System (Directorial Resolution No. 003-2011-EF/68.01, Annex SNIP 10-V3.1)) . Ministry of Economy and Finance is indicated SCF as shown in Table -4.4.2-1.

Table-4.4.2-1 Standard conversion factor (SCF)

Correction Factors for Social Rates (Methodology MEF)

DESCRIPCION	VALOR
·National Property Expenditures	0.85
·Imported Goods Expenditures	0.92
·Indirect Imported Goods Expenditures*	
Tasa Ad. Valorem	0.12
General Sales Tax Rate	0.18
·Currency correction factor	1.08
·Fuel costs	0.66
·Indirect costs (administrative and financial)	0.85
Legal entity	0.85
Natural Person	0.91
·Expenditures on skilled labor	0.91
·Expenditures on non skilled labor	0.68
Lima Metropolitana urbano	0,86
Urban Coast Region	0,68
Rural Coast Region	0,57
Urban Sierra Region	0,60
Urban Sierra Region	0,41
Urban Forest Region	0,63
Rural Forest Region	0,49
·Indirect taxes Manpower **	
Fourth Category Rate for Non-Personal Services (10%)	0.91

As an example, the process of conversion from private price to social price for the direct cost of river structures is as shown in the Table-4.4.2-2. For other costs the process is shown in the Annex-10 Socio-economy and Economic Evaluation, Attachment-3...

Table-4.4.2-2 Conversion process from private price to social price for direct cost of river structure

4.5 Social Assessment

4.5.1 Private Prices Costs

(1) Benefits

Flood control benefits are flood loss reduction that would be achieved by the implementation of the Project and is determined by the difference between the amount of loss with and without Project. Specifically, in order to determine the benefits that will be achieved by the works' construction. First, the flood amount per flood loss of the different return periods (between 2 to 50 years) is calculated;

assuming that the flood control works have a useful life of 50 years. To finish, determine the annual average amount of the loss reduction from the loss amount of different return periods. [The Methodological Guideline for Protection and/or Flood Control Projects in agricultural or urban areas, 4.1.2p-105)] establishes similar procedures.

Above find the description of the procedures to determine concrete benefits.

①Determine the flood loss amount in the flood area by analyzing the magnitude of overflow that occurs without the Project for each return period (between 2 and 50 years).

②After, determine the amount of flood loss in the flood area by analyzing the magnitude of overflow that occurs when flood control priority works are built.

③Determine the difference between ① and ②. Add the benefits of other works different than dikes (intakes, roads protection, etc.) in order to determine the total profits.

“Benefits of the Project” are considered as the sum of direct loss amount caused by overflow and indirect loss caused by the destruction of structures in vulnerable sections (farmland loss, interruption of traffic, etc.)

1) Method of loss amount calculation

In this study, the amount of loss from direct and indirect damages to the variables listed in Table 4.5.1-1 was determined.

Table 4.5.1-1 Flood loss amount calculation variables

Loss	Variables	Description
(1) Direct	① Crops	・ Crops in flooding season The amount of crop loss by flooding is determined by multiplying the damage % regarding water depth and the number of days flooded ・ Agricultural land and infrastructure (channels, etc.) ・ Crop loss amount is determined by multiplying the damage % regarding water depth and the number of days flooded
	② Hydraulic Works	・ Loss amount due to hydraulic structures destruction (intakes, channels, etc.).
	③ Road Infrastructures	・ Flood damage related to road infrastructure is determined by the damage in transport sector
	④ Housing	・Residential and industrial buildings It is calculated applying the loss coefficient depending on the
		・flood depth Housing: residential and industrial buildings; household goods: furniture, household appliances, clothing, vehicles, etc. Flood damages in housing, commercial buildings, assets and inventories (buildings and assets) is determined applying the loss coefficient according to the flood depth
	⑤ Public Infrastructures	・ Determine the loss amount in roads, bridges, sewers, urban infrastructures, schools, churches and other public facilities ・ Determine the loss amount in public works by applying the correspondent coefficient to the general assets loss amount
	⑥ Public Services	・ Electricity, gas, water, rail, telephone, etc.
(2) Indirect	① Agriculture	・ Estimate the loss caused by irrigation water interruption due to the damage of hydraulic structures

		・ Determine the construction and repair costs of hydraulic structures such as direct year costs
	② Traffic Interruption	・ Estimate the loss lead by traffic interruption due to damages on flooded roads ・ Determine road's repair and construction costs as damage direct cost

a) Direct loss

Direct loss is determined by multiplying the damage coefficient according to the inundation depth as the asset value.

b) Indirect loss

- Indirect loss is determined taking into account the impact of intakes and damaged
- roads. Below, calculation procedures are described.

i). Intake damage

The loss amount due to intake damage is calculated by adding the direct loss (intake's rehabilitation and construction) and the indirect loss amount (harvest loss due to the interruption of irrigation water supply)

① Calculating the infrastructure cost

Works Cost = construction cost per water unit taken × size (flow, work length)

Unit cost of the work: for intakes and channels, it is required to gather information on the water intake volume of the existing work and the works' execution cost (construction or repair). The unit cost is calculated by analyzing the correlation among them both.

It was estimated that the work will be completely destroyed by the flow with a return period of 10 years.

② Crop loss

Annual earnings are determined according to the crops grown in the correspondent irrigation district.

Annual Profit = (crops selling - cost) × frequency of annual harvest

Crop Sale = planted area (ha) x yield (kg/ha) × transaction unit price

Cost = unit cost (s/ha) × planted area (ha)

ii) Road infrastructure damage

Determine the loss due to traffic interruption.

Amount of loss = direct loss + indirect loss

Direct loss: road construction cost (construction, rehabilitation)

Indirect Loss: opportunity loss cost due to road damage (vehicle depreciation + staff expenses loss)

Then, a 5 days period takes place of non-traffic ability (usually in Peru it takes five days to complete the rehabilitation of a temporary road)

2) Loss estimated amount according to different return periods

The loss amount according to the different return periods is calculated as shown in the Table 4.5.1-2 as an example. For further detail refer to I-7 Data Book.

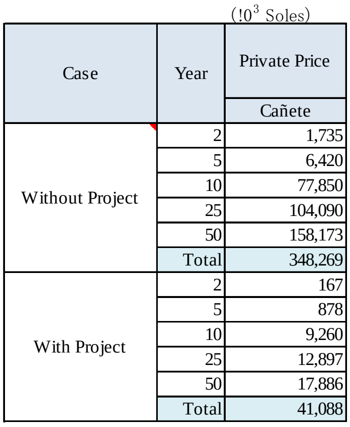
Table 4.5.1-2 Estimated loss by flooding at private price (Cañete river)

（1,000 soles）

Description	T=50 years	
	Without Project	With Project
Agricultural Product	102,502	14,573
Hydraulic Structure	16,221	2,538
Road	24,502	92
Housing	11,685	683
Public Facility	3,103	0
Public Service	161	0
Total	158,173	17,886

In the Table 4.5.1-3, the estimated amounts of loss by flooding of different return periods with or without Project, for Cañete river is shown.

Table 4.5.1-3 Loss estimated value (at private prices)



(!0³ Soles)

Case	Year	Private Price
		Cañete
Without Project	2	1,735
	5	6,420
	10	77,850
	25	104,090
	50	158,173
	Total	348,269
With Project	2	167
	5	878
	10	9,260
	25	12,897
	50	17,886
	Total	41,088

The estimated loss by flood without project in return period of 50- year will be 158.2 million soles in Cañete river.

3) Loss amount (annual average) expected to be reduced by the Project

The average annual damage reduction amount is calculated by multiplying the annual damage reduction corresponding to probable flood with occurrence probability and by accumulating the annual damage reduction of each probable flood. The calculation method is as shown in the Table 4.5.1-4.

Table 4.5.1-4 Calculation method of annual average of loss reduction amount

Probabilities	Loss Amount			Average path's loss	Paths' Probabilities	Loss reduction annual average amount
	Without Project	With Project	Loss Reduction			
1/1			$D_0 = 0$			
				$(D_0+D_1)/2$	1-(1/2) = 0,500	$d_1 = (D_0+D_1)/2$ x 0,67
1/2	L_1	L_2	$D_1 = L_1\text{-}L_2$			
				$(D_1+D_2)/2$	(1/2)-(1/5) = 0,300	$d_2 = (D_1+D_2)/2$ x 0,300
1/5	L_3	L_4	$D_2 = L_3\text{-}L_4$			
				$(D_2+D_3)/2$	(1/5)-(1/10) = 0,100	$d_3 = (D_2+D_3)/2$ x 0,100
1/10	L_5	L_6	$D_3 = L_5\text{-}L_6$			
				$(D_3+D_4)/2$	(1/10)-(1/20) = 0,050	$d_4 = (D_3+D_4)/2$ x 0,050
1/20	L_7	L_8	$D_4 = L_7\text{-}L_8$			
				$(D_4+D_5)/2$	(1/20)-(1/30) = 0,017	$d_5 = (D_4+D_5)/2$ x 0,017
1/30	L_9	L_{10}	$D_5 = L_9\text{-}L_{10}$			
				$(D_5+D_6)/2$	(1/30)-(1/50) = 0,013	$d_6 = (D_5+D_6)/2$ x 0,013
1/50	L_{11}	L_{12}	$D_6 = L_{11}\text{-}L_{12}$			
				$(D_6+D_7)/2$	(1/50)-(1/100) = 0,010	$d_7 = (D_6+D_7)/2$ x 0,010
1/100	L_{13}	L_{14}	$D_7 = L_{13}\text{-}L_{14}$			
Foreseen average annual amount of loss reduction			$d_1+d_2+d_3+d_4+d_5+d_6+d_7$			

4) Results of the loss amount calculation (annual average)

In Table 4.5.1-5 the results of the loss amount calculation are shown (annual average), which are expected to be reduced by implementing each river's Project.

Table 4.5.1-5 Annual average of loss reduction amount (private prices)

(10^6 Soles)

Basin	Return Period	Probability	Total Damage (10^6 Soles)			Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
			Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,735	167	1,568	784	0.500	392	392
	5	0.200	6,420	878	5,542	3,555	0.300	1,067	1,459
	10	0.100	77,850	9,260	68,590	37,066	0.100	3,707	5,165
	25	0.040	104,090	12,897	91,193	79,891	0.060	4,793	9,959
	50	0.020	158,173	17,886	140,287	115,740	0.020	2,315	12,273

(2) Social assessment

1) Assessment's objective and indicators

The social assessment's objective in this Study is to evaluate investment's efficiency in structural measures using the analysis method of cost-benefit (C/B) from the national economy point of view. For this, economic assessment indicators were determined (relation C/B, Net Present Value - NPV and IRR). The internal return rate (IRR) is an indicator that denotes the efficiency of the project's investment. It is the discount rate to match the current value of the project's generated cost regarding the benefit's current value. It is the discount rate necessary so the Net Present Value (NPV) equals zero and the relation C/B equals one. It also indicates the percentage of benefits generated by such investment. The internal return rate used in the economic assessment is called "economical internal return rate (EIRR)". The market price is turned into the economical price (costs at social prices) eliminating the impact of market distortion.

The IRR, C/B relation and NPV are determined applying mathematical expressions shown in the Table below. When IRR is greater than the social discount rate, the relation C/B is greater than one and NPV is greater than zero, it is considered that the project is efficient from the national economic growth point of view.

Table 4.5.1-6 Evaluation indicator of economic benefit and its characteristics

Indicators	Definition	Characteristics
Net Present Value (NPV)	$NPV = \sum_{i=1}^{n} \frac{B_i}{(1+r)^i} - \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$	- Allows comparing net benefit magnitude performed by the project - It varies depending on the social discount rate
Cost-Benefit Relation (C/B)	$B/C = \sum_{i=1}^{n} \frac{B_i}{(1+r)^i} \Big/ \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$	- Allows comparing the investment efficiency by the magnitude of benefit per investment unit - Varies depending on the social discount rate
Economical Internal Return Rate (EIRR)	$\sum_{i=1}^{n} \frac{B_i}{(1+r)^i} = \sum_{i=1}^{n} \frac{C_i}{(1+r)^i}$	- Allows knowing the investment efficiency comparing it to the social discount rate - Does not vary depending on the social discount rate
Where Bi: benefit per “i” year / Ci: cost per “i” year / r: social discount rate (11 %) / n: years of assessment		

2) Assumptions

Next, find the assumptions of every indicator used from the economical assessment

i) Assessment Period

The assessment period is set between 2013 and 2027 (15 years after construction works started). This Project implementing schedule is the following:

2012: Detailed Design
2013-2014: Construction
2013-2027: Assessment Period

The assessment period is 15 years which is same period as the adopted period in the Perfil program report of this Project. The SNIP regulation stipulates that the assessment period is to be 10 years basically, however the period can be changed if the project formulation agency (DGIH in this Project) admits that it is necessary. DGIH adopted 15 years in the Perfil program report and which was approved by OPI and DGPI (March 19, 2010). In JICA’s development project the evaluation period of 50 years is generally adopted, so that JICA Study Team inquired DGIH and OPI on this matter, they directed to adopt 15 years. In case of 50 years, the evaluation will be made in the Annex-14, Implementation Program of Japan Yen Loans Project.

ii) Standard Conversion Factor (SCF)

The standard conversion factor (SCF) is the relationship between socioeconomic prices established along the border and national private prices of all goods in a country’s economy. It is used to convert goods and services prices purchased in the local market at affordable prices. SCF is stipulated by MEF as shown in the previous Table 4.4.2-1.

iii) Other preliminary conditions
Price level: 2011
Social discount rate: 10% (according to SNIP regulation)
Annual maintenance cost: estimated in the Table 4.4.1-14

3) Cost-benefit relation analysis

A comparison of the total cost and total benefit of flood control works converted to present values applying the social discount rate was performed. In this case, the total cost is the addition of construction, operation and maintenance costs. The total benefit is the loss amount that was reduced due to the works. For this, a base year was established for the conversion into the current value at the moment of the assessment, and the assessment period was set for the next 15 years from the beginning of the Project. The total cost was determined adding-up the construction, operation and maintenance costs of the works converted into present values; and the total benefit adding-up the annual average loss amount turned into current values. In Table 4.5.1-7 results of calculations C/B, NPV and IRR to private prices is shown.

Table 4.5.1-7 Social assessment (C/B, NPV, IRR) (at private prices)

The social evaluation at private price level is calculated as shown in the Table 4.5.1-8 for Cañete river.

Table-4.5.1-8 Social evaluation at private prices(Cañete river)

Table-4.5.1-9 Social evaluation at social prices(Cañete river)

4.5.2 Social Prices Costs

(1) Benefits

1) Estimated loss amount according to different return periods

The loss amount according to the different return periods is calculated as shown in the Table 4.5.2-1. For further detail refer to I-7 Data Book.

Table 4.5.2-1 Estimated loss by flooding at social price (Cañete river)

（1,000 soles）

Description	T=50 years	
	Without Project	With Project
Agricultural Product	180,161	19,037
Hydraulic Structure	13,415	2,099
Road	19,357	73
Housing	9,897	579
Public Facility	2,628	0
Public Service	128	0
Total	**225,586**	**21,787**

In the Table 4.5.2-2, the estimated amounts of loss by flooding of different return periods with or without Project, for the 4 Watersheds is shown.

Table 4.5.2-2 Loss estimated value (at social prices)

(!0^3 Soles)

Case	t	Social Price
		Cañete
Without Project	2	2,711
	5	11,180
	10	110,910
	25	153,056
	50	225,586
	Total	503,443
With Project	2	293
	5	1,077
	10	10,834
	25	15,524
	50	21,787
	Total	49,515

2) Loss amount (annual average) is expected to be reduced with the Project

In Table 4.5.2-3 results of loss amount calculation (annual average) that are expected to reduce to implement the Project in each River are shown.

Table 4.5.2-2 Annual average of loss reduction amount (social prices)

(10^6 Soles)

Basin	Return Period	Probability	Total Damage (10^6 Soles)			Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
			Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,711	293	2,418	1,209	0.500	605	605
	5	0.200	11,180	1,077	10,103	6,216	0.300	1,865	2,469
	10	0.100	110,910	10,834	100,076	55,090	0.100	5,509	7,978
	25	0.040	153,056	15,524	137,532	118,804	0.060	7,128	15,107
	50	0.020	225,586	21,787	203,799	170,665	0.020	3,413	18,520

(2) Social Assessment

In Table 4.5.2-4 results of the calculation C/B, NPV and IRR at social prices are shown.

Table 4.5.2-4 Social assessment (C/B, NPV, IRR) (at social prices)

The social evaluation at social price level is calculated as shown in the Table 4.5.1-9.

4.5.3 Social Assessment Conclusions

The social evaluation of Cañete river is high at private price and social price and also the following hardly quantifiable positive economical Projects effects are as shown below:

- Contribution to local economic development when soothing the fear due to economic activities suspension and damage
- Contribution by increasing local employment opportunities for the construction of the project
- Strengthening the local population's awareness for floods damage and other disasters
- Income increase contributions due to an stable agricultural production because flood damages are soothed
- Increase of agricultural land price

For the economic assessment results previously presented, it is considered that this Project will contribute substantially to the local economic development.

4.6 Sensitivity Analysis

(1) Objective

A sensitivity analysis was made in order to clarify the uncertainty due to possible changes in the future of the socioeconomic conditions. For the cost-benefit analysis it is required to foresee the cost and benefit variation of the project, subject to assessment, to the future. However, it is not easy to perform an adequate projection of a public project, since this is characterized for the long period required from planning to the beginning of operations. Also because of the long useful life of works already in operation and the intervention of a number of uncertainties that affect the future cost and benefit of the project. So, analysis results are obtained frequently and these are discordant to reality when the preconditions or assumptions used do not agree with reality. Therefore, for the uncertainty compensation of the cost-benefit analysis it should be better to reserve a wide tolerance-margin, avoiding an absolute and unique result. The sensitivity analysis is a response to this situation.

The objective of the sensitivity analysis is to provide the cost-benefit analysis results a determined margin that will allow a proper managing of the project's implementation, give numbers to the population and achieve greater accuracy and reliability of the project's assessment results.

(2) Sensitivity analysis

1) General description of the sensitivity analysis

There are three methods of the sensitivity analysis, as indicated in Table 4.6-1.

Table 4.6-1 Sensitivity analysis methods

Methods	Description	Products
Variables sensitivity analysis	It consists in changing only one predetermined variable (precondition or hypothesis), to assess how the analysis result is affected	Margin values from the analysis when a precondition or hypothesis varies
Better and worst alternatives	It consists in defining the cases in which the analysis results are improved or worsen when changing the main pre-established preconditions or hypothesis to assess the analysis result margin	Margin values from the analysis when the main precondition or hypothesis vary
Monte Carlo	It consists in knowing the probability distribution of the analysis results by simulating random numbers of Monte Carlo simulation of pre-established preconditions and hypothesis	Probable results distribution when all main precondition or hypothesis vary

2) Description of the sensitivity analysis

In this project the sensitivity analysis method of the variables usually used in public works investments was adopted. Next, the scenarios and economic indicators used in the sensitivity analysis are shown.

Table 4.6-2 Cases subjected to the sensitivity analysis and economic indicators

Indicators	Variation margin according to factors	Economic indicators to be evaluated
Construction cost	In case the construction cost increases in 5 % and 10 %	IRR, NPV, C/B
Benefit	In case of reducing the benefit in 5 % and 10 %	IRR, NPV, C/B
Social discount rate	In case of increase and reduction of the discount social rate in 5 % respectively	NPV, C/B

3) Results of the sensitivity analysis

In table 4.6-3 the results of the sensitivity analysis of each assessed case to private and social prices is shown.

Table 4.6-3 Results of the sensitivity analysis of IRR, C/B and NPV

	Basin		Item	Basic Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
					Cost increase 5%	Cost increase 10%	Benefit decrease 5%	Benefit decrease 10%	Disc.rate increase 5%	Disc. rate decrease 5%
PRIVATE PRICE	EACH BASIN SEPARATELY	CAÑETE	IRR (%)	33%	32%	30%	32%	30%	33%	33%
			B/C	2.63	2.51	2.41	2.50	2.37	2.04	3.51
			NPV(s)	44,681,147	43,388,857	42,096,567	41,078,521	37,475,894	26,429,301	74,757,445
SOCIAL PRICE	EACH BASIN SEPARATELY	CAÑETE	IRR (%)	55%	53%	51%	53%	51%	55%	55%
			B/C	4.73	4.51	4.32	4.49	4.25	3.66	6.30
			NPV(s)	85,780,474	84,694,340	83,608,206	80,340,479	74,900,484	56,890,166	132,831,360

(3) Assessment of the sensitivity analysis

The impact on the economic evaluation due to the socio-economic change in the Project is as follows:

The Project in Cañete river has the high economic viability even in the base case so that IRR, B/C and NPV have no significant variation for the change of cost or benefit of the project, and which is still effective project.

4.7 Risk Analysis

The risk analysis is performed for flood prevention facilities of Cañete basin.

(1) Definition of risk

The increase % of cost and decrease % of benefit which make NPV value equal to zero, are calculated, then the magnitude of risk is defined as shown below.

High risk : When the cost increases from 0% to less than 15% or the benefit decrease from 0% to less than15%, NPV becomes zero.

Middle risk: When the cost increases more than 15% to less than 30% or the benefit decrease more than 15% to less than 30%, NPV becomes zero.

Low risk: When the cost increases more than 30% or the benefit decrease more than 30%, NPV becomes zero.

(2) Magnitude risk in each basin

The increase % of cost and decrease % of benefit which make NPV equal to zero, are calculated as shown in the Table 4.7-1. According to the Table, the risk is very low in the basin

Table 4.7-1 Increase % of cost and decrease % of benefit for NPV=0%

4.8 Sustainability Analysis

This project will be implemented by the central government (through the DGIH), irrigation committees and regional governments. Also, the project cost will be covered with the respective contributions of the three parties. Although the sharing percentage will be determined through discussions among stake holders, the percentage is assumed provisionally 80% for the central government (in this case MINAG), 15% for regional government and 5% for irrigation committee. On the other hand, the operation and maintenance (O & M) of the completed works is assumed by the irrigation committee. So, the sustainability of the project depends on the profitability of the Project and the ability of the irrigation committees for O & M.

(1) Profitability

The profitability of projects in Cañete river is high enough as shown in 4.5 social evaluation so that there is no questionable point in the sustainability of the Project.

(2) Irrigation committee

The irrigation committee is non-profitable organization established by local people based on the law（Resolución Ministerial Nº 0837-87-AG）issued on October 14, 1987. Peru irrigation committee is composed of 114 committees which are divided into 1582 sectors. It is registered to the National Committee (Junta Nacional, composed of 7 members elected by all irrigation committees) and acts as an representative of agricultural sector in all Peru, and recognized in the various sectors such as public and private agricultural departments. Each irrigation committee is composed of plural irrigation sectors. The irrigation sector means the unit irrigation area which has same characteristics of irrigation area with same topography, and same intake, secondary and thirdly irrigation canals etc.

The decisions of committee is made by the Assignment Board（Cesión de Consejo Directivo） held twice per month, which is composed of 7 members such as president, vice president, secretary, 2-directors, accountant and assistant accountant etc. The main task of the committee is as follows:

- To promote the agreement of will among members and to integrate members' will as the opinion of the committee
- Effective and fair distribution of water resources
- Administration and operation and maintenance of hydraulic facilities
- Education and capacity building for water resources
- Promotion of agricultural development and increase of life quality by increase of income

(3) Capacity of operation and maintenance

The recent annual budget of the irrigation committee of each basin is as shown in the Table 4.8-1.

Table 4.8-1 Irrigation Committee's budget

Rivers	Annual Budget			(Unit/ S)
	2007	2008	2009	2010
Cañete	2,355,539.91	2,389,561.65	2,331339.69	2,608,187.18

The annual revenue of irrigation committee is composed of ① irrigation water cost (/m3), ② rental cost of heavy equipment to private company etc. and there is no governmental subsidy. And the annual expenditure is composed of ① operation cost of intake facilities (operator cost of intake weir etc.) ② operation and maintenance cost for such as irrigation canal and intake etc., ③ investigation cost for upgrading of irrigation facilities, ④ operation cost for irrigation committee office.

On the other hand the required operation and maintenance cost is as shown in the Table 4.8-2 according to the clause 4.4.1. The ratio of O/M cost to the annual budget in 2009 and to the annual average of the damage reduction amount are also as shown in the same table. The ratio of O/M cost to the annual budget in 2009 is 11.1 % in Cañete river.

On the other hand the ratio of O/M cost to the annual average of the damage reduction amount is 2.1 %, which seems to be very low. The ratio of O/M cost to the annual budget seems to be rather high, however the ratio of O/M cost to the annual average flood damage amount is very low so that after the flood damage is reduced and profit of farmer increase so that it is quite possible that the irrigation committee bears the O/M cost.

And the irrigation committee has heavy equipment such as bull-dozer, excavator, trailer, dump truck etc. and has performed maintenance works for dike, revetment, intake, irrigation channel etc., therefore the committee could carry out the O/M of the facilities constructed in the Project under the technical assistance of MINAG and the regional government.

Table 4.8-2 Ratio of O/M cost to annual budget and damage reduction amount

Irrigation Committee	Annual Budget(1,000soles)	O/M Cost(1,000soles)	Percentage of O/M cost(%)	Average Yearly Damage Reduction(1,000soles)	Percentage of O/M cost(%)
	①	②	③=②/①	④	⑤=②/④
Cañete	2,331	260	11.1	12,274	2.1

(4) Agreement with irrigation committee

The following items are to be discussed and made agreement between the central government (MINAG) and the irrigation committee as soon as possible.

- Sharing ratio of Project cost
- Delivery of flood prevention facilities
- O/M of facilities

- Delivery of plantation along river structure and O/M

4.9 Environmental Impact

4.9.1 Procedure of Environmental Impact Assessment

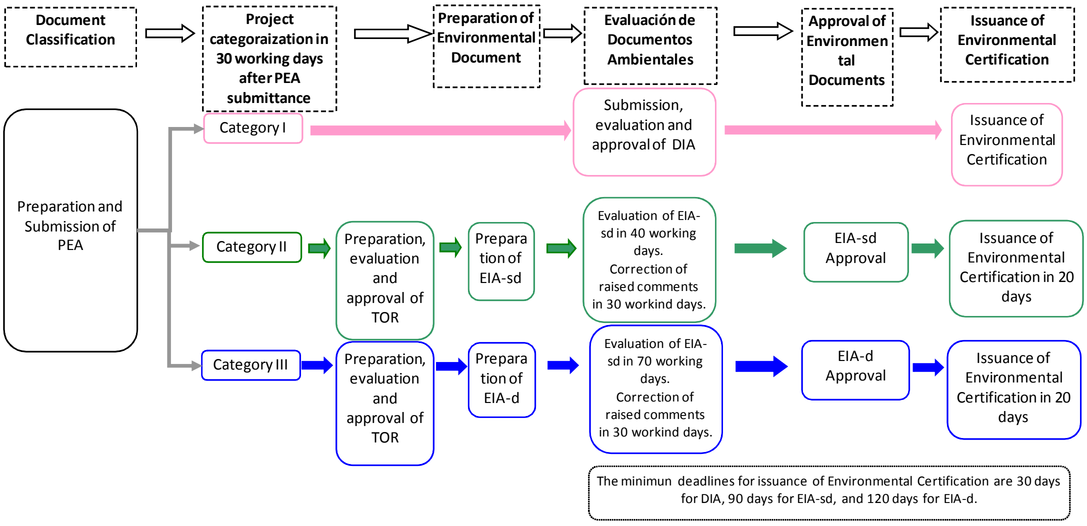
Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The following table shows the environmental management instruments that are required for each category. The Project holder should submit the Environmental Impact Statement (DIA, in Spanish) for all Projects under Category I. The project holder should prepare an EIA-sd or an EIA-d if the Project is categorized under Category II or III, respectively, to be granted the Environmental Certification from the relevant Ministry Directorate.

Table 4.9.1-1 Project categorization and environmental management instruments

	Description	Required Environmental Management Instrument
Category I	It includes those Projects that when carried out, they cause no significant negative environmental impacts whatsoever.	PEA that is considered a DIA after the assessment for this category
Category II	It includes those Projects that when carried out, they can cause moderate environmental impacts, and their negative effects can be removed or minimized through the adoption of easily applicable measures.	Semi-Detailed Environmental Impact Assessment (EIA-sd)
Category III	It includes those Projects than can cause significant quantitative or qualitative negative environmental impacts because of their characteristics, magnitude and/or location. Therefore, a deep analysis is required to revise those impacts and set out a relevant environmental management strategy.	Detailed Environmental Impact Assessment (EIA-d)

Source: Prepared by the JICA Study Team based on the SEIA Law (2001)

The next graph shows the Environmental Document's Classification, the Environmental Document's Assessment, and the Environmental Certification.



Source: Prepared by the JICA Study Team based on the SEIA Regulations (2009)

Figure 4.9.1-1 Process to obtain the environmental certification

First, the Project holder applies for the Project classification, by submitting the Preliminary Environmental Assessment (PEA). The relevant sector assesses and categorizes the Project within the next 30 working days after the document's submission. The Project's PEA that is categorized under Category I becomes an EID, and those Projects categorized under Category II or III should prepare an EIA-sd or EIA-d, as applicable. There are cases in which the relevant sector prepares the Terms of Reference for these two studies, and submits them to the holder. There are other cases in which the holder prepares the Terms of Reference and these are approved by the relevant sector, based on the interview with DGAA. Number of working days required for EIA-sd revision and approval is 90, and number of working days required for EIS-d is 120; however, these maximum deadlines may be extended. The progress of the environmental impact study is as shown below.

The JICA Study Team subcontracted a local Consultant (CIDE Ingenieros S.A.), and a Preliminary Environmental Assessment (PEA) was carried out, from December 2010 to January 2011 for Cañete river.

EAP for the Cañete river was submitted to DGIH from JICA on January 25, 2011. DGIH submitted the EAP to DGAA on July 19, 2011.

EAP for Cañete river was examined by DGAA, and DGAA issued their comments on EAP to DGIH. JICA Study Team revised EAP upon the comments and submitted it to DGAA on September 21, 2011. DGAA completed examination on the revised EAP and issued approval letter on Cañete river in which DGAA classified Cañete river into Category I. Therefore the additional environmental impact analysis for Cañete river is not required.

The positive and negative environmental impact associated with the implementation of this project was confirmed and evaluated, and the plan for prevention and mitigation measures are prepared by

EAP results, field investigation and hearing by JICA Study Team.

The proposed works in this project include: the reparation of existing dikes, construction of new dikes, riverbed excavation, bank protection works, repair and improvement of the derivation and intakes works, and also river expansion. Table 4.9.1-2 describes "working sites" to be considered in the Environmental Impact section for Cañete river.

Table 4.9.1-2 Works description

River	Location		Critical Point	Main Protection Objects	Measure	Feature of Work	
Rio Canete	Ca-1	4..2-5.2 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length Bank Protection Large Boulder Riplap	1,100 m 5,430 m3 9,230 m3
	Ca-2	6.7～8.3 km	Innnuded Point		Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	3,200 m 113,700 m3 28,200 m3
	Ca-3	10.1-11.2 km	Narrow Section		Riverbed Excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=700 m, V=80,270m3 1,630 m 16,730 m3
	Ca-4	24.6-25.0 km	Existing Intake Weir (w:150m, i: 1:2, crest w:2.0m)	Intake Weir, Agricultural Lands	Riverbed excavation、Dike with Bank Protection	Riverbed Excavation Dike with Bank Protection Large Boulder Riplap	L=370 m, V=34,400 m3 L=710m, V=20,150 m3 7,300 m3
	Ca-5	25.1-26.6 km	Narrow Section	Agricultural Lands (Apple, Grape, Cotton, etc.)	Dike with Bank Protection	Length Dike with Bank Protection Large Boulder Riplap	1,520 m 95,125 m3 14,000 m3

Source: JICA Study Team

4.9.2 Methodology

In order to identify environmental impacts of the works to be executed in the different watersheds, we developed identification impact matrixes for watershed.

First, the operation and activities for each project based on typical activities of "hydraulic works" construction were determined. Afterwards, the concrete activities type was determined which will be executed for each work that will be developed in the watersheds. Then, to evaluate Socio-environmental impacts the Leopold matrix was used.

Table 4.9.2-1 Evaluation criterion - Leopold matrix

Index		Description	Valuation
"Na" nature		It defines whether change in each action on the means is positive or negative	Positive (+) : beneficial Negative (-): harmful
Probability of Occurrence "P.O."		It includes the probability of occurrence of the impact on the component	High (>50 %) = 1.0 Medium (10 – 50 %) = 0.5 Low (1 – 10 %) = 0.2
Magnitude	Intensity (In)	It indicates the magnitude of change in the environmental factor. It reflects the degree of disturbance	Negligible (2) Moderate intensity (5) Extreme Disturbance (10)
	Extension "Ex"	It indicates the affected surface by the project actions or the global scope on the environmental factor.	Area of indirect influence: 10 Area of direct influence: 5 Area used up by the works: 2
	Duration "Du"	It refers to the period of time when environmental changes prevail	➢ 10 years: 10 5 – 10 years : 5 1 – 5 years: 2
	Reversibility "Rev"	It refers to the system's capacity to return to a similar, or an equivalent to the initial balance.	Irreversible: 10 Partial return: 5 Reversible: 2

Source: Prepared based on PEAs of 6 Basins

Table 4.9.2-2 Impact significance degrees

SIA	Extent of Significance
≤ 15	Of little significance
15.1 - 28	Significant
≥ 28	Very significant

Source: Prepared based on PEAs of 6 Basins

4.9.3 Identification, Description and Social Environmental Assessment

(1) Identification of social environmental impacts

In the following matrix (construction/operation stages) in all Watersheds, elaborated based on the report analysis of the Preliminary Environmental Assessment.

Table 4.9.3-1 Impact identification matrix (construction and operation stage) – Cañete river

Construction Stage			**Work**	**1-5**	**1-5**	**1-5**	**4,5**	**1,2,3**	**2,4,5**	**1-5**	**1-5**	**1-5**	**1-5**	**1-5**		
Environment	Component	Environmental Factors	**Activity**	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	**Total Negative**	**Total Positive**
Physique	**Air**	PM-10 (Particulate matter)			N	N	N	N		N	N		N	N	**8**	**0**
		Gas emissions			N	N	N	N	N	N	N		N	N	**9**	**0**
	Noise	Noise			N	N	N	N	N	N	N	N	N	N	**10**	**0**
	Soil	Soil fertility			N					N	N				**3**	**0**
		Land Use			N					N	N				**3**	**0**
	Water	Calidad del agua superficial				N	N	N		N		N			**5**	**0**
		Cantidad de agua superficial							N						**1**	**0**
	Physiography	Morfología fluvial				N	N	N		N					**4**	**0**
		Morfología terrestre			N						N				**2**	**0**
Biotic	**Flora**	Terrestrial flora			N						N				**2**	**0**
		Aquatic flora				N	N	N		N					**4**	**0**
	Fauna	Terrestrial fauna			N						N				**2**	**0**
		Aquatic fauna				N	N	N		N					**4**	**0**
Socio-economic	**Esthetic**	Visual landscape								N	N				**2**	**0**
	Social	Quality of life		P								N	N	N	**3**	**1**
		Vulnerability - Security													**0**	**0**
	Economic	PEA		P											**0**	**1**
		Current land use													**0**	**0**
Total				**2**	**8**	**7**	**7**	**7**	**3**	**10**	**9**	**3**	**4**	**4**	**62**	**2**
Percentage of positive and negative															**97 %**	**3 %**

:

Negative, P:Positive
Source: Prepared by the JICA Study Team

Operation Stage			**Works**	Riverbed without Silting Point 1	Dike-Right Side Point 2	Riverbed without Silting Point 3	Intake Point 4	Protection - Right Side Point 5	**Total Negative**	**Total Positive**
Environment	**Component**	**Environmental Factors**								
Physique	**Air**	PM-10 (Particulate matter)							**0**	**0**
		Gas emissions							**0**	**0**
	Noise	Noise							**0**	**0**
	Soil	Soil fertility						P	**0**	**1**
		Land Use							**0**	**0**
	Water	Calidad del agua superficial					P	P	**0**	**2**
		Cantidad de agua superficial		P	P	P	P		**0**	**3**
	Physiography	Morfología fluvial		N	N	N			**3**	**0**
		Morfología terrestre							**0**	**0**
Biotic	**Flora**	Terrestrial flora							**0**	**0**
		Aquatic flora							**0**	**0**
	Fauna	Terrestrial fauna							**0**	**0**
		Aquatic fauna		N	N	N			**3**	**2**
Socio-economic	**Esthetic**	Visual landscape		P	P	P		P	**0**	**4**
	Social	Quality of life		P	P	P	P	P	**0**	**5**
		Vulnerability - Security		P	P	P	P	P	**0**	**5**
	Economic	PEA							**0**	**0**
		Current land use		P	P	P	P	P	**0**	**4**
Total				**7**	**7**	**7**	**5**	**6**	**6**	**26**
Percentage of positive and negative									**19 %**	**81 %**

N: Negative, P:Positive
Source: Prepared by the JICA Study Team

On the Cañete River basin, based on the impact identification results for the construction stage, a total number of 64 interactions have been found. 62 of these interactions (97 %) correspond to impacts that will be perceived as negative, and 2 (3 %) correspond to impacts that will be perceived as positive. In addition, 32 interactions have been found for the operation stage; 6 of these interactions (19 %) correspond to impacts that will be perceived as negative, and 26 (81 %) correspond to impacts that will be perceived as positive.

(2) Environmental and social impact assessments

Environmental and social impacts are assessed with the methodology that was explained in 4.9.2 Methodology. The following tables show the environmental and social assessment results for each basin, during the construction and operation stages.

Table 4.9.3-2 Environmental impact assessment matrix – Cañete river

			The Cañete River Basin															
			Construction Stage											Operation Stage				
Medio	**Componente**	**Acciones del proyecto**	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Diversion of riverbed (Cofferdams)	Digging and refilling in riverside	Digging and refilling in riverbed	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	**Ca1**	**Ca2**	**Ca3**	**Ca4**	**Ca5**
		Puntos de Obras: **Factores Ambientales**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**	**Ca 4 y 5**	**Ca 1, 2 y 3**	**Ca 4 y 5**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**	**Ca 1-5**					
Physique	**Air**	PM-10 (Particulate matter)	0.0	-12.0	-12.0	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0	0.0	0.0	0.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0	0.0	0.0	0.0	0.0
	Noise	Noise	0.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0
	Soil	Soil fertility	0.0	-11.5	0.0	0.0	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.0
		Land Use	0.0	-14.2	0.0	0.0	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-17.5	-12.0	-23.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.0	31.0
		Cantidad de agua superficial	0.0	0.0	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	31.0	26.0	31.0	26.0	0.0
	Physiography	Morfología fluvial	0.0	0.0	-12.0	-20.0	-31.0	0.0	-23.0	0.0	0.0	0.0	0.0	-30.5	-25.5	-30.5	0.0	0.0
		Morfología terrestre	0.0	-33.0	0.0	0.0	0.0	0.0	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Biotic	**Flora**	Terrestrial flora	0.0	-28.0	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic flora	0.0	0.0	-12.0	-14.5	-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-12.0	-14.5	-22.5	0.0	-15.0	0.0	0.0	0.0	0.0	-30.5	-25.5	-30.5	0.0	0.0
Socio-economic	**Esthetic**	Visual landscape	0.0	0.0	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0	36.0	36.0	0.0	36.0
	Social	Quality of life	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-17.5	-17.5	-17.5	36.0	36.0	36.0	31.0	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	31.0	36.0
	Economic	PEA	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0	36.0	36.0	36.0	36.0

Grade of Positive Impacts			Grade of Negative Impacts		
⬜	0–15.0	Little significant	⬜	0–15.0	Little significant
🟩	15.1–28.0	Significant	🟥	15.1–28.0	Significant
🟩	28.1–	Very significant	🟧	28.1–	Very significant

Source: Prepared based on PEAs from 6 Basins

It must be pointed out that in the Cañete River basin only 15 out of a total of 62 negative impacts have been quantified as significant, and 2 have been quantified as very significant, during the construction stage. Meanwhile, out of a total of 6 negative impacts, only 2 have been quantified as significant, and 4 have been quantified as very significant, during the operation stage.

During the construction stage, the works site preparation component and the DME installation and operation will significantly affect the land morphology. During the operation stage, river morphology and aquatic fauna will be significantly affected at “Ca1” and “Ca3” points, where the river basin will be unclogged.

During the construction stage, actions that will generate most significant negative impacts along the basin include: “Site Works Preparation and Clearance”, “Riverbed Excavation and Filling”, and “Surplus Material Deposits Operation (DME, in Spanish).” “Site works Preparation and Clearance” will bring about a significant modification to the land morphology, whereas “Riverbed Excavation and Filling” will bring about a significant modification to river morphology.

During the operation stage, hydraulic infrastructure works that will bring about most significant negative environmental impacts include “Riverbed excavation and embankment” that will cause a modification to the river morphology and subsequently, decreased river habitability conditions that will directly impact the aquatic fauna.

Most significant positive impacts are related to all works to be constructed along the river basins, and are directly related to improve the quality of the lives of the population around the area of influence, improve the “Current Use of land / soil”, improve the security conditions, and reduce vulnerability at social and environmental levels.

4.9.4 Socio-Environmental Management Plans

The objective of the Socio-Environmental Plans is to internalize both positive and negative significant and very significant environmental impacts that are related to the Project’s construction and operation stages, so that prevention and/or mitigation of significant and very significant negative impacts, preservation of environmental heritage, and Project sustainability are ensured.

During the construction stage, Project of Cañete river has set out the following measures: “Local Hiring Program”, “Works Sites Management and Control Program”, “Riverbed Diversion Program”, “Riverbank Excavation and Filling Management”, “Riverbed Excavations and Filling Management”, “Quarry Management”, “DME Management”, “Camp and Site Residence Standards”, and “Transportation Activity Management.” During the operation stages, Project for the basin has considered the development of activities with regard to “Riverbed and Aquatic Fauna Management”. These activities should develop riverbed conditioning downstream the intervention points, for erosion probabilities to be reduced, and habitability conditions to be provided for aquatic fauna species. The following are measures related to those negative impacts to be mitigated or those positive impacts to be potentiated. Overall measures have been established for the basin, based on the impacts.

Table 4.9.4-1 Environmental impact and prevention/mitigation measures

Item	Impact	Counter Measures	Period
Natural environment	Water quality of surface water	Management of river diversion and coffering	Construction period
		Management of bank excavation and banking	
		Management of riverbed excavation and back filling	
	River topography	Management of bank excavation and banking	
		Management of riverbed excavation and back filling	
		Management of quarry site	
	Other topography	Management of construction site	
		Management of large amount of excavated or dredged material	
	Dust	Management of construction site	
		Management of large amount of excavated and dredged material	
Biological environment	Aquatic fauna	Management of riverbed excavation and back filling	O/M period
	Terrestrial fauna	Management of construction site	Construction period
		Management of large amount of excavated and dredged material	
	Terrestrial flora	Management of construction site	
		Management of large amount of excavated and dredged material	
Social environment	Quality of life	Management of labor and construction office	
		Management of traffic of construction vehicle	
		Employment plan of local people	
	Population of economic activity	Employment plan of local people	

Source: JICA Study Team

4.9.5 Monitoring and Control Plan

(1) Follow up and monitoring plan

The follow-up plan has to implement firmly the management of environmental plan. The monitoring plan is to be carried out to confirm that the construction activity fulfill the environmental standard such as Environmental Quality Standards (EQS) either or Maximum Permissible Limits (MPL). And the monitoring and control must be carried out under the responsibility of the project's owner or a third party under the supervision of the owner.

· Construction stage
During the construction period of the projects to be done in the watershed, the Monitoring and Control Plan will be directed to the verification of the fulfillment measures designed as part of the environmental monitoring plan and the verification of the fulfillment of laws and regulation of the Peruvian Legislation. The following aspects will also be monitored:

Water Quality and Biological Parameters:
Water quality and biodiversity parameters control shall be performed at downstream of these works must be monitored. In the following table the profile of this plan is shown.

Table 4.9.5-1 Monitoring to water quality and biological parameters

Item	**Unit**	**Measured Value (Mean)**	**Measured Value (Max.)**	**Country's Standards**
pH	pH			"National Standard for Water Quality" D.S. No. 002-2009 MINAM
TSS	mg/l			
BOD/COD	mg/l			
DO	mg/l			
Total Nitrogen	mg/l			
Heavy Metals	mg/l			
Temperature	^{o}C			
Biological Diversity indices: Shannon; Pielou; richness and abundance				

[Measurement Points]
-50 meters upstream the intervention points
-50 meters downstream the intervention points
-100 meters downstream the intervention points
[Frequency]
Quarterly
[Person in charge of Implementation]
DGIH-MINAG, or a third party under the project holder's supervision
Source: JICA Study Team

Air quality:
During impact analysis, in the projects to be developed in the watershed no significant impacts will be seen in the activities related to hydraulic infrastructure works. However, the generation of dust and atmospheric contaminant emissions always affects the working area and the workers and inhabitants health. So, it is recommended to monitor air quality.

Table 4.9.5-2 Monitoring to air quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Peruvian Standards (D.S. No 074-2001-PCM)	Referred International Standards
SO^2				"National Standard for Air Quality" D.S. No.074-2001-PCM	National Ambient Air Quality Standards (NAAQS) (Updated in 2008)
NO^2					
CO					
O^3					
PM-10					
PM-2.5					

[Measurement Points]
*02 stations per monitoring point: Windward and downwind (upwind and against the wind direction)
-1 point at the working zones
-1 point at a quarry, away from the river (the largest and / or the closest point to a populated area)
-1 point at a D.M.E. (the largest and / or the closest point to a populated area)
[Frequency]
Quarterly
[Person in charge of the Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

<u>Noise quality</u>

Likewise, it is proposed to perform a noise monitoring at the potential receptors located near the noise emission spots towards the working sites, in the next table 4.9.5-3, the terms are described.

Table 4.9.5-3 Monitoring to noise quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards
Noise level	LAeqT (dB(A))			National Environmental Quality Standards for noise (EQS) - S.N. N° 085-2003-PCM	-IEC 651/804 – International -IEC 61672- New Law: Replaces IECs 651/804 -ANSI S 1.4 – America

[Measurement Point]
Monitoring to acoustic contamination levels will be carried out at the potential receivers that are located around the noise emission points per work front.
01 point per potential receiver will be monitored.
[Frequency]
Every two months during construction phase
[Person in charge of the Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

· Operation stages

Regarding works impact of all projects, it is mainly recommended to monitor biologic parameters and water quality as river topography and the habitat of aquatic life.

Table 4.9.5-4 Monitoring to water quality (operation stage)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards
pH	pH			"National Standard for Water Quality" D.S. No. 002-2009 MINAM
TSS	mg/l			
BOD/COD	mg/l			
DO	mg/l			
Total Nitrogen	mg/l			
Heavy Metals	mg/l			
Temperature	^{o}C			
Biological Diversity indices: Shannon; Pielou; richness and abundance				

[Measurement Points]
-50 meters upstream the intervention points
-50 meters downstream the intervention points
-100 meters downstream the intervention points
[Frequency]
Quarterly in first two years of operation phase
[Person in charge of Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

(2) Closure or abandon plan

Closure or abandon plans have been made for each watershed. These will be executed at the end of construction activities and involves the removal of all temporary works and restoration of intervened and/or affected areas as a result of the works execution. The restoration includes the removal of contaminated soil, disposal of waste material, restoration of soil morphology and restoration with vegetation of intervened sites.

(3) Citizen participation

Citizen participation plans have been made for each watershed, which must be executed before and during construction and when the works are completed. The recommended activities are:

- Before works: Organize workshops in the surrounding community's area near the project and let them know what benefits they will have. Informative materials in communities, which will explain the profile, lapse, objectives, benefits, etc. of the Project
- During works execution: Give out information on the construction progress. Responding complaints generated from the local community during works execution. For this, a consensus wants to be previously achieved with the community in order to determine how claims will be met
- When works are completed: Organize workshops to inform about works completion. Works delivery to the local community inviting local authorities for the transfer of goods, which means the work finished.

4.9.6 Cost for the Environmental Impact Management

The cost for the environmental management in this Project is as shown in the Table 4.9.6-1. In the table, (1) shows the cost for the environmental management of each facility, based on which the cost required in the basin (2) is calculated. And the cost for the counter measures 1) – 7) is calculated based on the accumulated construction period of each facility which is described in the Annex-9 Construction Plan/Cost Estimate, Table 2.1-1.

Table 4.9.6-1 Cost of environmental management plan

4.9.7 Conclusions and Recommendations

(1) Conclusions

According to the Preliminary Environmental Appraisals to Cañete basin, most impacts identified during the construction and operation stages were found out to be of little significance. Significant and very significant negative impacts can be controlled or mitigated, as long as suitable Environmental Management Plans are carried out. In addition, the Project will be implemented in the short term, as environmental conditions will be quickly restored. However, the execution of a follow – up and monitoring plan is important, and in the event that unexpected impacts are generated, immediate mitigation measures must be taken.

In addition, significant positive impacts are also present, especially during the operation stage. These positive impacts include: An enhanced security / safety and a decreased vulnerability at social and environmental levels; an improved quality of life among the population in the area of influence, and an improved “Current use of land / soil”.

(2) Recommendations

1) We mainly recommend that the beginning of the construction activities coincides with the beginning of the dry seasons in the region (May to November) when the level of water is very low or the river dries up. Each river characteristics / features should be taken into account, that is, that the Cañete river is year - round rivers. At the same time, the crop season cycle in the areas of direct influence should be taken into account, so that traffic jams caused by the large trucks and farming machinery is prevented.
2) It is recommended that the Project holder (DGIH) should define the limit of river area during detailed design stage, and identify the people who live within the river area illegally. Continually the DGIH should carry on the process of land acquisition based on the Land Acquisition Low, which are; Emission of Resolution for land acquisition by the State, Proposition of land cost and compensation for land owner, Agreement of the State and land owner, Payment, archaeological

assessment certification.

3) DGIH has to promote the process to obtain the CIRA in the detail design stage. The process to be taken is i) Application form, ii) Copies of the location drawings and outline drawings, iii) voucher, iv) Archaeological Assessment Certificate.

4) The participation of the women in the workshops can be promoted through the existing women group such as Vaso de Leche.

Finally, the DGAA submitted the resolutions (Environmental Permissions) for Cañete basin, which has been categorized as “Category I”, which means that the Project is not required to carry out neither EIA-sd nor EIA-d.

4.10 Institutions and Administration

Peruvian institutions regarding the Project’s execution and administration are the Agriculture Ministry, Economy and Finance Ministry and Irrigation Commission, with the following roles for each institution. The following description was prepared by the local consultant and governmental offices and is used in the office of DGIH.

Ministry of Agriculture (MINAG)

＊The Ministry of Agriculture (MINAG) is responsible for implementing programs and the Hydraulic Infrastructure General Direction (DGIH) is responsible for the technical administration of the programs. The Hydraulic Infrastructure General Direction (DGIH) is dedicated to the coordination, administration and supervision of investment programs

＊In investment stage, the PSI(Programa Subsectorial de Irrigaciones, Ministerio de Agricultura) is dedicated to calculate project costs, detail design and supervision of the works execution.

＊The Planning and Investment Office (OPI) from the Agriculture Ministry is the one responsible for pre-feasibility and feasibility studies in the pre-investment stage of DGIH projects and requests approval of DGPI(previous DGPM) from the Economy and Finance Ministry (MEF)

＊The General Administration Office of the Agriculture Ministry (OGA-MINAG) along with the Public Debt National Direction (DGETP, previous DNEP) of the Economy and Finance Ministry is dedicated to financial management. It also manages the budget for procurement, commissioning works, contracting, etc. from the Agriculture Ministry

＊The Environmental Affairs General Direction (DGAA) is responsible for reviewing and approving the environmental impact assessment in the investment stage

Economy and Finance Ministry (MEF)

＊The DGPI approves feasibility studies. It also confirms and approves the conditions of loan contracts in yen. In the investment stage, it gives technical comments prior to the project execution.

＊Financial management is in charge of DGETP (previous DNEP) from the Economy and Finance Ministry and OGA-MINAG

＊The Public Debt National Direction DGETP (previous DNEP) of the Economy and Finance Ministry administers expenses in the investment stage and post-investment operation

Irrigation Commission

＊Responsible for the operation and maintenance of facilities at the post-investment operation stage

The relationship between the involved institutions in the Project's execution is shown in Figures 4.10-1 and 4.10-2.

In this Project, PSI from MINAG is scheduled to be the execution agency in the investment stage (Project execution). The PSI is currently performing JICA projects, etc. and in case of beginning a new project, it forms the correspondent Project Management Unit (PMU), and PSI is responsible of employment of international consultant with deep experience on Japanese Yen Loan project and carried out the detail design, procurement of contractor, and supervision of construction work etc. The following figure describes the structure of the different entities involved in the Project's execution stage. PMU is organized directly under PSI and the organization is as shown in the Figure-4.10-4.

The Agreement of Fund Transfer and Fund Management in the Figure-4.10-1 means MEF transferrs the fund to PSI and controls the expenditure.

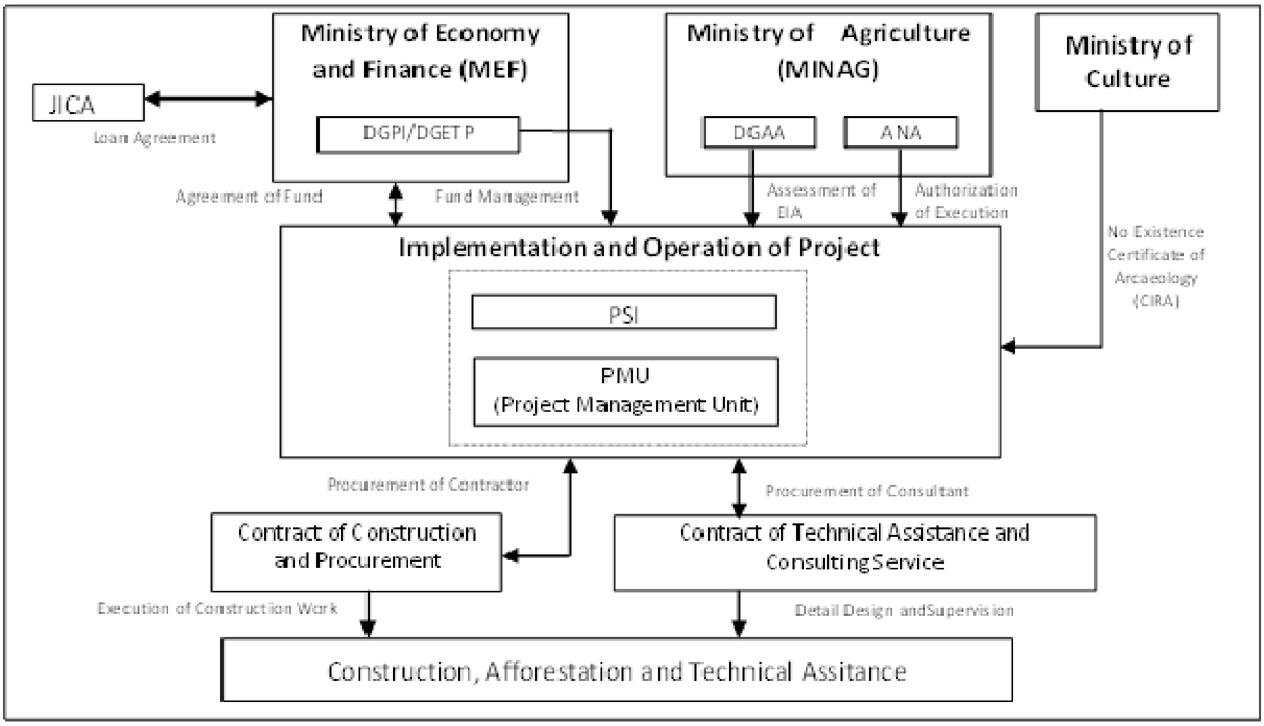


Figure 4.10-1 Related agencies in implementation stage of project

The main operations in the post-investment stage consist of operation and maintenance of the built works and the loan reimbursement. The O & M of the works will be assumed by the respective irrigation commission.

Next, the relationship of different organizations involved in post-project implementation stage is detailed.

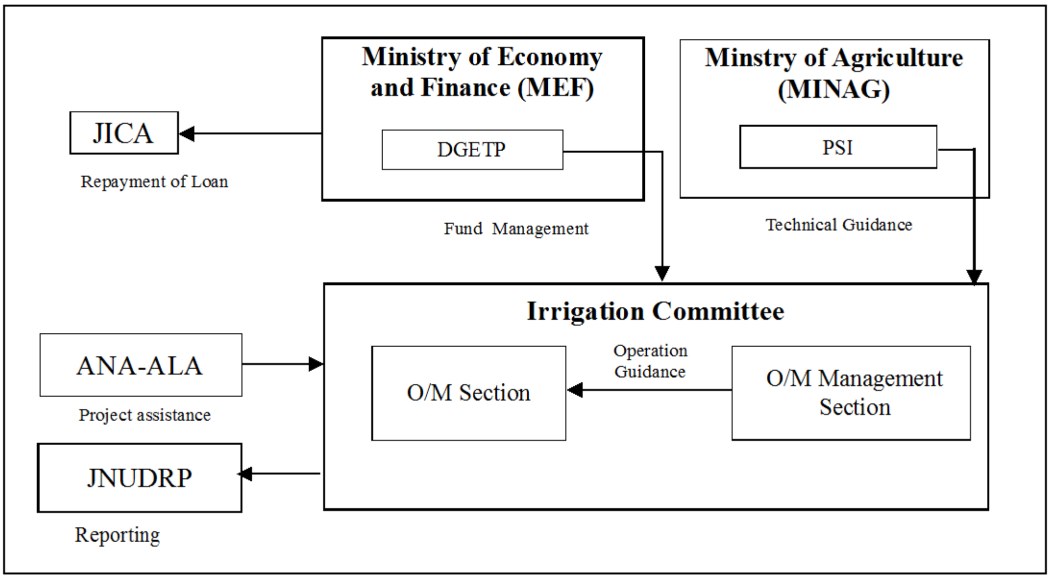


Figure 4.10-2 Related agencies in operation stage of project

(1) DGIH

1) Role and functions

The Hydraulic Infrastructure General Direction is in charge of proposing public policies, strategies and plans aimed to promoting water infrastructure development, according with the Water Resources National Policy and the Environmental National Policy.

Water Infrastructure development includes studies, works, operation, maintenance and construction risk management, fit-out, improve and expand dams, intakes, river beds, irrigation channels, drains, meters, outlets, groundwater wells and modernize plot irrigation.

2) Main functions

a) Coordinate with the planning and budget office to develop water infrastructure and propose sectorial and management policies on infrastructure development. Monitor and assess the implementation of sectorial policies related to hydraulic infrastructure development

b) Propose government, region and provinces intervention regulations, as part of sectorial policies

c) Verify and prioritize hydraulic infrastructure needs

d) Promote and develop public investment projects at the hydraulic infrastructure profile level

e) Elaborate technical regulations to implement hydraulic infrastructure projects

f) Promote technological development of hydraulic infrastructure

g) Elaborate operation and maintenance technical standards for hydraulic infrastructure

(2) PSI

1) Function

The Irrigation Sub-sectorial Program (PSI) is responsible of executing investment projects. A respective management unit is formed for each project.

2) Main functions

a) Irrigation Sub-sectorial Program - PSI, under the Agriculture Ministry, is a body with administrative and financial autonomy. It assumes the responsibility of coordinating, managing and administering involved institutions in projects in order to meet goals and objectives proposed in investment projects

b) Also, it coordinates the disbursements of foreign cooperation agencies financing, such as JICA.

c) The Planning, Budget and Monitoring Office of PSI is responsible for hiring services, elaborating investment programs, as well as project execution plans. These Project preparation works are executed by hiring "in-house" consultants.

d) Likewise, it gathers contractors, makes a lease, executes works and implements supply projects, etc.

e) Contract management is leaded by the Planning, Budget and Monitoring Office

3) Budget

In Table 4.10-1 the PSI budget for 2011 is shown.

Table 4.10-1 PSI budget (2011)

Programs / Projects / Activities	**PIM (S/.)**
JBIC Program (Loan Agreement EP-P31)	69.417.953
Program - PSI Sierra (Loan Agreement 7878-PE)	7.756.000
Direct management works	1.730.793
Southern Reconstruction Fund (FORSUR)	228.077
Crop Conversion Project (ARTRA)	132.866
Technified Irrigation Program (PRT)	1.851.330
Activity- 1.113819 small farmers...	783.000
PSI Management Program (Other expenses)	7.280.005
TOTAL	**89.180.024**

4) Organization

PSI is confirmed by 235employees, from which 14 are assigned for JBIC Projects and 29 technicians and assistants are working under them.

Table 4.10-2 PSI payroll

Central Level	**Data from May 31, 2011**		
	CAS	**Servic. and Consult.**	**TOTAL**
Main Office	61	43	104
Zonal Office LIMA	12	24	36
Zonal Office AREQUIPA	14	12	26
Zonal Office CHICLAYO	17	13	30
Zonal Office TRUJILLO	13	26	39
TOTAL	**117**	**118**	**235**

In Figure 4.10-3, PSI organization is detailed:

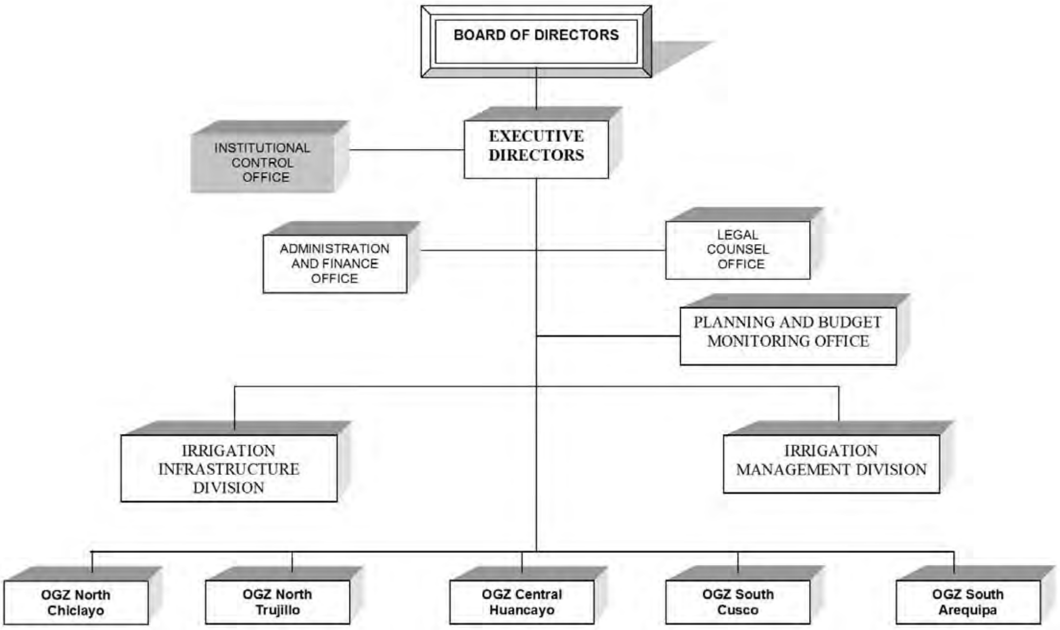
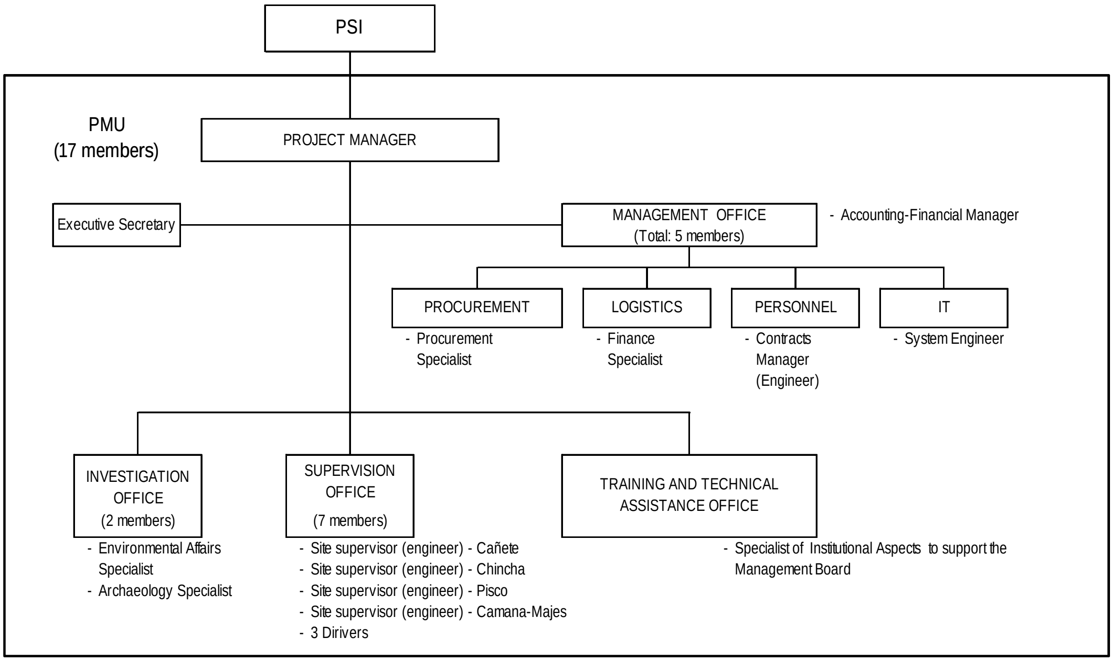


Figure 4.10-3 Organization of PSI

(3) Organization of PMU(Project Management Unit)

1) Organization

PMU is installed directly connected the Irrigation Infrastructure Division of PSI. The organization of PMU is as shown in the Figure 4.10-4.



Note: ( ) shows number of personnel

Figure 4.10-4 Organization of PMU

2）Main staff

PMU is composed of the following main staff.

—Project manager

—Contract specialist

—Construction supervisor

—IT specialist

—Procurement specialist

—Financial specialist

—Organization specialist (Adviser to the irrigation commitee)

—Environmental assessment specialist

—Archeological specialist

—Accountant

3）Cost

The cost for operation of PMU is budgeted at 8.5 million soles as described in the clause 4.4.1, Table 4.4.1-11.

The Project will be promoted safely, by installing PMU in the implementation agency PSI) and receiving the assistance of the consultant procured separately.

4.11 Execution Plan

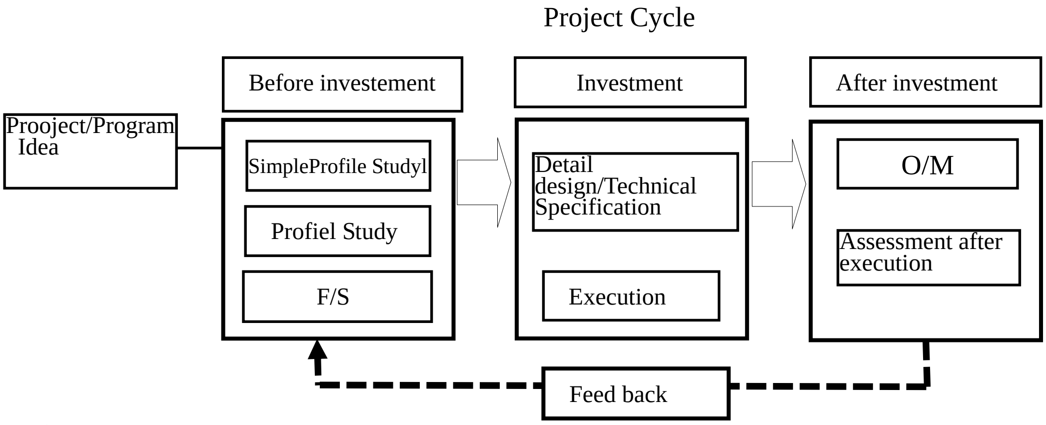
The Project's Execution Plan will be examined in the preliminary schedule, which includes the following components. For pre-investment stage: ① full execution of profile and feasibility studies to obtain SNIP's approval in the pre-investment stage; for the investment stage: ② signing of loans (L/A), ③ consultant selection, ④ consulting services (detailed design and elaboration of technical specifications), ⑤ constructor selection and ⑥ work execution. For the post-investment stage: ⑦ Works' completion and delivery to water users associations and beginning of the operation and maintenance stage.

(1) Review by the Public Investment National System (SNIP)

In Peru, the Public Investment National System (SNIP hereinafter) is under operation. This reviews the rationality and feasibility of public investment projects, and will be applied to this Project.

In SNIP, among previous studies to an investigation, it will be conducted in 3 stages: profile study (study on the project's summary), pre-feasibility and feasibility. SNIP was created under Regulation N° 27293 (published on June 28, 2000) in order to achieve efficient use of public resources for public investment. It establishes principles, procedures, methods and technical regulations to be fulfilled by central/regional governments in public investment scheme plans and executed by them.

SNIP, as described below, is all public works projects which are forced to perform a 3-stage pre-investment study: profile study, pre-feasibility and feasibility, and have them approved. However, following the Regulation amendment in April 2011, the execution of pre-feasibility study of the intermediate stage was considered unnecessary; but in return, a study based on primary data during the profile study is requested. The required precision degree throughout all stages of the study has hardly changed before and after this modification.

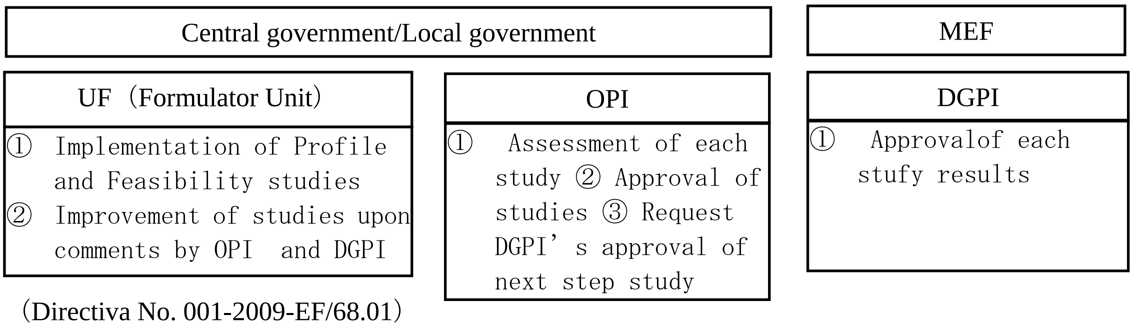


（Source：DGPI)

Figure 4.11-1 SNIP Project cycle

In order to carry out this Project, which is a project composed by several programs, pre-investment studies at investments' programs level are required to be performed and also have them approved.

Although the procedure is a little bit different in each stage, in SNIP procedures, the project's formulation unit (UF) conducts studies of each stage, the Planning and Investment Office (OPI) assesses and approves the UF's presented studies and requests Direction General of Investment Policy (hereinafter referred to DGPI) to approve feasibility studies and initiation of following studies. Finally DGPI evaluates, determines and approves the public investment's justification.



Central government/Local government

MEF

UF（Formulator Unit）

① Implementation of Profile and Feasibility studies
② Improvement of studies upon comments by OPI and DGPI

OPI

① Assessment of each study ② Approval of studies ③ Request DGPI' s approval of next step study

DGPI

① Approvalof each stufy results

（Directiva No. 001-2009-EF/68.01）

Figure 4.11-2 Related institutions to SNIP

Due to the comments of examining authorities (OPI and DGPI) to UF, it will be necessary to prepare correspondent responses and improve the studies. Since these authorities officially admit applications after obtaining definitive answers, there are many cases in which they take several months from the completion of the study report until the completion of the study.

It is important to obtain well recognition of the contents and effectiveness of the project, for which UF is required to present the effect of project from the view point of study, design, construction plan as well as public investment and operation in continuity of the project. The study of natural conditions, planning of facilities, cost estimate, financial analysis etc. and also the table of contents of the study report should follow the regulation of SNIP.

DGIH registered Cañete river to SNIP on July 21, 2011 based on the Project Report of Cañete river.

OPI had examined project reports with pre-F/S level of Cañete river from the end of July and issued their comments on September 22, 2011. DGIH revised the report of Cañete river, and submitted to OPI in May 2012. OPI transferred the revised report to DGPI with its comments in July 2012 and DGPI approved the proceed to F/S with its comments in October 2012.

(2) Yen loan contract

Once the feasibility report of this Project is submitted, then the OPI and DGPI examine the contents of report, and finally the declaration of viability of the Project is to be issued by DGPI. When the declaration of viability is almost confirmed, the appraisal mission of JICA is dispatched and the negotiation of loan agreement is commenced and Loan Agreement (LA) is concluded. The period of negotiation period is assumed about 6 months.

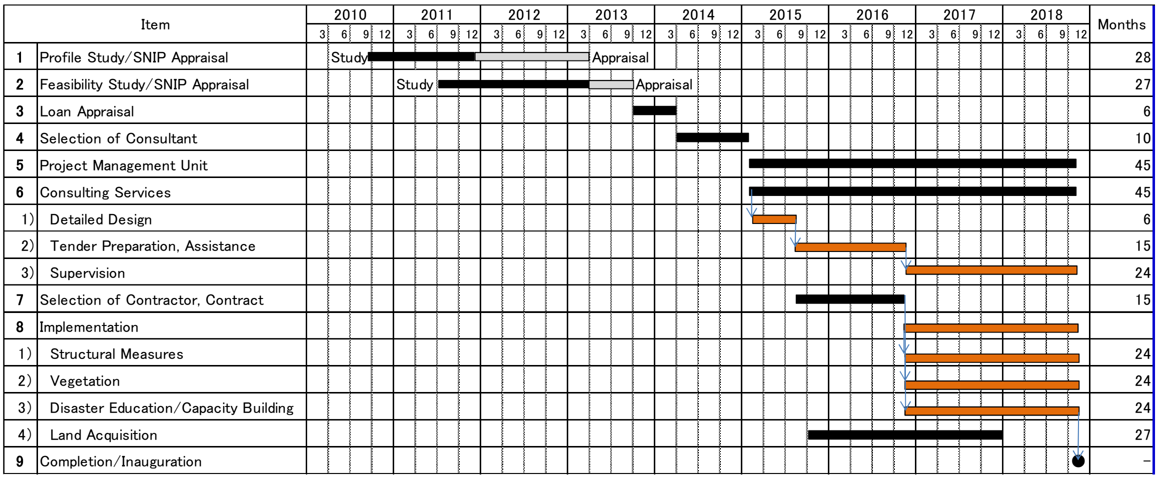
(3) Procedure of the project's execution

After the documents are assessed by SNIP and a loan agreement between Japan (JICA) and the

Peruvian counterpart is signed, a consultant will be selected. The consulting service includes the detailed design and technical specifications, the contractors' selection and the work's supervision. Next find the required time for each process. Table 4.11-1 presents the Project's overall schedule (As to the details of construction time schedule, refer to Annex-9 Construction Planning and Cost Estimate).

1) Consultant selection: 10 months
2) Detailed design and technical specifications of the work: 6 months
3) Contractor selection: 15 months
4) Construction supervision by Consultant on river structures and plantation along river structures: 24 months
5) The afforestation along river structures is carried out in parallel with the construction.
6) Disaster prevention education/Capacity development is carried out from time to time in parallel with construction work.

Table 4.11-1 Implementation plan



(4) Procurement

1) Employment of consultants

The employment of consultant is to be made according the following itmes:

① The consultants should be active in international market and have enough qualification and experience.

② The consultants are to have efficiency, transparency and non-discrimination among eligible consultants

③ The selection procedure should be taken in accordance with the stipulation in the Loan Agreement and the guideline for the Employment of Consultants under Japanese ODA Loans prepared by JICA

2) Procurement of contractor

The procurement of contractors is to be made according to the following items:

① The procurement of contractors is to be made using due attention to consideration s of economy, efficiency, transparency and non-discrimination among eligible bidders.

② The procurement procedure should be taken in accordance with the stipulation in the Loan Agreement and the guideline for the Employment of Consultants under Japanese ODA Loans prepared by JICA

③ The International Competitive Bidding: ICB is to be applied.

④ The pre-qualification (PQ) of bidders is to be applied in order to confirm the technical and financial capability of bidders. The following items are to be considered in PQ: a) experience of and past performance on similar contracts, b) capabilities with respect to personnel, equipment and plant, c) financial position.

4.12 Financial Plan

(1) Sharing ratio of project cost

This project will be implemented by the central government (through the DGIH), irrigation committees and regional governments. Also, the project cost will be covered with the respective contributions of the three parties.

As to the sharing ratio among the central government, regional government and irrigation committee, DGIH reported that in some dam project the ratio among the central government, regional government , local government and irrigation committee is 50%, 30%, 10% and10% respectively and JICA Peru office reported that in some irrigation project, the irrigation committee bore 20 %. However there are no such examples as the flood protection project of this Project

Considering the direct benefit received by the irrigation committee is not so much as in the irrigation project, the sharing percentage will be determined through discussions among stake holders, the ratio is assumed provisionally 80% for the central government (in this case MINAG), 15% for regional government and 5% for irrigation committee. And the final ratio will be determined through negotiation among 3 parties.

(2) Financial plan

The total project cost is

The counter fund is divided into stakeholders as shown in the Table 4.12-1. The contribution of regional government and irrigation committee is distributed in proportion of project cost of each basin.

Table 4.12-1 Financial plan at implementation of project

(3) Repayment of loan

The yen loan shall be repaid according to the conditions stipulated in the Loan Agreement which is estimated as shown in the Table 4.12-2. The repayment will be made by the stakeholders according to the sharing ratio including the interest of loan.

Table 4.12-2 Estimated conditions of Japan Yen Loan

Interest	1.70%
Commitment Charge	0.10%
Maturity Period	25 years

Grace Period	7 years

4.13 Logical Framework of The Eventually Selected Option

In Table 4.12-1 the logical framework of the definite selected option is shown.

Table 4.13-1 Logical framework of the definite selected option

Narrative Summary	Verifying Indicators	Verifying Indicators Media	Preliminary Conditions
Superior Goal			
Promote socioeconomic local development and contribute in communities' social welfare.	Improve local productivity, generate more jobs, increase population's income and reduce poverty index	Published statistic data	Socio-economic and policy stability
Objectives			
Relief the high vulnerability of valleys and local continuity to floods	Types, quantity and distribution of flood control works, population and beneficiaries areas	Monitoring annual calendar works and financial plan, budget execution control	Ensure the necessary budget, active intervention from central and regional governments, municipalities, irrigation communities, local population, etc.
Expected results			
Reduction of number and flooded areas, functional improvement of intakes, irrigation channels protection, bank erosion control	Number of areas and flooded areas, water intake flow variation, bank erosion progress	Site visits, review of the flood control plan and flood control works reports and periodic monitoring of local inhabitants	Maintenance monitoring by regional governments, municipalities and local community, provide timely information to the superior organisms
Activities			
Component A: Structural Measures	Dikes rehabilitation, intake and bank protection works construction of 23 works, including dike's safety	Detailed design review, works reports, executed expenses	Ensure the works budget, detailed design/works execution/good quality works supervision
Component B: Non-Structural Measures (Reforestation and vegetation recovery)	Reforested area, coastal forest area	Works advance reports, periodic monitor by local community	Consultants support, NGO's, local community, gathering and cooperation of lower watershed community
Component C: Disaster prevention and capabilities development education	Number of seminars, trainings, workshops, etc	Progress reports, local governments and community monitoring	Predisposition of the parties to participate, consultants and NGO's assessments
Project's execution management			
Project's management	Detailed design, work start order, work operation and maintenance supervision	Design plans, work's execution plans, costs estimation, works specifications, works management reports and maintenance manuals	High level consultants and contractors selection, beneficiaries population participation in operation and maintenance

4.14 Baseline For Impact Assessment

The indicators of impact assessment are as shown below.

- Scale of flood discharge
- Inundation area
- Damage caused by flood
- Environment impact
- Operation and maintenance cost

1) Scale of flood discharge

As to the flood which causes the damage, the flood discharge is to be estimated using the rainfall and discharge observation data. Since the probable flood discharges were estimated in each basin in this Study, the occurrence probability of actual flood could be estimated and the impact given by the flood could be assessed.

2) Inundation area

The inundation caused by the actual flood is to be plotted on the topographical map or satellite image so that the inundation area around flood prevention facilities can be identified. Since the inundation area corresponding to the probable flood was estimated in the this Study, this area can be compared with the actual inundation area and the impact given by the actual inundation can be assessed.

3) Flood damage

The actual flood damage is to be estimated foe crops, loss of farm land, irrigation facilities, intake, traffic interruption, and other indirect damage. The actual damage can be compared with the damage caused by the probable flood. The impact caused by the actual damage can be assessed.

4) Environment impact

In the operation and maintenance stage, the environment impact is to be assesses regularly using the same method in this Study. The results are to be compared with the original results, then the environmental impact of the project can be assessed.

5) Operation and maintenance cost

The operation and maintenance cost of the Project was estimated in this Study. The actual O/M cost incurred to the irrigation committee is monitored in every year. The actual cost is to be compared with the estimated and the impact on O/M cost can be assessed.

4.15 Middle and Long Term Plan

Up to this point, only flood control measures have been proposed and these must be executed most urgently, due to the limitations on the available budget for this Project. However, there are other measures that must be performed in the long term framework. In this section we will be talking about the middle and long term flood control plan.

4.15.1 Flood Control General Plan

There are several ways to control floods in the entire watershed, for example building dams, reservoirs, dikes or a combination of these.

In case of building a dam proposal, assuming that this dam will reduce the flood peak with a 10 year return period reaching a return period flow of 50 return years, it will be necessary to build a dam with a very big capacity, calculating it in 14.6 million m3 for Cañete River. Usually upstream of an alluvial area, there is a rough topography in order to build a dam, a very high dam will be required to be built, which implies investing a large amount (more than thousand million of soles).

Also, it would take between three to five years to identify the dam site, perform geological survey, material assessment and conceptual design. The impact on the local environment is huge. So, it is considered inappropriate to include the dam analysis option in this Study.

Likewise, the option of building a retarding basin would be lightly viable for the same reasons already given for the dam, because it would be necessary to build a great capacity reservoir and it is difficult to find a suitable location because most of the flat lands along the river’s downstream are being used for agricultural purposes. So, its analysis has been removed from this Study. Therefore, we will focus our study in the construction of dike because it is the most viable option.

(1) Plan of the river course

1) Discharge capacity

An estimation was done on the discharge capacity of the current flow of this River based on longitudinal and cross sectional survey of the river, which results are shown in Table 3.1.10 and Figure 3.1.10-3.

2) Inundation characteristics

The inundation analysis of Cañete river was performed. In Table 3.1.10 and in Figure 3.1.10-4 the inundation condition for flood with probabilities of 50 years is shown.

In the upstream area from 10km (distance mark) from the river mouth, although it overflows due to the shortage of discharge capacity, it remains in the influence of the farmland on the circumference of the channel. However, in downstream area from 10km from the river mouth, the flood flow spreads greatly just in the right-bank side, and the damage becomes large.

3) Design flood level and dike's standard section

The design flood level was determined in the flood water level with a return period of 50 years applying the standard section of dike already mentioned in section 4.3.1, 5), 1) to the present river channel. In Table 4.2-1, 4.2, the theoretical design flood level and the required height of the dike's crown is shown.

4) Dikes' alignment

Considering the current conditions of existing dikes the alignment of the new dikes was defined. Basically, the broader possible river width was adopted to increase the discharge capacity and the retard effect. In Figure 4.15.1-1 the current channel and the setting alignment method of a section where the current channel has more width is explained schematically. In a normal section, the dike's crown has the same height to the flood water level with a return period of 50 years plus free board, while in the sections where the river has greater width, double dikes be constructed with inner consistent dike alignment and continuous with normal sections upstream and downstream. The crown height is equal to the flood water level with a return period of 50 years. The external dike's crown height is equal to flood water level with a return period of 50 years, so in case the river overflows the internal dike, the open gap between the two dikes will serve to store sediments and retarding water.

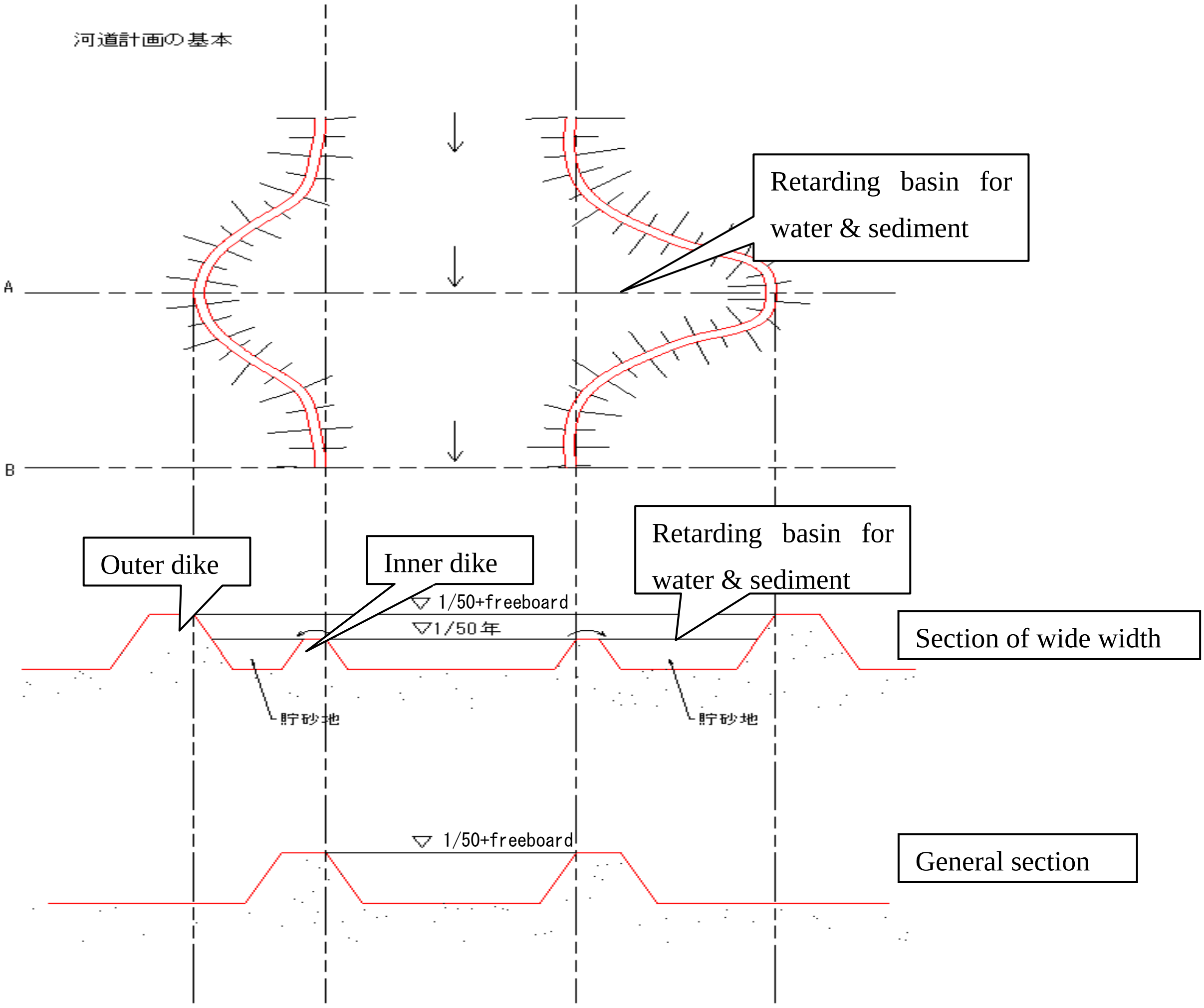


Figure 4.15.1-1 Definition of dike alignment

5) Plan and section of river

The plan and longitudinal section of river are as shown in the Figure 4.15.1-2 and -4.15.1-3.

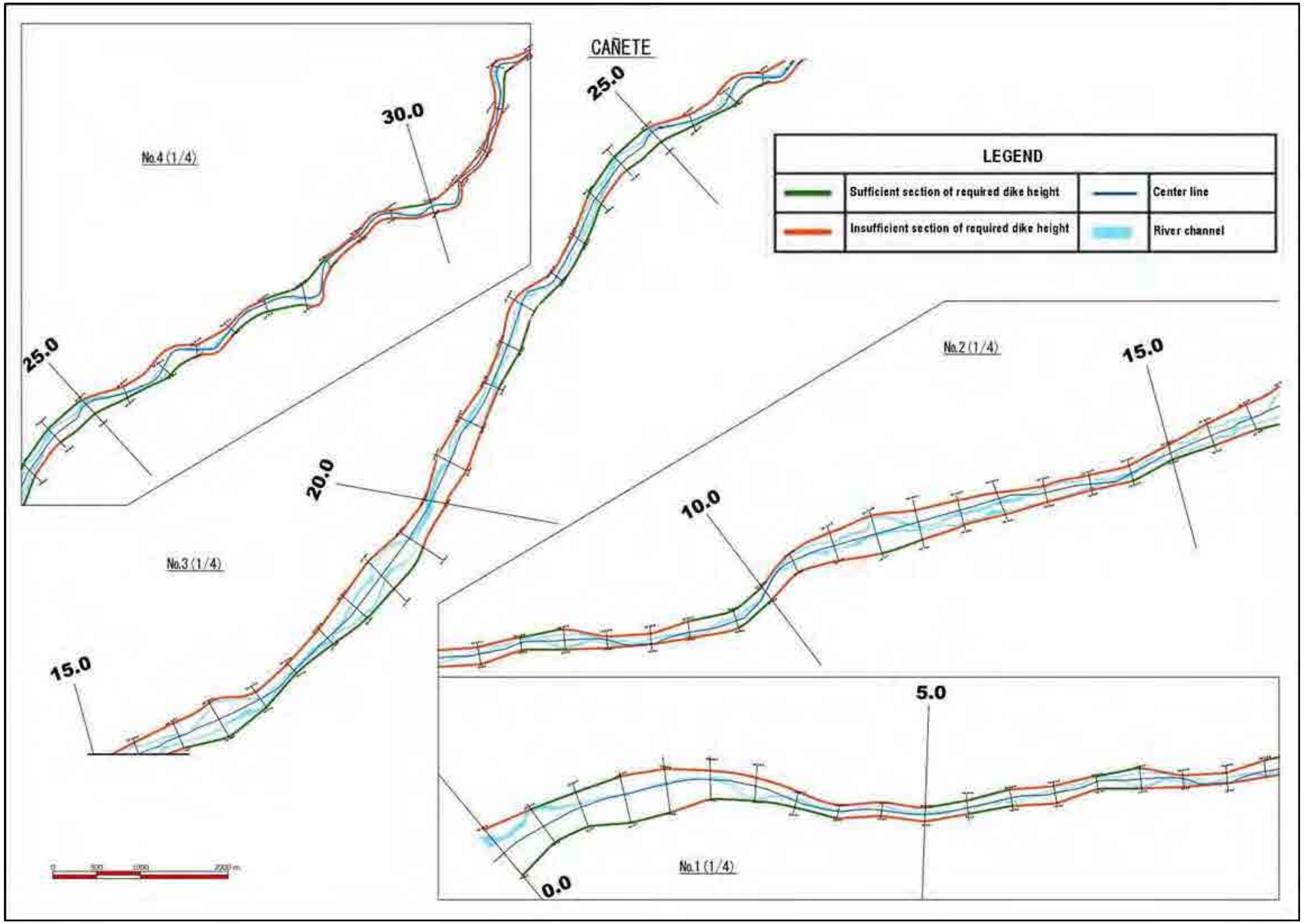
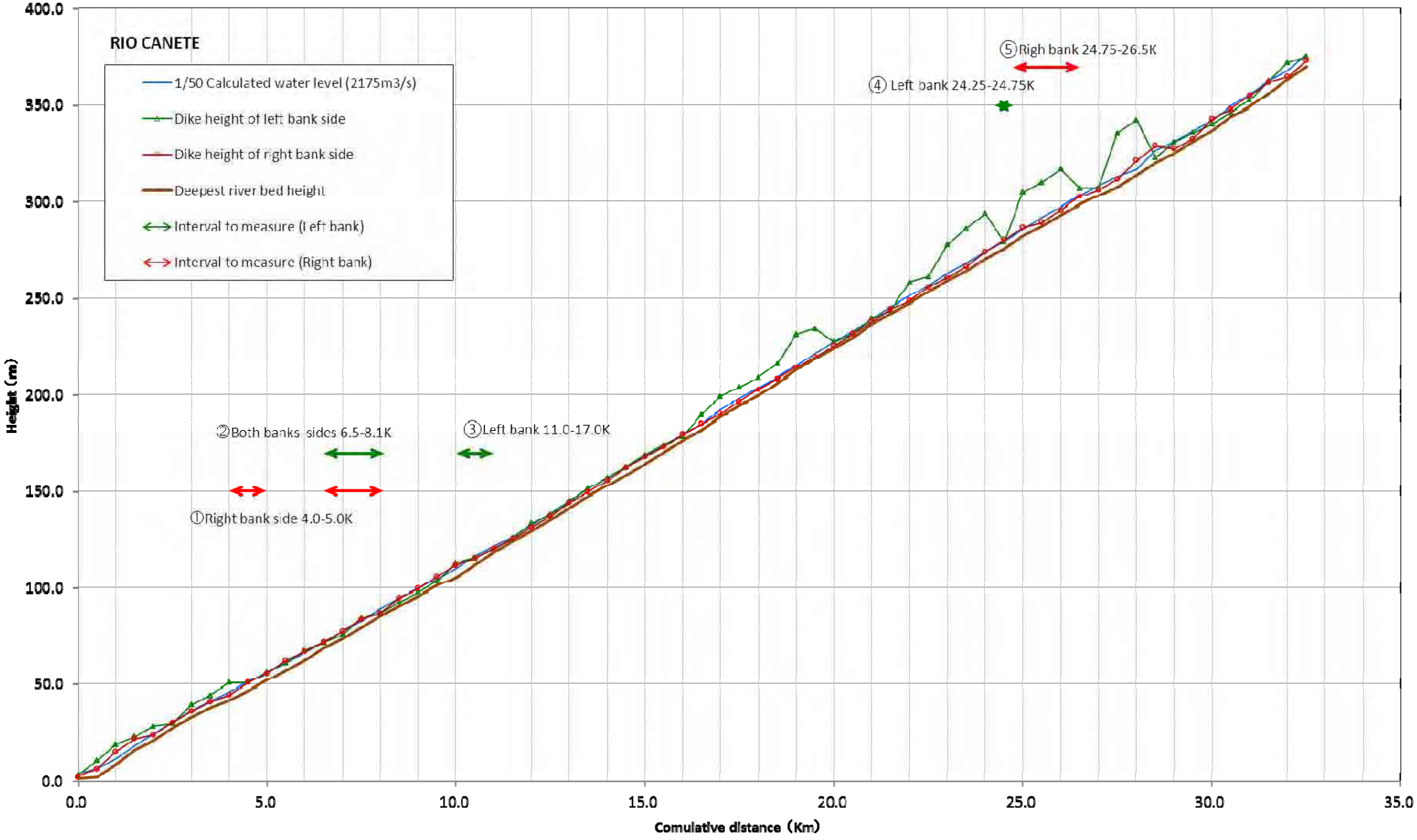


Figure 4.15.1-2 Plan of Cañete river



4.15.1-3 Cañete river longitudinal profile

6) Dike’s construction plan

Next, basic policies for the dike’s construction plan on the Cañete River are shown:

- Build dikes that allow flood flow safe passage with a return period of 50 years
- The dikes will be constructed in areas where overflowing water will enter the dike, according to the flood simulation
- The dikes will be placed in the sections above mentioned, where the design water level exceeds the existing dike’s height or the ground level within the dike
- The dike’s height is defined in the flood water level with a return period of 50 years plus the free board

Table 4.15.1-1 and Figure 4.15.1-4 show the dike’s construction plan on the Cañete River

Table 4.15.1-1 Dike’s construction plan

River	Sections to be improved		Dike missing heigth average (m)	Dike proposed size	Dike length (km)
Cañete River	Left bank	0,0k-21,5k	1,20	Dike heigth = 1,5m Bank protection works heigth = 3,0m	12,0
	Right bank	0,0k-21,5k	1,48		18,5
	Total		1,38		30,5

Cañete River Sections were the water design level (1/50 years) surpasses dikes height (overflowing in every section)

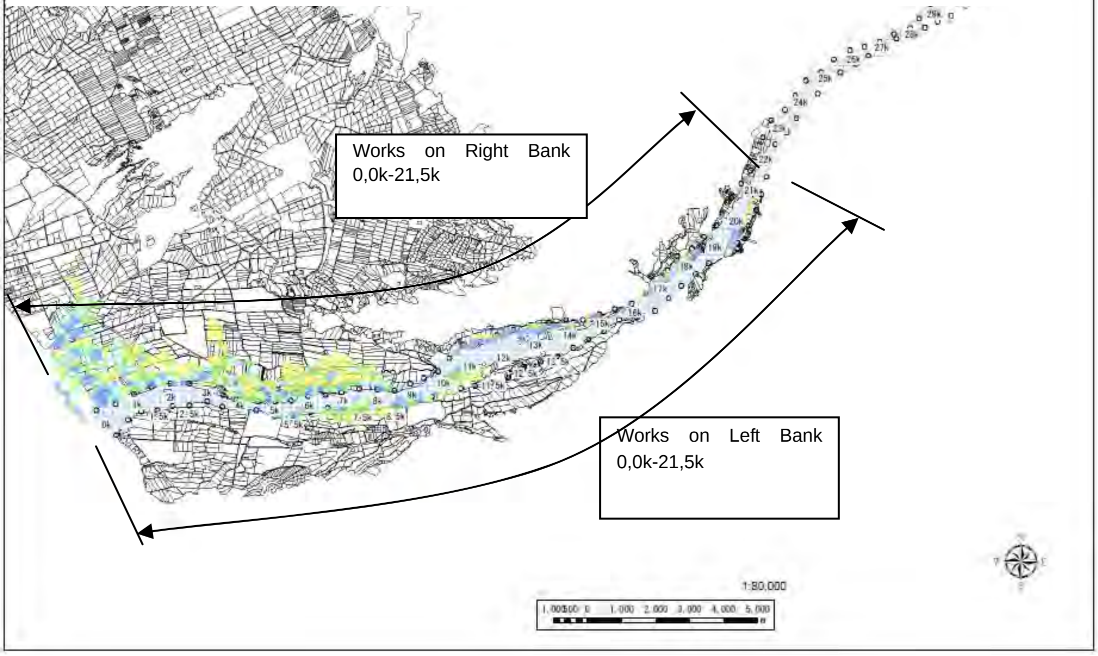


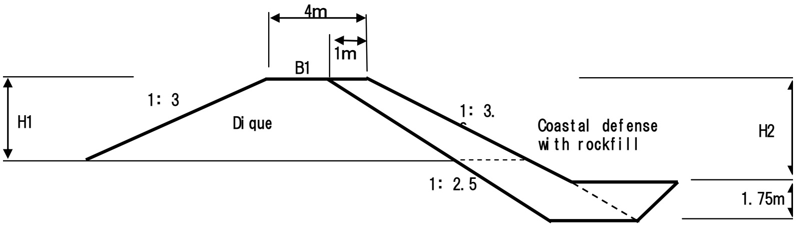
Figure 4.15.1-4 Cañete river dike construction works approach

7) Project cost

In Tables 4.15.1-2 and 4.15.1-3 works' direct costs in private prices and the Project's cost are shown. Also, the cost of the project in social prices is presented in Table 4.15.1-4.

Table 4.15.1-2 Direct works' cost (at private prices)

Dike building					Coastal defense			
B1	H1	B2	A		B1	H2	B2	A
3.0	1.0	8.5	5.8		1.0	1.0	2.4	10.8
3.0	2.0	14.0	17.0		1.0	2.0	2.9	13.4
3.0	3.0	19.5	33.8		1.0	3.0	3.4	16.5
3.0	4.0	25.0	56.0		1.0	4.0	3.9	20.1
3.0	5.0	30.5	83.8		1.0	5.0	4.4	24.3
3.0	1.5	11.3	10.7		1.0	6.0	4.9	28.9
					1.0	1.5	2.6	12.0
					1.0	10.0	6.9	52.4



Watershed	Works	Amount	Unit	Unitary Price	Work direct cost/m	Work direct cost/km	Dike length	Work direct cost
				(in soles)	(in soles)	(in thousand soles)	(k m)	(in thousand soles)
Ca·ete	Dikes	17.0	m3	10.0	170.0	170.0	30.5	5,185.0
	Margin protection	16.5	m3	100.0	1,650.0	1,650.0		50,325.0
Total					1,820.0	1,820.0		55,510.0

Table 4.15.1-3 Projects' cost (at private prices)

(soles)

Basin 流域名	Direct Cost			Indirect Cost								Total Project Cost 構造物･事業費 (12) = (8)+(9)+(10)+(11)
	Direct Cost 直接工事費計 (1)	Common Temporary Work Cost 共通仮設費 (2) = 0.1 x (1)	Construction Cost 工事費 (3) = (1) + (2)	Overhead Cost 諸経費 (4) = 0.15 x (3)	Profit 利益 (5) = 0.1 x (3)	Structure Construction Cost 構造物工事費 (6) = (3)+(4)+(5)	Tax (IGV) 税金 (7) = 0.18 x (6)	Construction Cost 建設費 (8) = (6)+(7)	Environment Cost 環境影響 (9)=0.01 x (8)	Detail Design Cost 詳細設計 (10) = 0.05 x (8)	Construction Supervision Cost 施工管理費 (11) = 0.1 x (8)	
CAÑETE	55,510,000	5,551,000	61,061,000	9,159,150	6,106,100	76,326,250	13,738,725	90,064,975	900,650	4,503,249	9,006,498	104,475,371

Table 4.15.1-4 Projects' cost (at social prices)

(soles)

Basin 流域名	Direct Cost			Indirect Cost								Total Project Cost 構造物･事業費 (12) = (8)+(9)+(10)+(11)
	Direct Cost 直接工事費計 (1)	Common Temporary Work Cost 共通仮設費 (2) = 0.1 x (1)	Construction Cost 工事費 (3) = (1) + (2)	Overhead Cost 諸経費 (4) = 0.15 x (3)	Profit 利益 (5) = 0.1 x (3)	Structure Construction Cost 構造物工事費 (6) = (3)+(4)+(5)	Tax (IGV) 税金 (7) = 0.18 x (6)	Construction Cost 建設費 (8) = (6)+(7)	Environment Cost 環境影響 (9)=0.01 x (8)	Detail Design Cost 詳細設計 (10) = 0.05 x (8)	Construction Supervision Cost 施工管理費 (11) = 0.1 x (8)	
CAÑETE	44,630,040	4,463,004	49,093,044	7,363,957	4,909,304	61,366,305	11,045,935	72,412,240	724,122	3,620,612	7,241,224	83,998,198

(1) **Operation and maintenance plan**

The operation and maintenance cost was calculated identifying the trend of the sedimentation and scouring of riverbed based on the one-dimensional analysis results of the bed variation, and a long-term operation and maintenance plan was created.

The current river course has some narrow sections where there are bridges, farming works (intakes, etc.) and there is a tendency of sediment deposit upstream of these sections. Therefore, in this project there is a suggestion to increase the discharge capacity of these narrow sections in order to avoid as possible upstream and in the bed (main part) sedimentation, together with gathering sediments as much as possible when floods over a return period of 50 years occur.

1) Riverbed fluctuation analysis

The summary of the riverbed fluctuation analysis model is as shown in the Table 4.15.1-5 and the analysis conditions are as shown in the Table 4.15.1-6.

The Figure 4.14.1-6 shows the results of the riverbed fluctuation analysis of the river for the next fifty years. From this figure a projection of the riverbed's sedimentation and scouring trend and its respective volume can be made.

Table 4.15.1-5 Summary of riverbed fluctuation analysis model

Items	Content
Water Flow	One-dimensional Non-uniform Flow Model
Sediment Transportation	One-dimensional Mixed Grain Size Riverbed Fluctuation Model
Bed Load	Ashida & Michiue’s Bed load formula
Suspended Load	Ashida & Michiue’s Suspended Load formula considering non-equilibrium of suspended sediment
Calculation Method	MacCormack Method

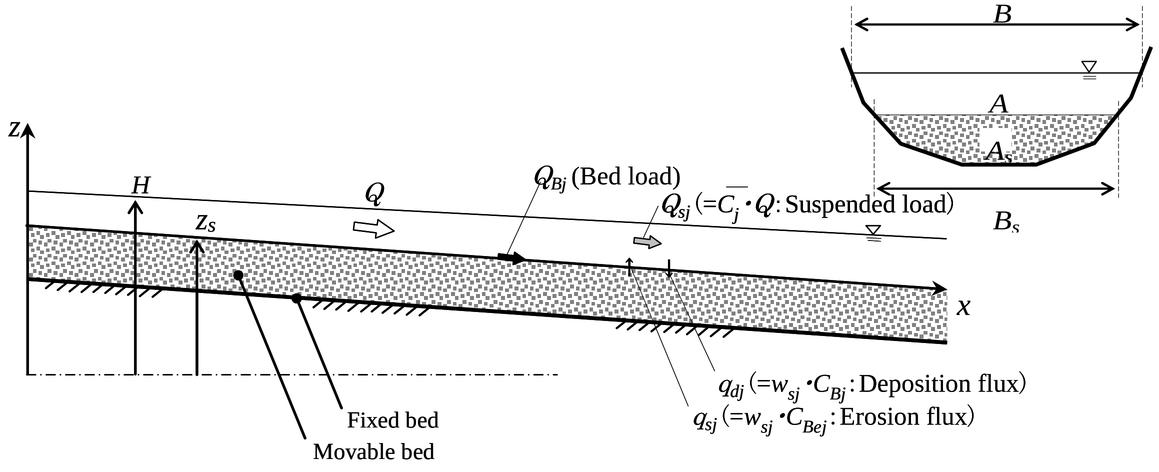


Figure 4.15.1-5 Pattern diagram of riverbed fluctuation analysis model

Table 4.15.1-6 Analysis condition of each river

	Cañete
Calculation river length	32.5km
Period	For future 50 years
Space interval（Δx）	100m
Time interval（Δt）	2.0sec
Input discharge	50 years discharge prepared based on observation data (max. annual discharge), in case of insufficient year number prepared by repeating the limited year data.
Sediment Supply	60,000m3/year
Tributary inflow	Disregarded since there are only small tributaries
Grain size	Based on the grain size distribution in the riverbed material, 8～ 9 grain size are assumed（d=0.075mm ～500mm）.
Water level at downstream end	Assumed normal water depth at the downstream end
Roughness coefficient	n=0.05（all section）
Void ration	0.4（representative value of sand and gravel）

2) Sections that need maintenance

In the Table 4.15.1-7 possible sections that require a process of long-term maintenance in the river is shown.

Table 4.15.1-7 Sections/places to be carried out maintenance works

River Name	Excavation Area		Method of Maintenance Works
Canete River	Place 1	Target Section：3.0km-7.0km Target Volume：135,000m^3	It is a past flood occurrence part. Since the riverbed aggradation advances gradually, it is considered that periodical excavation should be carried out from now on.
	Place 2	Target Section：27.0km-31.0km Target Volume：287,000m^3	In the object section, the channel is narrow, and since sediments are not fully passed, the possibility of riverbed aggradation is high. Since the riverbed aggradation advances gradually from now on and flood may be occurred, the periodical excavation maintenance should be carried out.

※Design sediment volume: Sediment volume deposited in 50 years

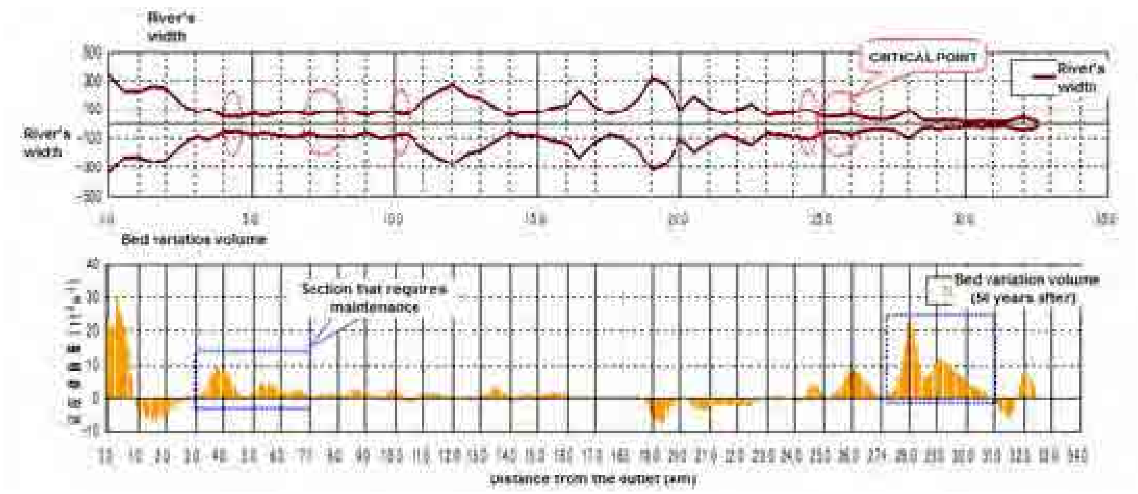


Figure 4.15.1-6 Section that requires maintenance (Cañete)

3) Operation and maintenance cost

The direct cost at private prices for maintenance (bed excavation) required for Cañete watershed in the next 50 years is as shown below:

Direct cost(private price) = 422,000 m3 x 10ssoles = 4,220,000 soles

The Project's cost for 50 years on private and social prices is as shown in the Table 4.15.1-8 and 4.15.1-9.

Table 4.15.1-8 Excavation works cost for a 50 year bed (at private prices)

(1,000 soles)

Basin 流域名	Direct cost 直接工事費計 (1)	Common Temporary Work Cost 共通仮設費 (2) = 0.1*(1)	Construction cost 工事費 (3) = (1) + (2)	Overhead Cost 諸経費 (4) = 0.15*(3)	Profit 利益 (5) = 0.1*(3)	Structure Construction Cost 構造物工事費 (6) = (3)+(4)+(5)	Tax (IGV) 税金 (7) = 0.18*(6)	Construction Cost 建設費 (8) = (6)+(7)	Environment Cost 環境影響 (9)=0.01*(8)	Detail Design Cpst 詳細設計 (10) = 0.05*(8)	Construction Supervision Cost 施工管理費 (11) = 0.1*(8)	Total Project Cost 事業費 (12) = (8)+(9)+(10)+(11)
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	68	342	685	7,942

Table 4.15.1-9 Excavation works cost for a 50 year bed (at social prices)

(1,000 soles)

Basin 流域名	Direct Cost 直接工事費計 (1)	Common Temporary Work Cost 共通仮設費 (2) = 0.1*(1)	Construction Cost 工事費 (3) = (1) + (2)	Overhead Cost 諸経費 (4) = 0.15*(3)	Profit 利益 (5) = 0.1*(3)	Structure Construction Cost 構造物工事費 (6) = (3)+(4)+(5)	Tax(IGV) 税金 (7) = 0.18*(6)	Construction Cost 建設費 (8) = (6)+(7)	Conversion Factor 修正係数 fc	Construction Cost 建設費 (9) = fc*(8)	Environment Cost 環境影響 (10) = 0.01*(9)	Detail Design Cost 詳細設計 (11) = 0.05*(9)	Construction Supervision Cost 施工管理費 (12) = 0.1*(9)	Total Project Cost 事業費 (13) = (9)+(10)+(11)+(12)
CAÑETE	4,220	422	4,642	696	464	5,803	1,044	6,847	0.804	5,505	55	275	550	6,386

(3) Social assessment

1) Private prices cost

a) Damage amount

Table 4.15.1-10 shows the damage amount calculated analyzing the overflow caused by floods in the Cañete River with return periods between 2 and 50 years.

Table 4.15.1-10 Amount of damage for floods of different return periods (at private prices)

（10^3 Soles）

Year	Damage Amount
	Cañete
2	1,735
5	6,420
10	77,850
25	104,090
50	158,173
Total	348,269

b) Damage reduction annual average

Table 4.15.1-11 shows the damage reduction annual average of each watershed calculated with the data of Table 4.15.1-10.

c) Project's Cost and the operation and maintenance cost

Table 4.15.1-3 shows the projects' cost. Also, the annual operation and maintenance (O & M) cost for dikes and bank protection works can be observed in the table. This is calculated from the 0.5% of the construction cost plus the bed excavation annual average cost indicated in Table 4.15.1-8.

d) Economic evaluation

In Table 4.15.1-12 the results of economic assessment are shown.

Table 4.15.1-11 Damage reduction annual average

（10^6 Soles）

Basin	Return Period	Probability	Total Damage			Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
			Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,735	0	1,735	868	0.500	434	434
	5	0.200	6,420	0	6,420	4,078	0.300	1,223	1,657
	10	0.100	77,850	0	77,850	42,135	0.100	4,214	5,871
	25	0.040	104,090	0	104,090	90,970	0.060	5,458	11,329
	50	0.020	158,173	0	158,173	131,132	0.020	2,623	13,952

Table 4.15.1-12 Economic assessment results (private prices costs)

流域名 Basin	年平均被害軽減額 Annual Average Damage Reduction	評価期間被害軽減額(15年) Damage Reduction in Evaluation Period(15years)	事業費 Project Cost	維持管理費 O&M Cost	B/C Cost Benefit Ration	NPV Net Present Value	IRR(%) Internal Return of Rate
Cañete	181,369,899	81,903,051	104,475,371	8,236,962	0.86	−13,204,737	7%

2) Social prices cost

a) Damage amount

Table 4.15.1-13 shows the damage amount calculated analyzing the overflow caused by floods in the Cañete river with return periods between 2 and 50 years in each watershed.

Table 4.15.1-13 Amount of damage for floods of different return periods (at social prices)

(10^3 Soles)

Year	Damage Amount
	Cañete
2	2,711
5	11,180
10	110,910
25	153,056
50	225,586
Total	503,443

b) Damage reduction annual average

Table 4.15.1-14 shows the damage reduction annual average of each watershed calculated with the data of Table 4.15.1-13.

c) Project’s Cost and the operation and maintenance cost

Table 4.15.1-4 shows the projects’ cost. Also, the annual operation and maintenance (O & M) cost for dikes and bank protection works can be observed in the table. This is calculated from the 0.5% of the construction cost, as well as the bed excavation annual average cost indicated in Table 4.15.1-8.

d) Economic evaluation

In Table 4.15.1-15 the results of economic assessment are shown.

Table 4.15.1-14 Damage Reduction Annual Average

(10^6 Soles)

Basin	Return Period	Probability	Total Damage			Average Damage ④	Section Probability ⑤	Annual Average Damage ⑥=④×⑤	Accumulation of Annual Average Damage
			Wiyhout Project ①	With Project ②	Damage Reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,711	0	2,711	1,356	0.500	678	678
	5	0.200	11,180	0	11,180	6,946	0.300	2,084	2,762
	10	0.100	110,910	0	110,910	61,045	0.100	6,105	8,866
	25	0.040	153,056	0	153,056	131,983	0.060	7,919	16,785
	50	0.020	225,586	0	225,586	189,321	0.020	3,786	20,572

Table 4.15.1-15 Economic assessment results (social prices costs)

流域名 Basin	年平均被害軽減額 Annual Average Damage Reduction	評価期間被害軽減額(15年) Damage Reduction in Evaluation Period(15years)	事業費 Project Cost	維持管理費 O&M Cost	B/C Cost Benefit Ration	NPV Net Present Value	IRR(%) Internal Return of Rate
Cañete	267,429,377	120,765,806	83,998,198	6,622,517	1.58	44,299,144	19%

(2) Conclusions

The economic assessment result shows that the Project has positive economic impact at social prices, but the required cost is extremely high (104.5 million soles) so that this Project is difficult to be adopted.

4.15.2 Reforestation and Recovery of Vegetation Plan

(1) Reforestation of the upper watershed

Long-term reforestation in all areas considered to be critical of the upper watershed is recommended. So, a detail analysis of this alternative will be explained next.

1) Basic policies

- Objectives: Improve the water source area's infiltration capacity, reduce surface soils water flow and at the same time, increase water flow in intermediate soils and ground-water level. Because of the above mentioned, water flow is interrupted in high flood season, this increases water resources in mountain areas, reduces and prevents floods increasing with it the amount and greater flow of ground-water level, reducing and preventing floods
- Forestry area: means forestry in areas with planting possibilities around watersheds with water sources or in areas where forest area has decreased.
- Forestry method: local people plantations. Maintenance is done by promoters, supervision and advisory is leaded by NGOs.
- Maintenance after forestry: Maintenance is performed by the sow responsible in the community. For this, a payment system (Payment for Environmental Services) will be created by downstream beneficiaries.
- Observations: After each thinning the area will have to be reforested, keeping and preserving it in a long-term sustainable way. An incentive for community people living upstream of the watershed shall be designed.

The forest is preserved after keeping and reforesting it after thinning, this also helps in the support and prevention of floods. For this, it is necessary that local people are aware, encourage people downstream, promote and spread the importance of forests in Peru during the project's execution.

2) Selection of forestry area
As mentioned in 1) Forestry on upper watershed is performed with the support of the community. In this case, the local inhabitants will participate in the upper watersheds during their spare time. However, take into account that the community mostly lives in the highlands where inhabitants live performing their farming and cattle activities in harsh natural conditions. Therefore, it is difficult to tell if they have the availability to perform forestry. So, finding comprehension and consensus of the inhabitants will take a long time.

3) Time required for the reforestation project

Since it is a small population, the workforce availability is reduced. So, the work that can be carried out during the day is limited, and the work efficiency would be very low. The JICA Study Team estimated the time required to reforest the entire area throughout the population in the areas within the reforestation plan, plant quantity, work efficiency, etc. According to this estimate, it will take 14 years to reforest approximately 40,000 hectares from the Chincha River Watershed. When estimating the required time for other watersheds, by simply applying this rate to the respective watershed area, we obtained that reforestation in Cañete River Watershed will take 35 years.

4) Total reforestation volume in the upper watershed and project's period and cost

It has been estimated that the surface needed to be reforested in the Cañete River Watershed, as well as the execution cost, having as reference Chincha River Watershed project reforestation data. According to this estimate, the area to be reforested is approximately a total of 110,000 hectares. The required period is 35 years, and the cost is calculated in 300 million nuevos soles. In other words, investing a great amount of time and money is required to reforest.

Table 4.15.2-1 Upstream Watershed Forest General Plan

Watershed	Surface to reforest (ha)	Time Required (years)	Cost required (soles)
Cañete	110,111	35	297,206,251

(Source: JICA Study Team)

5) Conclusions

The objective of this project is to execute the most urgent works and give such a long period for reforestation which has an indirect effect with an impact that takes a long time to appear would not be consistent with the proposed objective for the Project. Considering that 35 years and invested 300 million soles are required, we can say that it is impractical to implement this alternative in this project and that it shall be timely executed within the framework of a long-term plan after finishing this project.

4.15.3 Sediment Control Plan

For the long-term sediment control plan, it is recommended to execute the necessary works in the upper watershed.

The Sediment Control Plan in the upper watershed will mainly consist in construction of sediment control dikes and bank protection works. In Figure 4.15.3-1 the sediment control works disposition proposed to be executed throughout the watershed is shown. The cost of Cañete River works was estimated focusing on: a) covers the entire watershed, and b) covers only the priority areas, analyzing the disposition of works for each case (refer to Annex-6 Sediment Control Plan, 2.3). The results are shown in Table 4.14.3-1.

Due to the Cañete River extension, the construction cost for every alternative would be too high in case of carrying-out the bank protection works, erosion control dikes, etc. Apart from requiring a considerably long time. This implies that the project will take a long time to show positive results. So, it is decided that it is impractical to execute this alternative within this project and should be timely executed within the framework of a long-term plan, after finishing this project.

Table 4.15.3-1 Upper watershed sediment control works execution estimated costs

Watershed	Approach	Bank Protection		Strip		Sediment control dike		Total works direct cost	Project Cost (Millions S/.)
		Vol. (km)	Direct Cost (Million S/.)	Vol. (units)	Direct Cost (Million S/.)	Vol. (units)	Direct Cost (Million S/.)		
Cañete	All Watershed	325	S/.347	32	S/.1	201	S/.281	S/.629	S/.1.184
	Prioritized Section	325	S/.347	32	S/.1	159	S/.228	S/.576	S/.1.084

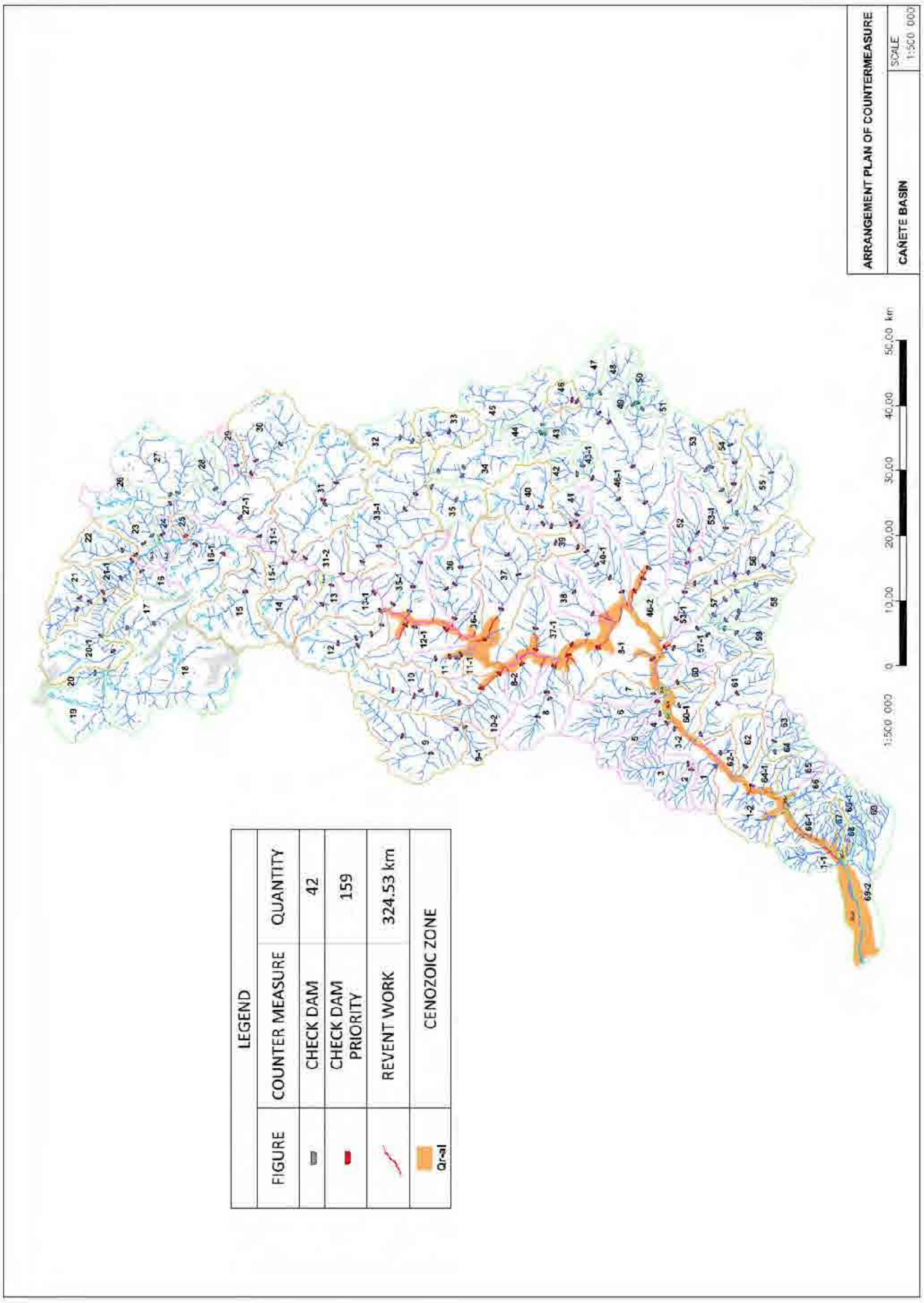


Figure 4.15.3-1 Sediment control works location Cañete River Watershed

5. Conclusion and Recommendation

5.1 Conclusion

The flood prevention facilities selected finally in this Project are safe in structural, and have high viability and give scarcely impact to the environment. It is concluded that the Project should be implemented as soon as possible so that the high vulnerability against flood in valleys (Valles) and rural communities could be reduced and the social economic development will be promote d in the Project area.

5.2 Recommendation

Based on the knowledge and experience obtained from this Study, the following recommendations are presented on the implementation of this Project and the future flood control measures in Peru.

5.2.1 Recommendation on Implementation of This Project

(1) Problems to be solved at present

1) The project cost will be covered by the central government (through the DGIH), regional governments and irrigation committees. The sharing ratio among stakeholders is assumed provisionally 80% for the central government (in this case MINAG), 15% for regional government and 5% for irrigation committee. Since the total cost of this Project was determined in the Feasibility Study, the final ratio will be determined through negotiation among 3 parties as soon as possible.

2) The area to be occupied by the flood prevention facilities and the plantation along river was determined in this study. It is recommended that the Project holder (DGIH) should define the limit of river area with private land and continually should carry on the process of land acquisition based on the Land Acquisition Low, which are; Emission of Resolution for land acquisition by the State, Proposition of land cost and compensation for land owner, Agreement of the State and land owner, Payment etc.

3) Confirmation of implementation agency of the Project The implementation agency is assumed to be PSI, MINAG, however DGPI, MEF and OPI,MINAG do not always agree that, so that the final implementation agency will be determined as soon as possible.

4) As to the environment impact assessment of this Project, DGAA,MINAG evaluated the Initial Environment Assessment (EAP) of the Project and classified this Project in to Category I so that the additional environment assessment is not required, however it is necessary to promote the process of preservation of archeological heritage.

5) Acquisition of CIRA（Certificación de Inexistente de Restos Arqueológicos）

DGIH has to promote the process to obtain the CIRA in the detail design stage. The process to be taken is i) Application form, ii) Copies of the location drawings and outline drawings, iii) voucher, iv) Archaeological Assessment Certificate.

6) The operation and maintenance after implementation of the Project will be carried out by the irrigation committee. They are not familiar the flood prevention facilities which are different type of structure from the agricultural facilities such as irrigation channel, intake and so on, so that that the technical and economic assistance by MINAG and local government

(2) Structural measures

1) Basic policy of flood control

In the basic policy of flood control, the flood prevention measures should be prepared gradually from the downstream to the upstream of river. However the facilities with high priority such as wide inundation area and giving serious impact on the socio-economy of the region were selected and planned to be implemented in this Project.

Once the preparation in the upstream area is completed, of which influence occurs in the opposite bank or downstream area. And the asset will be accumulated by preparation of flood prevention measures which means the increase of damage potential, if the flood over design flood will occur the damage might be enlarged more than before due to increase of damage potential. Therefore it could not be said that the damage will be not always decreased, which should be noticed to people and the land use regulation should be prepared.

2) Problems for flood control planning in Cañete river

Cañete river has narrow sections at the main bridges and intake at the downstream of 10 km from the river mouth, and upstream of which the inundation is apt to occur. The inundation spreads widely to the right bank side causing big damage, although the inundation upstream of 10 km is limited to nearby crop areas. Therefore the embankment and bank protection in the lower section of 10 km, which has large damage potential, is to be implemented with priority securing the discharge capacity at narrow sections.

And upstream of Cañete river there is tourist area due to rich water flow and short access from Lima. In order to keep short access to the area, the conservation of principal regional road are important from view point of regional economic activities, so that the bank protection work for scouring is also selected as flood prevention work.

At the Pan-American road the river width is narrowed, so that the widening the river width with building new bridge is considered, however taking account of the large traffic volume, necessity of access road to the bridge causing large cost, and that DGIH judged that the construction of new bridge is difficult for demarcation of administrative responsibility among Ministries, the construction of new bridge is not adopted in this Project.

The sections with high priority are selected as described above, even when the facility in each section is complete it cannot be said that the preparation of whole Cañete river is completed. In future the sections where discharge capacity is not enough and need the strengthening dike will be prepared for flood control. In addition to that the bridges at narrow sections should be rebuilt with cooperation of road department.

3) Problems in design and construction work

i) Construction work period

The dry season in the study area is from May to November when the level of water is very low or the river dries up, however the possible construction period is desirable to be from April to December considering the transition period from season to season.

The river characteristics / features should be taken into account, that is, that the Cañete is year - round river. At the same time, the crop season cycle in the areas of direct influence should be taken into account, so that traffic jams caused by the large trucks and farming machinery is prevented.

ii) Safety of dike

Dikes will be made of material available in the zone (river bed or banks). In this case, the material would be sand and gravel or sandy soil with gravel, of high permeability. The stability problems forecasted in this case are as follows.

- Infiltrate destruction caused by piping due to washing away fine material
- Sliding destruction of slope due to infiltrate pressure

In order to secure the stability of dike the appropriate standard section should be determined by infiltration analysis and stability analysis for sliding based on unit weight, strength and permeability of embankment material.

The importance in dike construction is sufficient compaction of dike material. The cost estimate standard in Peru the compaction is to be made by tractor; however for the sufficient compaction it is desirable to use compaction equipment such as vibration roller etc.

And in order to supervise the compaction of material, the density test and grain size analysis are important, of which are specified in the technical specification of the tender document (refer to Annex-9 Construction Planning/Cost Estimate, 3.3 Cost Estimate of Direct Cost, Item 2.2 Survey and Quality Control of Integrated List).

iii) Reduction of bank protection cost

The cost of construction work for the revetment occupies over 80% of the direct cost of the project in the embankment section. Moreover, the conveyance cost for the rocks from quarry site occupies 45% of the revetment works. In the places where existing revetment works and groin works still remain, such as Cañete river, it should be considered that reusing of materials leads to reduction of construction costs.

iv) Balance of banking and excavation volume

As for balance of earth volume for embankment and excavation, there are shortages of earth materials for embankment with 240,000m3 in the Cañete river. Since the land along the river is used for farmland, the earth materials for embankment shall be taken from riverbed material. In case of excavation in riverbed for making flow capacity increase, there is a possibility that dike height will be lower a little. On the other hand, there is a possibility for promoting riverbed scouring due to steep slope of river. In the detail design phase, the selection of adequate places for borrow pits shall be important.

(3) Non-structural measures

1) Afforestation

The afforestation and vegetation recovery plan is divided into i) short term plan, ii) long term plan (upstream area in the river), among which the short term plan is adopted in this Project. In future flood control plan it is necessary that the long term plan will be executed; however the long term plan requires enormous project period and project cost. Therefore it is recommended that the long term plan will be realized by the effort of securing budget step by step.

2) Sediment control and riverbed fluctuation

i) Sediment control plan

Cost for sediment control plan in the mountainous area is expensive, in addition the project needs long term period. There are no objects to be conserved in the mountainous area, so cost-benefit performance is low. Main purpose in this project is mitigation of the flood disaster. With the view to this purpose, it is judged that sediment control works in the alluvial fans is most effective.

Despite being distinct from the project purpose, in Peru sediment disasters have occurred frequently. So Non-structural measures to mitigate the sediment disasters would be suggested as shown below. These Non-structural measures are more economical than structural measures and have function to prevent the human life and minimum property from the sediment disaster.

- Regulation of agricultural areas and residential areas
- Setting the alert rainfall for each region and establishment early warning Systems.
- Collect sample of sediment disaster and raise awareness of disaster prevention through education and patrimony of disaster prevention

ii) Riverbed fluctuation

The results of field investigation and reverbed fluctuation analysis show no urgent necessity of sediment control measures in the Cañete river. However from the long term point of view the decrease of riverbed elevation is forecasted in the Cañete river upstream of which the dam is located.

From now on the monitoring system for topography of river channel and local scouring should be established in the river depending on the riverbed fluctuation characteristics, and the accumulation of such basic data is required.

(4) Disaster prevention education/capacity development

1) Soft counter measures for reduction of flood damage

The design flood discharge in this Study is a flood with return period of 50 years which is calculated based on the past rainfall observation data. However the flood over design flood may occur due to El Niño or extraordinary meteorological phenomena. Since the forecasting of such floods is difficult, it is impossible to prepare for such floods by hard counter measures. Since there is still risk for such floods, the establishment of soft countermeasures such as flood defense work, evacuation, preparation of hazard map and the notification and education to people is required.

2) Promotion of community disaster prevention

It is important to promote the community disaster prevention, which reinforces the effect of this Project and induces the local people participation to the Project. The long time approach and activities are required until that the self and mutual assistance is motivated and the people start voluntarily concrete activities as a first step of activation of voluntary disaster prevention organization.

It is necessary that the irrigation committee builds the community disaster prevention system as a core based on the disaster prevention education in this Project in order to increase the effect of the Project

5.2.2 Recommendation for Future Flood Control Plan in Peru

(1) Preparation of comprehensive mater pan for flood control

There are almost no flood prevention facilities in the Study area although the dikes are built in some places. The flood prevention facilities constructed in this Project are also partly, however they cover the important points and give the high economic effect as seen in the social evaluation results so that it can be said very significant project. However, as to the future flood control in Peru, the integral master plan for major basins should be established and implemented step by step for objectives of not only agricultural facilities but also urban areas, roads, bridges etc.

(2) Establishment of implementation agency for integral flood control project

The counterpart ministry of this Project is MINAG which is responsible for the agricultural sector so that they cannot easily implement the disaster prevention project belong to the other sector. In order to realize the above (1) it is necessary that the role of the existing agency will be change to be able to implement the flood control plan with integral purpose or establishment of new agency. By such agency the integral flood prevention measures and operation and maintenance of river such as dike, bank protection, groin, erosion of river bank, sedimentation in riverbed, intake weir etc. should be carried out completely.

(3) Execution of strict river management

The boundary of river area and private land is not clear, the river area is used sometimes as agricultural land, and the garbage is dumped in the river area illegally, which means the administration of river area is not well performed. Therefore the preparation of river law system and strict application of it is quite required.

(4) Establishment of nationwide network of rainfall and discharge observation stations

The estimation of flood discharge and flood pattern is indispensable as basic data for establishment of flood control plan. In order to estimate the above data with appropriate accuracy, the rainfall observation stations with enough density in the basin and the discharge observation stations at important points along the river are necessary as well as hourly observation data. And in order to estimate the flood discharge and flood pattern, the hourly data is indispensable. However the data to be used in the Study area is very limited, for example, in the Yauca basin with area of 4,312km2 there are 7 rainfall stations, of which only one station (Cora Cora2) is under operation. The observation data is all daily base for rainfall and discharge and is not hourly base.

To promote the flood control in Peru, the establishment of network of rainfall and observation stations is indispensable. To do so, it is necessary that the master plan of observation network covering all Peru is to be established and the base stations are selected and the observation is carried out The followings are to be examined to make the master plan and to select the basic stations.

＊Review of observation data of existing stations
＊Select observation stations to be used and digitalize of available data
＊Plan of observation network and classification of planned and existing stations depending on importance
＊Renewal of observation equipment in the existing stations depending on importance
＊Installation new basic stations
＊Plan of transmission system of data
＊Plan of recording and keeping system of observation data
＊Plan of operation and maintenance system
＊Trial observation at the stations above

In implementation of above project, the all Peru is divided into several areas depending on the importance, then the project will be implemented step by step, and the implementation might be done by the assistance of foreign country. The administration of observation data is performed by SENAMHI at present, the observation data will be opened regularly to the public and can be used widely by the utilizer.