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
PRE-FEASIBILITY STUDY REPORT

II-2 PROJECT REPORT (CHIRA RIVER)
II-3 PROJECT REPORT (CAÑTE RIVER)
II-4 PROJECT REPORT (CHINCHA RIVER)
II-5 PROJECT REPORT (PISCO RIVER)
II-6 PROJECT REPORT (YAUCA RIVER)
II-7 PROJECT REPORT (MAJES-CAMANA RIVER)

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.

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
PRE-FEASIBILITY STUDY REPORT
II-2 PROJECT REPORT (CHIRA RIVER)

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.

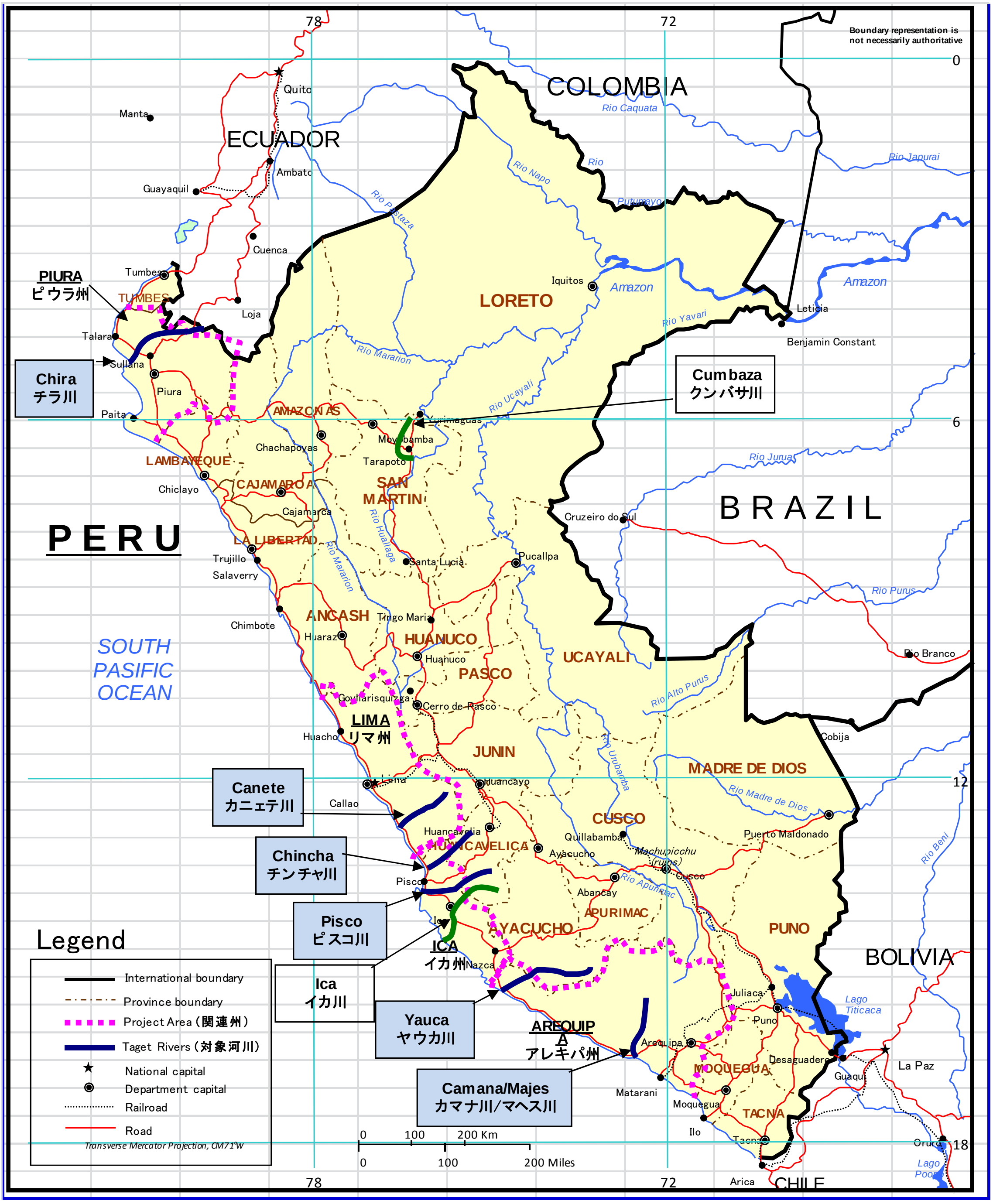
Composition of Final Report

I. Feasibility Study Report

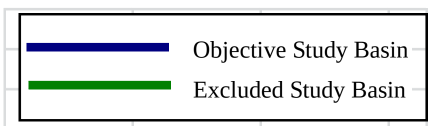
- I-1 Program Report
- I-2 Project Report (Cañete River)
- I-3 Project Report (Chincha River)
- I-4 Project Report (Pisco River)
- I-5 Project Report (Majes-Camana River)
- I-6 Supporting Report
  - Annex – 1 Metrology /Hydrology /Run-off Analysis
  - Annex – 2 Inundation Analysis
  - Annex – 3 River Bed Fluctuation Analysis
  - Annex－4 Flood Control Plan
  - Annex – 5 Forecasting and Warning System in Chira River
  - Annex – 6 Sediment Control
  - Annex – 7 Afforestation and Vegetation Recovery Plan
  - Annex – 8 Plan and Design of Facilities
  - Annex – 9 Construction Planning and Cost Estimate
  - Annex – 10 Socio-economy and Economic Evaluation
  - Annex – 11 Environmental and Social Considerations/ Gender
  - Annex – 12 Technical Assistance
  - Annex – 13 Stakeholders Meetings
  - Annex – 14 Implementation Program of Japanese Yen Loan Project
  - Annex－15 Drawings
- I-7 Data Book

II. Pre- Feasibility Study Report

- II-1 Program Report
- **II-2 Project Report (Chira River) (This Report)**
- II-3 Project Report (Cañete River)
- II-4 Project Report (Chincha River)
- II-5 Project Report (Pisco River)
- II-6 Project Report (Yauca River)
- II-7 Project Report (Majes-Camana River)



Location Map



Abbreviation

Abbreviation	Official Name or meaning
ANA	Water National Authority (Autoridad Nacional del Agua)
ALA	Water Local Authority (Autoridad Local del Agua)
C/B	Cost-Benefit relation (Cost-Benefit Ratio)
GDP	PBI (Producto Bruto Interno) (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)
DGPM	Dirección General de Programación Multianual del Sector Público (Public Sector Multiannual Program General Direction)
DNEP	Dirección Nacional de Endeudamiento Público (Public Indebtedness National Direction)
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)
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

ON

PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOODS IN THE REPUBLIC OF PERU

FINAL REPORT
PRE-FEASIBILITY STUDY REPORT
II-2 PROJECT REPORT
(CHIRA RIVER)

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 Chira River, Piura 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 data of the river with an interval of 500m, in each River's 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 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 field (supply) is the gap between demand and supply.

Table 1.3-1 shows the average of flood water levels, 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 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
Chira	31.85	29.27	31.38	1.20	32.58	2.71	3.53

1.4 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 4.12 “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) 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 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 project in Chira river was excluded from this Project due to the low viability.

(2) Selection of prioritized flood prevention works

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

1) Demand from the local community (based on historical flood damage)
2) Lack of discharge capacity of river channel (including the sections affected by the scouring)
3) Conditions of the adjacent area (conditions in urban areas, farmland, etc.).
4) Conditions and area of inundation (type and extent of inundation according to inundation analysis)
5) 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 four (4) 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

1.5 Non-structural measures

1.5.1 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 4.12 “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, 7.5km y 5.8ha respectively.

1.5.2 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 4.12 “Medium and long term plan”. 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.

In Chira River exists Poechos dam, which retains most part of sediments that are dragged to its reservoir, so the incidence on the lower watershed is very reduced. So, it is considered not to take necessary sediment control actions.

1.5.3 Chira River Early Alert System

As a model case, an early alert system is proposed to be installed in Chira River as described in the section 4.3.2.3 .

However, the following problems are revealed in installation the system.

a) The promising inundation area is almost composed of agricultural land and there is almost no urban area for which the early alert system is required.
b) Since the Poechos dam is located in the upstream of objective study area and the inflow discharge is observed, the forecasting of occurrence and increase of flood can be estimated to some extent of accuracy.

c) The system has a little meaning as an model case because there is the early alert system in the Piura river just adjacent to Chira river.

d) The flood prevention works in the Chira river are to be excluded from the Project. The cost for the system is so small that the system is not required to be adopted as Japanese Yen Loan project, the system can be implemented by the provincial government using its own budget in accordance with JICA plan.

e) The observation stations included in the system are under mobilization and rainfall and discharge data are being collected. However the present conditions data of installed equipment could not be collected so that the necessity of exchange of equipment cannot be judged. If the exchange of equipment is not necessary, 64% of the cost (2,640 nuevo soles) can be saved.

According to the above, the meeting among JICA Peru office, DGIH, OPI, DGPM and JICA Study Team held on December 5, 2011 concluded that the early alert system in Chira river will be excluded from the Project and if necessary, Piura provincial government will implement the system (Minutes of Meetings on Main Points of Interim Report, Lima, December 5, 2011).

1.6 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.”

Aiming to train characteristics of each watershed, courses for each one will be prepared. The beneficiaries are the representatives of the committees and irrigation groups from the watershed, governments employees (provincial and district), local community representatives, 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 four activities propose the following: “Course on riverside defense activities”, “Post-flood prevention and behavior course”, “Watershed (slope) management against fluvial sedimentation” and “Course for risk management information network to floods” in this component.

1.7 Costs

In the Table 1.7-1 the costs of this Project is shown. The cost of the watershed is around 64.0 million soles.

Table 1.7-1 Project Costs

(1,000 soles)

Watershed	Structural Cost					Non-structural cost		Technical Assistance Cost	Total
	Construction Cost	Detail Design Cost	Construction Supervision Cost	Environmental Cost	Sub total	Afforestation Cost	Flood Alert System Cost		
Chira	52,564	2,628	5,256	526	60,974	102	2,640	314	64,031

1.8 Social Assessment

(1) Benefits

The benefits of flood control are the reduction of losses caused by floods which would be achieved by the implementation of the project and is determined by the difference between the loss amount without project and with project. Specifically, to determine the benefits, first the amount of losses by floods is calculated from different return periods (between 2 and 50 years), assuming that flood control works will last 50 years, and then the average annual reduction loss amount is determined from the reduction of losses from different return periods. In Tables 1.8-1 and 1.8-2 show the average annual amount of reduction loss that would be achieved by implementing this project, expressed in costs at private prices and costs at social prices.

Table 1.8-1 Annual average damage reduction amount (at private prices)

s/1000

流域 Basin	流量規模 Return period	超過確率 Probability	被害額 (Total damage – miles de S/.)			区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
			事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②				
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	349,698	333,585	16,113	8,056	0.300	2,417	2,417
	10	0.100	427,001	411,472	15,529	15,821	0.100	1,582	3,999
	25	0.040	485,714	471,293	14,421	14,975	0.060	898	4,897
	50	0.020	562,385	525,002	37,382	25,901	0.020	518	5,415

Table 1.8-2 Annual average damage reduction amount (at social prices)

s/1000

流域 Basin	流量規模 Return period	超過確率 Probability	被害額 (Total damage - miles de S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②	区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	407,180	384,769	22,410	11,205	0.300	3,362	3,362
	10	0.100	494,866	473,618	21,248	21,829	0.100	2,183	5,544
	25	0.040	563,929	544,283	19,646	20,447	0.060	1,227	6,771
	50	0.020	649,089	605,046	44,043	31,844	0.020	637	7,408

(2) Social assessment results

The objective of the social assessment in this study is to evaluate the efficiency of investments in the structural measures using the method of cost-benefit relation (C/B) from the point of view of national economy. To do this, we determined the economic evaluation indicators (C/B 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.

In Tables 1.8-3 and 1.8-4 the costs at private prices and at social prices resulting from this project assessment are shown. It is noted that the project will have enough economic effect.

Table 1.8-3 Social Assessment (costs at private prices)

Watershed	Gathered Average Annual Benefit	Gathered Average Annual Benefit (in 15 years)	Project Cost	O&M Cost	Cost/Benefit Relation	Net Present Value (NPV)	Internal Return Rate (IRR)
Chira	70,400,707	31,791,564	64,030,772	3,415,669	0.55	-25,662,760	0.5%

Table 1.8-4 Social Assessment (costs at social prices)

Watershed	Gathered Average Annual Benefit	Gathered Average Annual Benefit (in 15 years)	Project Cost	O&M Cost	Cost/Benefit Relation	Net Present Value (NPV)	Internal Return Rate (IRR)
Chira	96,306,401	43,490,052	51,721,0005	2,747,002	0.34	-2,911,709	9%

Social assessment showed that Chira river watershed project is not viable at the both private and social prices. Below are the positive effects of the Project that are 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.

- Contribution to increase from stable agricultural production income, relieving flood damage.
- Rise in farmland prices

From the results of the economic evaluation presented above, it is considered that this project could not be implemented even if there are positive effects which are difficult to quantify in monetary term.

1.9 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. Usually the central government (in this case, the DGIH) assumes 80%, the irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both 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.

In Table 1.9-1 data of the irrigation commission's budget of the Chira River in the last years is shown.

Table 1.9-1 Irrigation commission Project's Budget

River	Annual Budget			(In soles)	
	2006	2007	2008	2009	4 year average
Chira	30.369.84	78.201.40	1.705.302.40	8.037.887.44	2.463.008

(1) Profitability

The cost for Chira river watershed is 64.0 million soles. The economic impact in terms of social prices costs of C/B = 0.94 , NPV=-2.9 million soles and IRR = 9%. So, these figures do not show a positive economic impact.

(2) Operation and maintenance costs

The annual cost of operation and maintenance required for the project, having as base year 2008 is estimated at 263,000 soles, which corresponds to 0.5% of the construction cost of the project in the Chira river watershed. On the other hand, the operating expenses average in the last four years of irrigation committees is 2,463,000.

When considering that the annual cost of operation and maintenance represents 10.75% of the annual irrigation budget, the project would be sustainable enough because of the financial capacity of these committees to maintain and operate the constructed works. However since the project has no economic viability it is difficult to implement this project.

1.10 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.

We reviewed and assessed the positive and negative environmental impact associated to the implementation of this project and the prevention and mitigation measures where set for these impacts. The preliminary environmental assessment (EAP) for Chira watershed was carried out between December 2010 and January 2011 by a consulting firm registered in the Ministry of Agriculture (CIDES Ingenieros S.A.). EAP for the Chira watershed was submitted to DGIH January 25, 2011 by JICA Study Team and from DGIH to DGAA July

19,2011.

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

（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 environment, biological and social) 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).

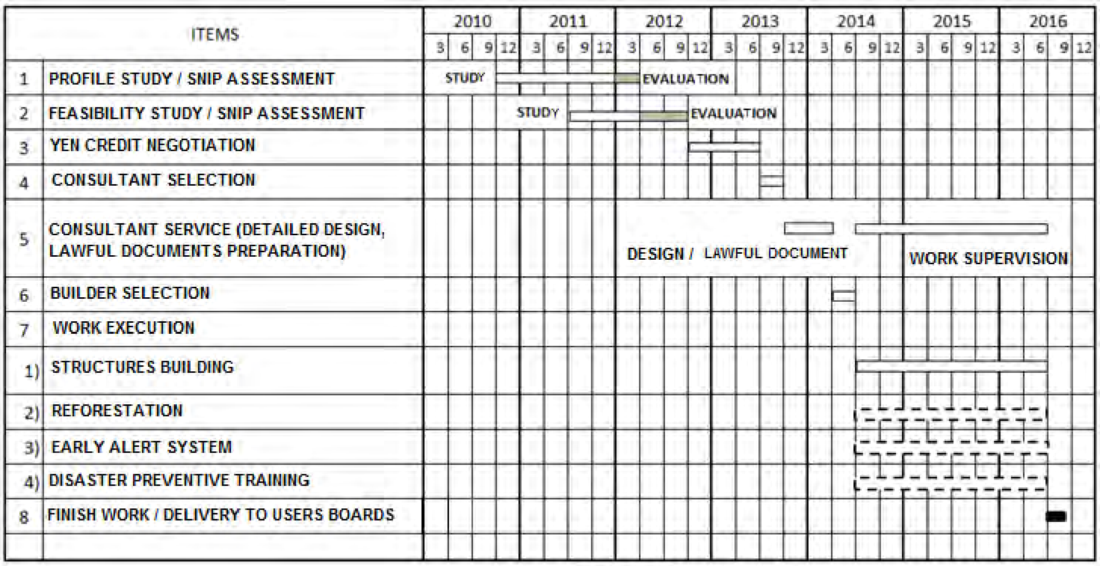
The EAP showed that the environmental impact would be manifested by the implementation of this project in the construction and maintenance stages, mostly, it is not very noticeable, and if it were, it can be prevented or mitigated by appropriately implementing the management plan environmental impact.

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.

1.11 Execution plan

Table 1.11-1 presents the Project execution plan.

Table 1.11-1 Execution plan



1.12 Institutions and management

The institutions and its administration in the investment stage and in the operation and maintenance stage after the investment, shown in the Figures 1.12-1 and 1.12-2.

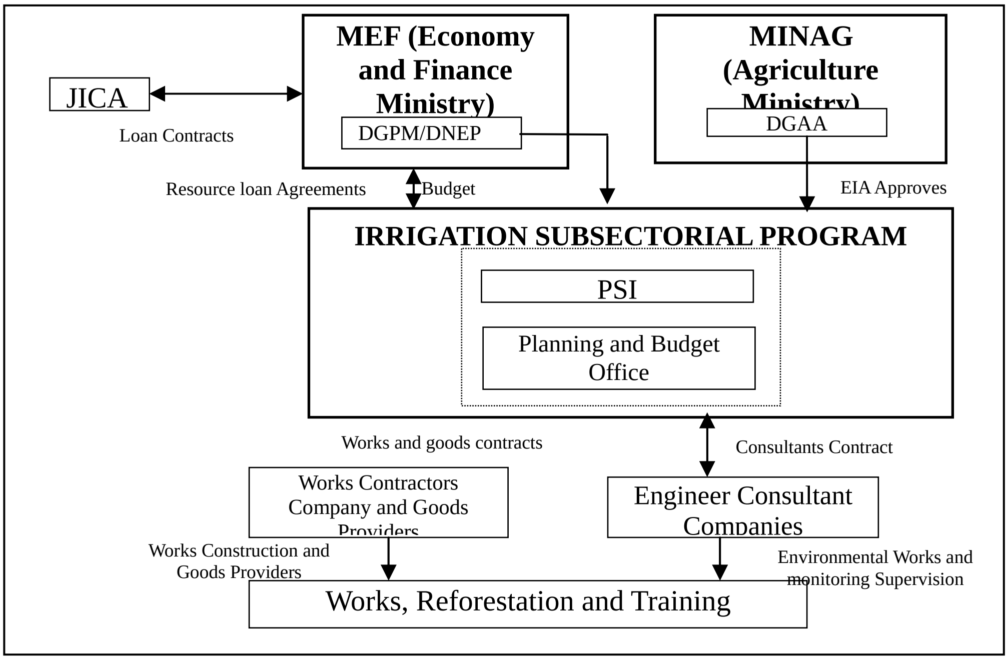


Figure 1.12-1 Institutions related to the project (investment stage)

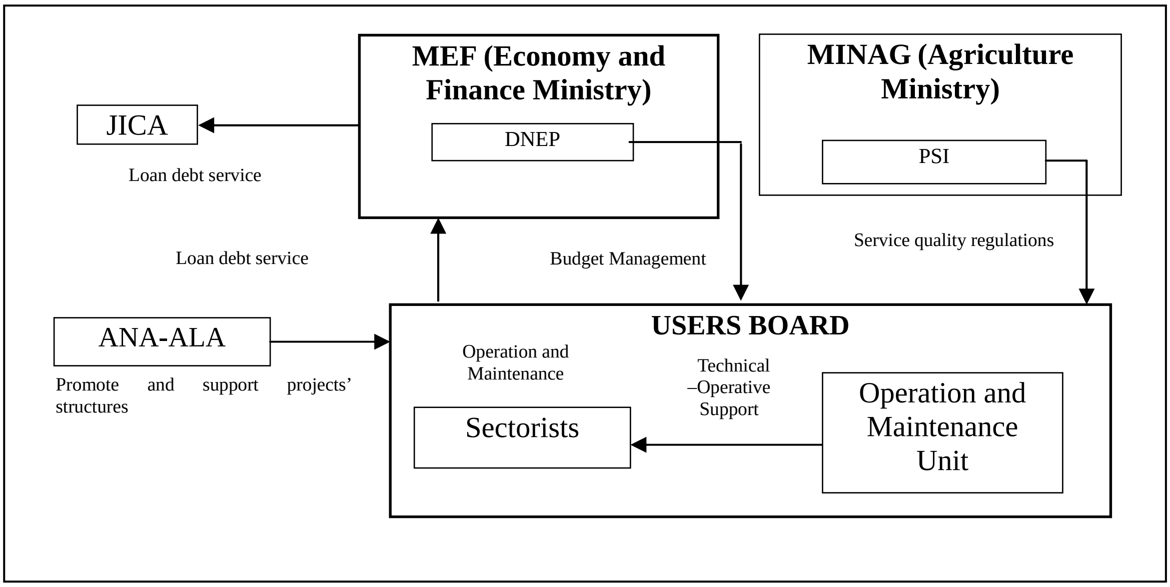


Figure 1.12-2 institutions related to the project (operation and maintenance stage)

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	Scio-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 areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, bank erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, bank erosion progress and watershed's downstream erosion.	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, road damages prevention, construction of 28 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			
B-1 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
B-2 Early alert system	Installed equipments, operational state, emitted alerts state, emitted alerts frequency and information transmission state	Work advance reports, public entity and local community monitoring	Equipment adequate functioning, appropriate staff training, communication and promotion, equipment and programs O & M
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, reservoirs, dikes or a combination of these. The options to build dams or reservoirs 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 each 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. 167km in Chira river. 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 50,000 m3.

In Tables 1.15-1 and 1.15-2 the flood control general plan project cost is shown as well as the social assessment results in terms of private and social prices.

Table 1.15-1 Project Cost and Social Assessment of the general flood control plan (private prices)

Watershed	Damage Annual Medial Reduction	Damage Reduction in Assessment Period (in 15 years)	Project Cost	O&M Cost	Cost/Benefit Relation	Net Present Value (NPV)	Internal Return Rate (IRR)
Chira	1.678,976217	758.192,379	809.055,316	59.450,746	1.03	23.878,182	11%

Table 1.15-2 Project Cost and Social Assessment of the general flood control plan (social prices)

Watershed	Damage Annual Medial Reduction	Damage Reduction in Assessment Period (in 15 years)	Project Cost	O&M Cost	Cost/Benefit Relation	Net Present Value (NPV)	Internal Return Rate (IRR)
Chira	1.950.952,884	881.011,542	650.480,474	47.798,400	1.49	290.623,026	18%

In case of executing flood control works in the watershed, the Projects' cost would elevate to 809.1 million soles, which is a huge amount. Regarding social prices evaluation at social prices, the project's economic impact in Chira watershed justifies the implementation of the Project.

(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' water reload, reduce surface water and increase semi-underground and underground. So, the flood maximum flow will be achieved, 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 reload areas has been lost.

In Table 1.15-3 the area to be afforested and the project's cost for the watershed is shown. This was calculated based on forestry plan of Chincha River. The total surface would be approximately 27,800hectares and in order to forest them the required time would be 9 years and 75.1 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 1.15-3 General Plan for forestry on upper stream watersheds

Watershed	Forestry Area (ha） A	Required Period for the project (years) B	Required Budget (soles) C
Chira	27.839	9	75.141,182

(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 1.15-4 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.

All the chosen watersheds for this Project are big. So, if margin 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 its positive impact will be seen in a long time.

Table 1.15-4 Projects Costs of Sediment Control Plan at Upstream of Watershed

Watersheds	Areas	Margin Protection		Bands		Dams		Works direct cost (total)	Project Cost (in millions de s/.)
		Qty. (km)	Works direct costs (million s/.)	Qty. (km)	Works direct costs (million s/.)	Qty. (km)	Works direct costs (million s/.)		
Chira	Totally	0	S/.0	0	S/.0	272	S/.423	S/.423	S/.796
	Prioritized areas	0	S/.0	0	S/.0	123	S/.192	S/.192	S/.361

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 Chira River, Piura Department"

2.2 Formulator and Executor Units

(1) Formulator Unit

Name: Hydraulic Infrastructure General Direction, Agriculture Ministry
Responsible: Orlando Chirinos Hernan Trujillo
General Director of the Water Infrastructure General Direction
Address: Av. Benavides N° 395 Miraflores, Lima 12 - Peru
Phone: (511) 4455457 / 6148154
Email: ochirinos@minag.gob.pe

(2) Executor Unit

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) Administration Office (OA)

- 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)

- 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)

Public Sector's Multiannual Programming General Direction (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 pre-feasibility 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.

The Special Project Chira-Piura, Regional Government of Piura implemented by the regional government of Piura also includes Chira River which is the area of this Study.

(5) Irrigation Commission

Currently there are 6 irrigation commissions in the Chira River Watershed. These have expressed a strong desire for the starting of works because these will help constructing dikes, protecting banks, repairing water intakes, etc. These commissions are currently suffering major damages due to rivers flooding. Next, a brief overview of the Chira River Watershed is described (for more details, see Section 3.1.3). Currently, the operation and maintenance of dikes, bank 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:	6
Number of Irrigation Commissions:	6
Irrigated Area:	48,676 ha
Beneficiaries:	18,796 productores

(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 the Civil Defense National System. 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 this context, the central government has implemented El Niño phenomenon I and II contingency plans in 1997-1998, throughout the Agriculture and Livestock Ministry (MINAG) in order to rebuild water infrastructures devastated by this phenomenon. Next, the Hydraulic Infrastructure General Direction (DGIH) of the Agriculture Ministry (MINAG) began in 1999 the River Channeling and Collection 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 punctual, without giving a full and integral solution to control floods. So, every time floods occur in different places, damages are still happening.

MINAG developed 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 help 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 draft from AOD of 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 Discussions Minutes (hereinafter "M/D") that were signed on January 21 and April 16, 2010. This study was implemented on this M/D.

(2) Progress of Study

The Profile Study Report for this Project at Program's level for nine(9) watersheds of five regions(5) has been 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) 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 going to be 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 an accurate pre-feasibility level and handed DGIH the Program Report of group A and the reports of the five watershed projects by late 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 received through 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 because they belong to a single watershed (Majes-Camana).

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 for the second time the Meeting Minutes (refer to Meetings Minutes Second Amendment about the Initial 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.
This report corresponds with the program report with pre-feasibility study level of five watersheds of Group A and one watershed (Majes-Camana watershed) of Group B. The feasibility study of Majes-Camana watershed wants to be finished by mid-January 2012, and the feasibility study for all selected watersheds around the same dates.

DGIH processed the registration of four of the five watersheds (except Yauca) to the SNIP system on July 21st, based on projects reports at pre-feasibility level prepared by JICA Study Team. And DHIG decided to discard Yauca River due to its low impact in economy.

The Project Reports with pre-feasibility level for 4 watersheds (Chira, Cañete , Chincha, Pisco) were submitted to OPI from DGIH, and OPI issued their comments on the reports on September 22, 2011. The revision of the reports is under discussion among OPI, DGIH and JICA Study Team.

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

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.

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

Article 118 .- From the maintenance programs of the bankal 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 bankal strips forestry protection from water erosive action.

Article 259 º .- Obligation to defend banks

All users have as duty to defend river banks 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 bank 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 Chira River, included in the Area of this study.

Figure 3.1.1-1 Location of Chira River

(2) Watershed overall description

The Chira River runs approx. 850km to the north of the Capital of Lima and it is managed by Piura province. It is an International river, because part of its upper watershed belongs to Ecuador. The biggest Dam in Peru, Poechos, is located 100km upstream from the mouth of this River. This Dam has a capacity for 800 million cubic meters (multipurpose dam for irrigation, urban water, electric generation and other). The watershed area is approx. 13,000km^2 upstream Poechos dam (of which 6,500km^2 belong to Ecuador) and approx. 4,000km^2 downstream. In the 100 km section downstream of the dam that constitutes the Study Area, the river is characterized for a soft slope approximately of 1/1400 with a width between 500 and 1,500 meters.

Annual rainfalls are approximately 100 to 1000mm at altitudes less than 500m.a.s.l; and between 600 and 1600mm at altitudes greater than 3,000m.a.s.l. This tendency of increasing precipitations at higher altitudes is similar in other watersheds, but Chira River outstands due to its high average precipitations.

As to vegetation, 90% of the watershed is covered with shrub and dry forests, with the exception of a part of the upper watershed which is covered by tropical forest. On the other hand, the lower watershed (downstream Poechos dam), it is also covered with shrub and dry forests in 80% and of crops in 20%. Chira River belongs to a tropical weather with high precipitations and few arid areas. Agriculture lands are based on banana and sugar cane. The natural gas is under development in the lowest watershed.

3.1.2 Socio-economic conditions of the Study Area

(1) Administrative Division and Surface

The Chira River is located in the provinces of Sullana and Paita in the Piura 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 Chira River with areas

Region	Province	District	Area (㎢)
Piura	Sullana	Sullana	488.01
		Ignacio Escudero	306.53
		Marcavelica	1687.98
		Querocotillo	270.08
		Salitral	28.27
	Paita	Amotape	90.82
		Colán	124.93
		La Huaca	599.51
		Tamariodo	63.36

(2) Population and number of households

The following Table, 3.1.2-2 shows how population varied within the period 1993-2007. From the total of 231.043 inhabitants in Sullana in 2007, 93% (215.069 inhabitants) lived in urban areas while 7% (15.974 inhabitants) lived in rural areas. Likewise, from the total of 29.906 inhabitants in Paita, 89% (26.494 inhabitants) lived in urban areas while 11% (3.412 inhabitants) lived in rural areas.

In both districts population is growing. In particular, Sullana outstood within the watershed for its quick population increase of approx 35.000 inhabitants.

Regarding population variation between 1993 and 2007, rural and urban population of Sullana and urban area of Paita registered an increase between 1.0 and 1.6% meanwhile rural area of Paita had a reduction of 1.3%.

Table 3.1.2-2 Variation of the urban and rural population

Province	District	Total Population 2007					Total Population 1993					Variation (%)	
		Urban	%	Rural	%	Total	Urban	%	Rural	%	Total	Urban	Rural
Sullana	Sullana	145.882	93%	10.719	7%	156.601	115.484	95%	6.410	5%	121.894	1,7%	3,7%
	Ignacio Escudero	17.202	96%	660	4%	17.862	13.486	95%	689	5%	14.175	1,8%	-0,3%
	Marcavelica	24.462	94%	1.569	6%	26.031	19.406	92%	1.586	8%	20.992	1,7%	-0,1%
	Querocotillo	21.916	90%	2.536	10%	24.452	19.218	86%	3.219	14%	22.437	0,9%	-1,7%
	Salitral	5.607	92%	490	8%	6.097	4.075	81%	979	19%	5.054	2,3%	-4,8%
Total		**215,069**	**93%**	**15.974**	**7%**	**231.043**	**171.669**	**93%**	**12.883**	**7%**	**184.552**	**1,6%**	**1,5%**
Paita	Amotape	2.139	93%	166	7%	2.305	2.135	96%	87	4%	2.222	0,0%	4,7%
	Colan	11.343	92%	989	8%	12.332	10.753	92%	908	8%	11.661	0,4%	0,6%
	La Huaca	8.876	82%	1.991	18%	10.867	6.408	70%	2.756	30%	9.164	2,4%	-2,3%
	Tamarindo	4.136	94%	266	6%	4.402	3.643	91%	345	9%	3.988	0,9%	-1,8%
Total		**26.494**	**89%**	**3.412**	**11%**	**29.906**	**22.939**	**85%**	**4.096**	**15%**	**27.035**	**1,0%**	**-1,3%**

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. The number of members per household has been 4.0 to 4.5. Each family has between 3.8 and 4.3 members.

Table 3.1.2-3 Number of households and families

Variables	District				
	Sullana	Ignacio escudero	Marcavelica	Querocotillo	Salitral
Population (inhabitants)	156,601	17,862	26,031	24,452	6,097
Number of households	34,218	4,024	6,309	5,730	1,468
Number of families	36,386	4,248	6,504	6,011	1,555
Members per household (person/home)	4.58	4.44	4.13	4.27	4.15
Members per family (person/family)	4.30	4.20	4.00	4.07	3.92

Variables	District			
	Amotape	Colan	La Huaca	Tamarindo
Population (inhabitants)	2,305	12,332	10,867	4,402
Number of households	544	2,725	2,422	1,075
Number of families	573	2,874	2,608	1,146
Members per household (person/home)	4.24	4.53	4.49	4.09
Members per family (person/family)	4.02	4.29	4.17	3.84

(3) Occupation

Table 3.1.2-4, shows occupation lists of local inhabitants itemized by sector. In Sullana, the workers of the tertiary sector have increased in 71.8%, but in the other districts the primary sector is still absorbing a high labor percentage (between 40 and 80%)

Table 3.1.2-4 Occupation

	District									
	Sullana		Ignacio escudero		Marcavelica		Querocotillo		Salitral	
	People	%	People	%	People	%	People	%	People	%
EAP	52,662	100	5,042	100	7,897	100	3,920	100	2,211	100
Primary Sector	8,230	15.6	2,813	55.8	4,195	53.1	3,231	82.4	1,065	48.2
Secondary Sector	6,636	12.6	616	12.2	716	9.1	69	1.8	227	10.3
Tertiary Sector	37,796	71.8	1,613	32.0	2,986	37.8	620	15.8	919	41.6

* 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. 39.6% of the Sullana total population (231.043 inhabitants) belongs to the poor segment and 6.7% (15.536 inhabitants) to the extreme poverty segment. In Paita, 43.3% of the population (12.955 inhabitants) belongs to the poor segment and 4.8% (1.447 inhabitants) to the extreme poverty segment. In particular, poor and extreme poverty sectors of Colan district are 49.8% and 6.5/ respectively, representing almost half of the total population.

Table 3.1.2-5 Poverty index

	Sullana											
	Sullana		Ignacio Escudero		Marcavelica		Querecotillo		Salitral			
	People	%	People	%	People	%	People	%	People	%	Total	%
Regional Population	156,601	100	17,862	100	26,031	100	24,452	100	6,097	100	231,043	100
In poverty	65,747	42.0	6,197	34.7	9,566	36.7	8,013	32.8	2,008	32.9	91,531	39.6
In extreme poverty	13,269	8.5	538	3.0	983	3.8	622	2.5	124	2.0	15,536	6.7

	Paita									
	Amotape		Colan		La Huaca		Tamarindo			
	People	%	People	%	People	%	People	%	Total	%
Regional Population	2,305	100	12,332	100	10,867	100	4,402	100	29,906	100
In poverty	858	37.2	6,081	49.3	4,538	41.8	1,478	33.6	12,955	43.3
In extreme poverty	91	3.9	801	6.5	465	4.3	90	2.0	1,447	4.8

(5) Type of housing

In Sullana, the walls of the houses are made 48% of bricks or cement, and 34% of adobe and mud. The floor is made 97% of earth or cement.
The public drinking water service exceeds 50%, except in Ignacio Escudero and Querecotillo, while the sewage service is more than 60% in Sullana and Salitral. Electrification reaches 82% in average.
In Paita, the walls of the houses are made 47% of bricks or cement, and 46% of adobe and mud. The floor is made 96% of earth or cement. The public drinking water service exceeds 60%, except in La Huaca, while the sewage service is less than 50%. Electrification reaches 70% in average.

Table 3.1.2-9 Type of housing (Sullana)

Variable/Indicator	Districts									
	Sullana		Ignacio escudero		Marcavelica		Querocotillo		Salitral	
	Houses	%	Houses	%	Houses	%	Houses	%	Houses	%
Name of housings										
Common residents housing	34.218	94,6	4.024	94,5	6.309	94,9	5.730	92,7	1.468	93
Walls materials										
Bricks or cement	18.384	53,7	1.108	27,5	1.769	28	1.308	22,8	391	26,6
Adobe and mud	7.930	23,2	2.200	54,7	1.353	21,4	1.611	28,1	96	6,5
Bamboo + mud or wood	6.662	19,5	664	16,5	3.041	48,2	2.777	48,5	974	66,3
Others	1.242	3,6	52	1,3	146	2,3	34	0,6	7	0,5
Floor Materials										
Soil	14.564	42,6	2.194	54,5	4.096	64,9	3.707	64,7	943	64,2
Cement	16.772	49	1.746	43,4	2.086	33,1	1.927	33,6	479	32,6
Ceramics, parquet, quality wood	2.706	7,9	50	1,2	107	1,7	83	1,4	41	2,8
Others	176	0,5	34	0,8	20	0,3	13	0,2	5	0,3
Running water system										
Public network within household	22.703	66,3	1.847	45,9	3.207	50,8	2.240	39,1	1.085	73,9
Public network within building	1.187	3,5	119	3	487	7,7	90	1,6	21	1,4
public use	960	2,8	642	16	31	0,5	449	7,8	8	0,5
Sewage										
Public sewage within household	21.836	63,8	643	16	1.351	21,4	1.860	32,5	645	43,9
Public sewage within building	842	2,5	99	2,5	138	2,2	78	1,4	22	1,5
Septic Tank	6.002	17,5	1.669	41,5	1.769	28	2.321	40,5	437	29,8
Electricity										
Public electric service	28.198	82,4	3.243	80,6	4.769	75,6	5.084	88,7	1.079	73,5
Member quantity										
Common residents housing	**36.386**	**100**	**4.248**	**100**	**6.504**	**100**	**6.011**	**100**	**1.555**	**100**
Appliances										
More than three	13.559	37,3	931	21,9	1.543	23,7	1.188	19,8	379	24,4
Communication Services										
Phones and mobiles	28.020	77,0	1.670	39,3	3.202	49,2	2.179	36,3	668	43,0

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

Table 3.1.2-7 Housing type (Paita)

Variable/Indicator	Districts							
	Amotape		Colan		La Huaca		Tamarindo	
	Hogares	%	Hogares	%	Hogares	%	Hogares	%
Name of housings								
Common residents housing	544	92,4	2.725	82,3	2.422	90,4	1.075	90,2
Walls materials								
Bricks or cement	188	34,6	958	35,2	683	28,2	202	18,8
Adobe and mud	14	2,6	428	15,7	383	15,8	115	10,7
Bamboo + mud or wood	337	61,9	1.304	47,9	1.323	54,6	745	69,3
Others	5	0,9	35	1,3	33	1,4	13	1,2
Floor Materials								
Soil	291	53,5	1.891	69,4	1.499	61,9	680	63,3
Cement	242	44,5	779	28,6	885	36,5	388	36,1
Ceramics, parquet, quality wood	10	1,8	52	1,9	29	1,2	6	0,6
Others	1	0,2	3	0,1	9	0,4	1	0,1
Running water system								
Public network within household	386	71	1.660	60,9	1.126	46,5	656	61
Public network within building	7	1,3	69	2,5	44	1,8	8	0,7
public use	11	2	21	0,8	12	0,5	3	0,3
Sewage								
Public sewage within household	4	0,7	977	35,9	332	13,7	500	46,5
Public sewage within building			68	2,5	45	1,9	25	2,3
Septic Tank	149	27,4	843	30,9	839	34,6	116	10,8
Electricity								
Public electric service	363	66,7	1.841	67,6	1.743	72	711	66,1
Member quantity								
Common residents housing	**573**	**100**	**2.874**	**100**	**2.608**	**100**	**1.146**	**100**
Appliances								
More than three	134	23,4	463	16,1	544	20,9	242	21,1
Communication Services								
Phones and mobiles	154	26,9	1.028	35,8	1.049	40,2	346	30,2

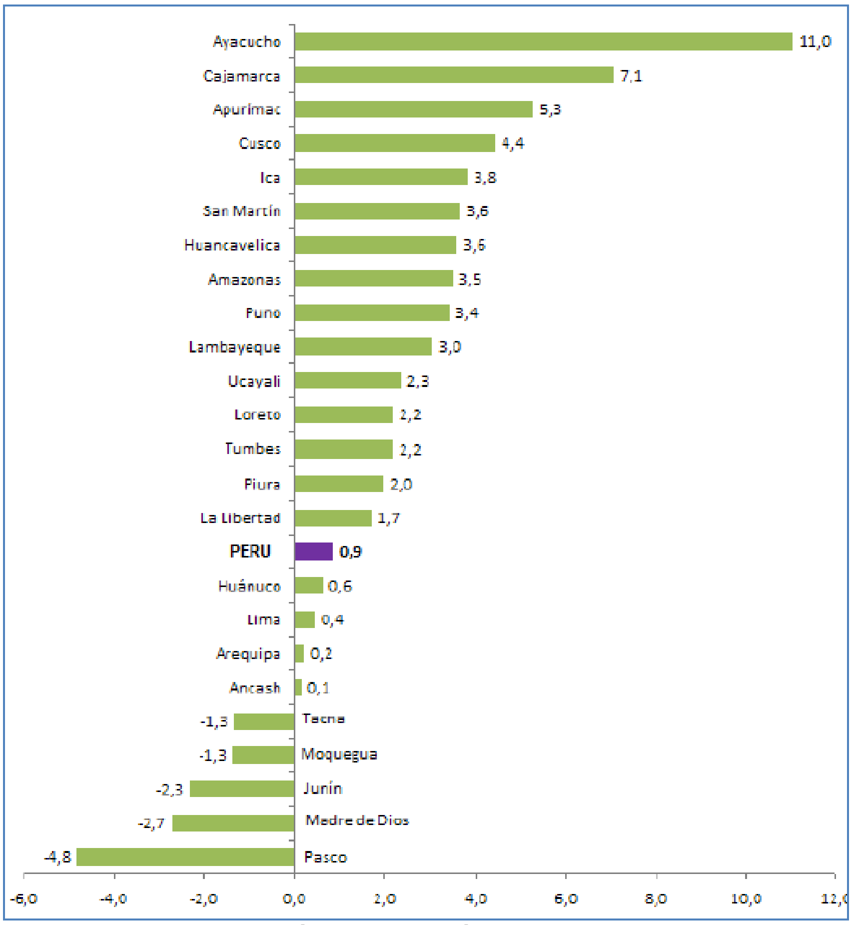
Source: Prepared by JICA Study Team, Statistics National Institute- INEI, 2007 Population and Housing Census

(6) GDP

Peru’s GDP in 2009 was S./392,565,000,000.

The growth rate in the same year was of + 0.9 % compared with the previous year with the poorest level within 11 years.

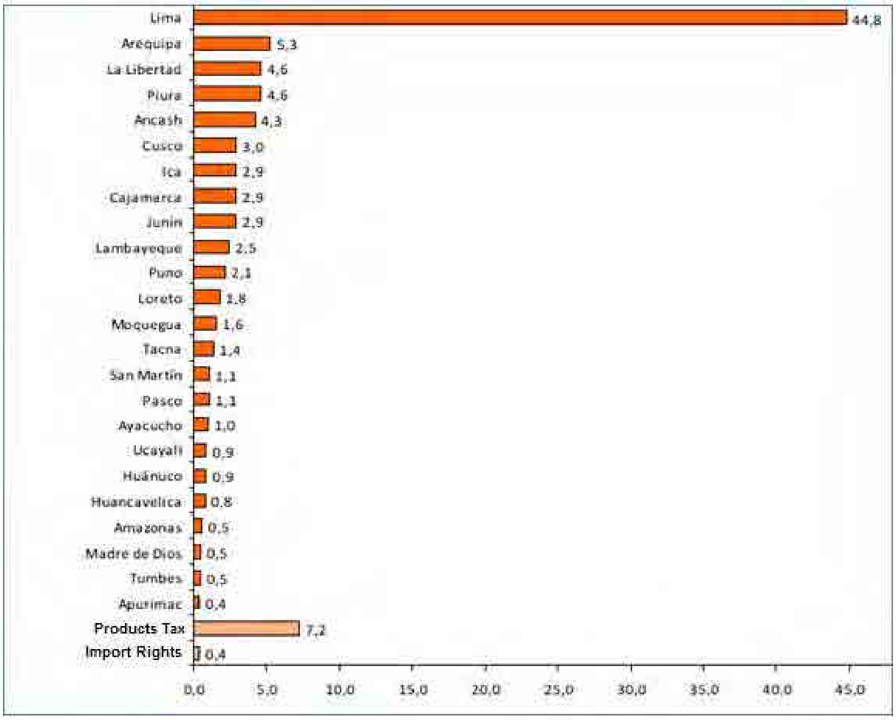
Itemized by regions, Ica registered a growth of 3.8 %, Piura 2.0 %, Lima 0.4 % and Arequipa 0.2 %. Particularly Ica and Piura regions registered Figures that were beyond the national average.



INEI Source – National Accounts National Direction

Figure 3.1.2-1 Growth rate of GDP per region (2009/2008)

The table below shows the contribution of each region to the GDP. Lima Region represents almost half of the total, that is to say 44.8%. Arequipa contributed with 5.3 %, Piura 4.6 % and Ica 2.9 %. Taxes and duties contributed with 7.2 % and 0.4 %, respectively.

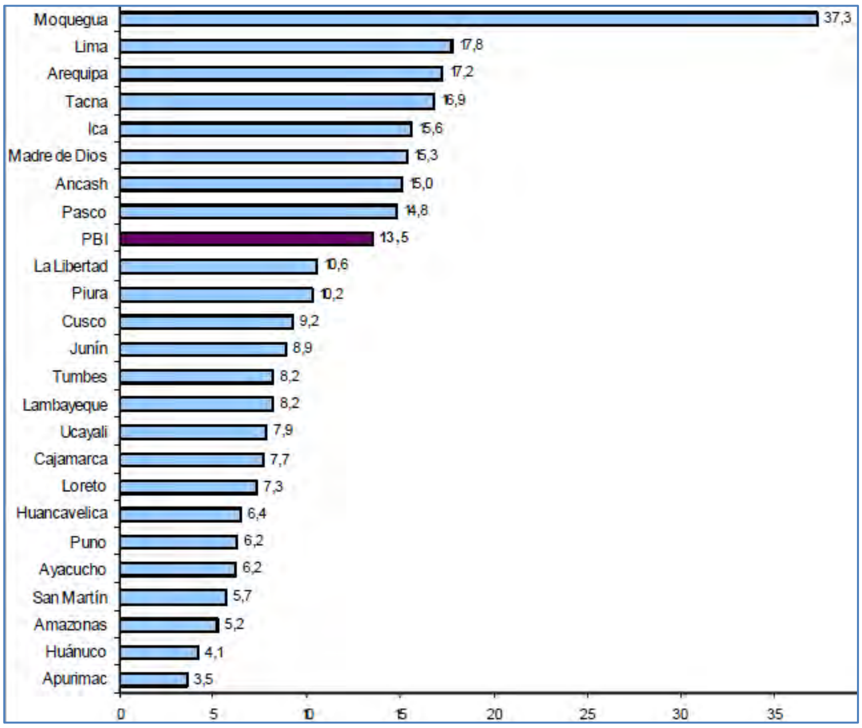


INEI Source – National Accounts National Direction

Figure 3.1.2-2 Region contribution to GDP

The GDP per capita in 2009 was of S/.13.475.

The Table below shows data per region: Lima S/.17,800, Arequipa S/.17,200, Ica S/.15,600 and Piura S/.10,200. The first three regions exceeded the national average, with exception of Piura.



INEI Source – National Accounts National Direction

Figure 3.1.2-3 GDP per capita (2009)

Table 3.1.2-8 shows the variation along the years of the GDP per capita per region, during the last 9 years (2001-2009).

The GDP national average increased in 44% within nine years from 2001 until 2009. The Figures per region are: +83.9 % for Ica, +54.2 % for Arequipa, +48.3 % for Piura y +42.9 % for Lima.

Figures in Table 3.1.2-8 were established taking 1994 as base year.

Table 3.1.2-8 Variation of the GDP per capita (2001-2009)

(1994 Base year, S/.)

Departament	2001	2002	2003	2004	2005	2006	2007P/	2008P/	2009E/	Accumulated Growth 2001-2009 (%)
Cusco	2 194	2 086	2 195	2 565	2 768	3 071	3 340	3 554	3 685	67,9
Ica	4 055	4 259	4 343	4 663	5 214	5 582	6 025	7 265	7 457	83,9
La Libertad	3 162	3 316	3 483	3 410	3 697	4 216	4 586	4 874	4 895	54,8
Ucayali	3 063	3 149	3 203	3 411	3 584	3 754	3 846	4 007	4 039	31,9
Moquegua	10 405	11 967	12 670	13 455	13 882	13 794	13 606	14 201	13 865	33,3
Arequipa	5 387	5 766	5 895	6 143	6 488	6 807	7 786	8 379	8 308	54,2
Apurimac	1 216	1 278	1 334	1 400	1 494	1 619	1 653	1 691	1 770	45,5
Piura	2 733	2 780	2 847	3 049	3 192	3 472	3 780	4 007	4 052	48,3
San Martín	2 026	2 059	2 094	2 232	2 393	2 476	2 655	2 870	2 928	44,5
Ayacucho	1 788	1 870	1 942	1 900	2 045	2 207	2 448	2 640	2 896	61,9
Amazonas	1 835	1 910	1 996	2 081	2 212	2 349	2 510	2 684	2 761	50,5
Madre de Dios	4 441	4 708	4 550	4 846	5 171	5 215	5 617	5 878	5 564	25,3
Cajamarca	2 493	2 731	2 947	2 968	3 165	3 113	2 864	3 094	3 295	32,2
Ancash	4 037	4 703	4 772	4 876	4 999	5 089	5 408	5 852	5 827	44,3
Tumbes	2 744	2 802	2 873	3 018	3 385	3 212	3 427	3 594	3 611	31,6
Lima	6 451	6 579	6 700	6 925	7 284	7 817	8 520	9 314	9 220	42,9
Puno	2 105	2 236	2 234	2 270	2 365	2 460	2 617	2 731	2 800	33,0
Lambayeque	2 941	3 046	3 132	2 959	3 164	3 300	3 615	3 882	3 963	34,8
Junín	3 245	3 311	3 350	3 527	3 505	3 856	4 072	4 379	4 248	30,9
Loreto	2 827	2 917	2 936	2 995	3 079	3 192	3 287	3 402	3 429	21,3
Huánuco	1 678	1 694	1 833	1 866	1 890	1 915	1 942	2 050	2 044	21,8
Pasco	5 137	5 552	5 481	5 634	5 644	6 062	6 711	6 729	6 349	23,6
Tacna	6 004	6 124	6 382	6 643	6 782	6 941	7 256	7 458	7 253	20,8
Huancavelica	2 700	2 632	2 683	2 697	2 864	3 014	2 903	2 959	3 039	12,5
GDP	4 601	4 765	4 890	5 067	5 345	5 689	6 121	6 643	6 625	44,0

INEI Source – National Accounts National Direction

3.1.3 Agriculture

Next is a summarized report on the current situation of agriculture in each Watershed, 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 Chira River Watershed there are 6 irrigation sectors, 6 irrigation commissions with 18.796 beneficiaries. The surface managed by these sectors reaches a total of 48,676 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	%		
Miguel Checa	Miguel Checa	12.701	26 %	8.499	Chira
El Arenal	El Arenal	3.608	7 %	2.045	
Poechos - Pelados	Poechos - Pelados	4.433	9 %	1.719	
Cieneguillo	Cieneguillo	6.859	14 %	1.451	
Margen Derecha	Margen Derecha	12.415	26 %	3.755	
Margen Izquierda	Margen Izquierda	8.660	18 %	1.327	
Total		**48,676**	**100 %**	**18,796**	

Source: Prepared by JICA Study Team, Users Board of Yauca, October 2010

(2) Main crops

Table 3.1.3-2 shows the variation between 2005 and 2010 of the planted surface and the performance of main crops.

In the Chira River Watershed, the main products would have been bananas and lime. However, in 2009 sugar cane production began in order to produce ethanol, which sales exceeded lime sales in 2009-2010.

The sowing area and sales vary depending on the year.

Table 3.1.3-3 Sowing and sales of main crops

	Variables	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	Total
Rice	Planted Area (ha)	16,769	21,943	23,921	22,226	19,973	**104,832**
	Unit Performance (kg/Ha)	9,882	9,764	9,785	9,588	9,753	
	Harvest (Kg)	165,711,258	214,251,452	234,066,985	213,102,888	194,796,669	**1,021,929,252**
	Unit Price (S/./kg)	0.81	0.93	1.12	0.76	0.81	
	Sales (S/.)	134,226,119	199,253,850	262,155,023	161,958,195	157,785,302	**915,378,489**
Banana	Planted Area (ha)	4,595	5,280	5,096	5,096	5,096	**25,163**
	Unit Performance (kg/Ha)	44,406	41,787	41,608	42,453	43,984	
	Harvest (Kg)	204,045,570	220,635,360	212,034,368	216,340,488	224,142,464	**1,077,198,250**
	Unit Price (S/./kg)	0.40	0.55	0.63	0.67	0.63	
	Sales (S/.)	81,618,228	121,349,448	133,581,652	144,948,127	141,209,752	**622,707,207**
Sugar Cane	Planted Area (ha)				565	5,482	**6,047**
	Unit Performance (kg/Ha)				138,969	139,859	
	Harvest (Kg)				78,517,485	766,707,038	**845,224,523**
	Unit Price (S/./kg)				0.07	0.07	
	Sales (S/.)				5,496,224	53,669,493	**59,165,717**
Lime	Planted Area (ha)	3,146	1,932	1,932	1,932	1,932	**10,874**
	Unit Performance (kg/Ha)	31,856	42,425	38,238	31,034	31,500	
	Harvest (Kg)	100,218,976	81,965,100	73,875,816	59,957,688	60,858,000	**376,875,580**
	Unit Price (S/./kg)	0.36	0.43	0.64	0.46	0.58	
	Sales (S/.)	36,078,831	35,244,993	47,280,522	27,580,536	35,297,640	**181,482,523**
Corn	Planted Area (ha)	1,156	1,472	1,677	1,255	1,069	**6,629**
	Unit Performance (kg/Ha)	5,216	5,177	5,266	5,320	5,141	
	Harvest (Kg)	6,029,696	7,620,544	8,831,082	6,676,600	5,495,729	**34,653,651**
	Unit Price (S/./kg)	0.55	0.77	0.76	0.78	0.85	
	Sales (S/.)	3,316,333	5,867,819	6,711,622	5,207,748	4,671,370	**25,774,892**
Mango	Planted Area (ha)	537	646	646	646	610	**3,085**
	Unit Performance (kg/Ha)	25,000	28,855	26,550	26,570	28,292	
	Harvest (Kg)	13,425,000	18,640,330	17,151,300	17,164,220	17,258,120	**83,638,970**
	Unit Price (S/./kg)	0.42	0.29	0.71	0.65	0.44	
	Sales (S/.)	5,638,500	5,405,696	12,177,423	11,156,743	7,593,573	**41,971,935**
Legume	Planted Area (ha)	366	674	279	303	272	**1,894**
	Unit Performance (kg/Ha)	1,399	1,480	1,743	1,780	1,589	
	Harvest (Kg)	512,034	997,520	486,297	539,340	432,208	**2,967,399**
	Unit Price (S/./kg)	1.77	1.87	1.98	2.04	2.00	
	Sales (S/.)	906,300	1,865,362	962,868	1,100,254	864,416	**5,699,200**
Corn	Planted Area (ha)	67	372	254	309	191	**1,193**
	Unit Performance (kg/Ha)	7,313	7,363	6,996	7,010	7,543	
	Harvest (Kg)	489,971	2,739,036	1,776,984	2,166,090	1,440,713	**8,612,794**
	Unit Price (S/./kg)	0.64	0.68	0.80	0.84	0.82	
	Sales (S/.)	313,581	1,862,544	1,421,587	1,819,516	1,181,385	**6,598,613**
Pasture	Planted Area (ha)	319	183	181	181	166	**1,030**
	Unit Performance (kg/Ha)	45,824	57,169	46,442	77,790	75,268	
	Harvest (Kg)	14,617,856	10,461,927	8,406,002	14,079,990	12,494,488	**60,060,263**
	Unit Price (S/./kg)	0.15	0.19	0.15	0.20	0.20	
	Sales (S/.)	2,192,678	1,987,766	1,260,900	2,815,998	2,498,898	**10,756,240**
Plums	Planted Area (ha)	160	160	160	160	160	**800**
	Unit Performance (kg/Ha)	3,519	3,056	3,131	2,867	3,667	
	Harvest (Kg)	563,040	488,960	500,960	458,720	586,720	**2,598,400**
	Unit Price (S/./kg)	0.40	0.35	0.33	0.49	0.44	
	Sales (S/.)	225,216	171,136	165,317	224,773	258,157	**1,044,598**
Others	Harvest (ha)	4,013	3,004	3,129	2,851	2,886	15,883
Total	Planted Area (ha)	31,128	35,666	37,275	35,524	37,837	177,430
	Harvest (Kg)	505,613,401	557,800,229	557,129,794	609,003,509	1,284,212,149	3,513,759,082
	Sales (S/.)	264,515,787	373,008,615	465,716,915	362,308,113	405,029,984	1,870,579,415

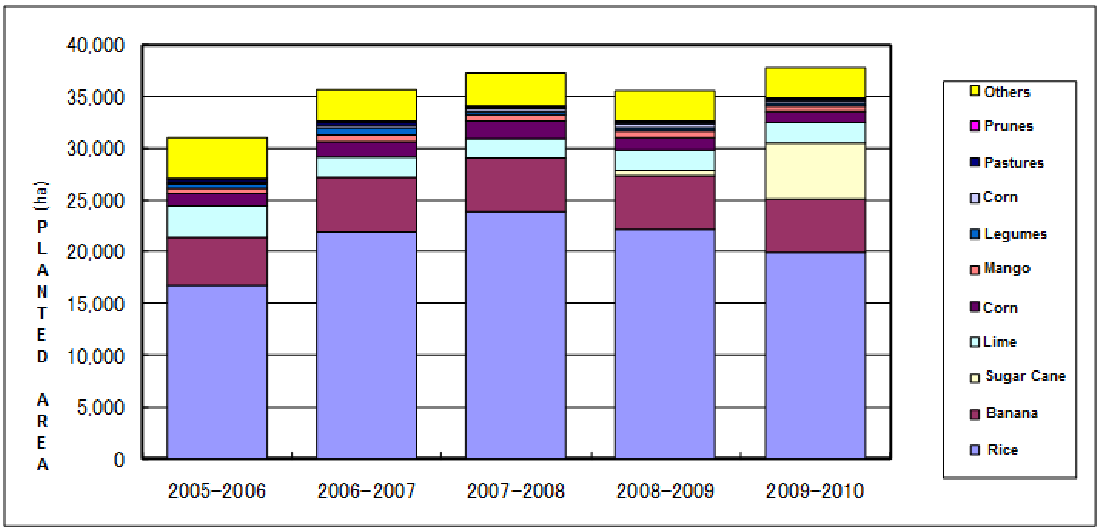


Figure 3.1.3-1 Planted Surface

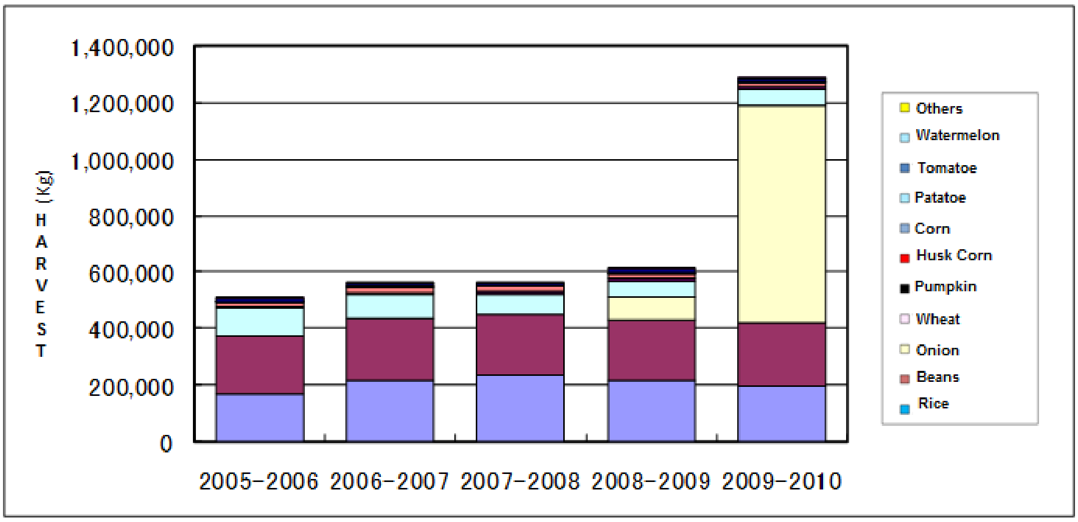


Figure 3.1.3-2 Harvest

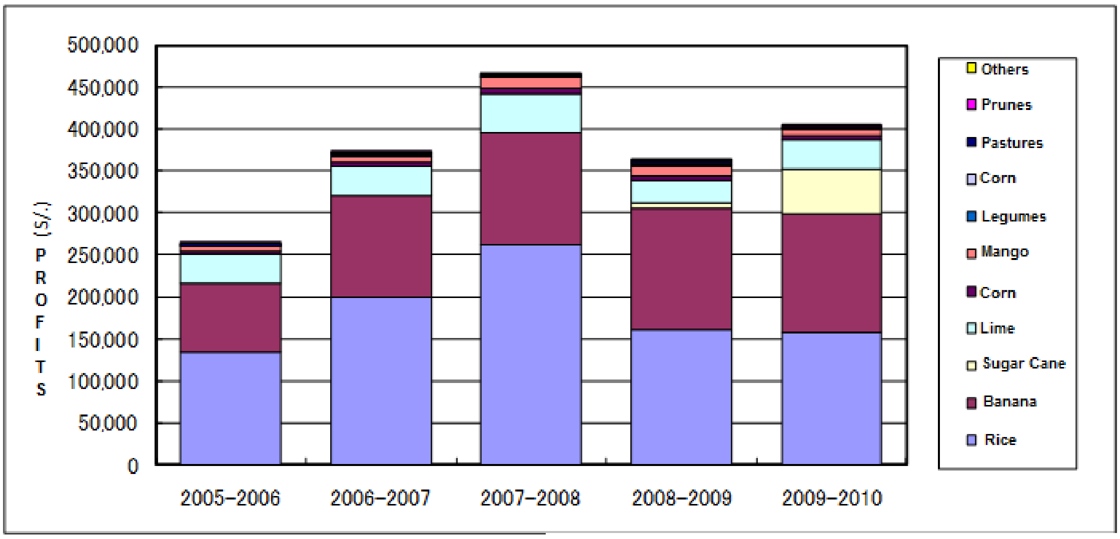


Figure 3.1.3-3 Sales

3.1.4 Infrastructure

(1) Road Infrastructures

In Table 3.1.4-1 basic data of road infrastructure of the Piura Region is presented. In total there are 4,398km of roads, from which 857.0km (19.5%) is national highways, 578.2km (13.1%) regional roads and 2,962.8km (67.4%) are municipal roads.

Table 3.1.4-1 Road Infrastructure Data

Roads	Total Length		Paving			
			Asphalted	Compacted	Non-compacted	Soil
National roads	857,0	19,5 %	664,5	126,5	29,0	37,0
Regional roads	578,2	13,1 %	144,8	159,0	68,1	206,3
Municipal roads	2962,8	67,4 %	134,3	51,7	313,6	2463,2
Total	4398,0	100,0 %	943,6	337,2	410,7	2706,5

(2) Irrigation Channels

According to irrigation commissions, data was obtained about the type, name, location, used materials, operation conditions and other channel details, but not data from derivation channels discrimination, of 1^{st}, 2^{nd} and 3^{rd} order, length and structure. About general data, see Data Book.

(3) PERPEC

In Table 3.1.4-2 PERPEC implemented projects between 2006 and 2009 are shown.

Table 3.1.4-2 Implemented Projects by PERPEC

Nº	Year	Work name	Location				Description			Total cost (S/.)
			Departamt	Province	District	Town				
1	2006	El Litoral trunk drain cleanliness and desilting	Piura	Paita	Colan	Pueblo Nuevo de Colan	Drain desilting	8.4	Km	289,724.70
2	2006	El Rosario trunk drain cleanliness and desilting	Piura	Paita	Colan	Pueblo Nuevo de Colan	Drain desilting	6.28	Km.	195,520.00
3	2006	Santa Elena trunk drain cleanliness and desilting	Piura	Paita	Colan	Pueblo Nuevo de Colan	Drain desilting	7.92	Km.	240,640.00
4	2007	Chira river coastal defense, Jaguay de Poechos-Querecotillo-Sullana-Piura areas	Piura	Sullana	Querecotillo	Jaguey de Poechos	Rockfilling dike	0.6	Km	480,104.00
5	2007	Chira river coastal defense, La Cuarta de Mallares Marcavelica-Sullana-Piura areas	Piura	Sullana	Marcavelica	La cuarta Mallares	Rockfilling dike	0.5	Km	491,151.00
6	2007	Chira river coastal defense, La Playa-Garabato-Marcavelica-Sullana-Piura areas	Piura	Sullana	Marcavelica	Playa Garabato	Breakwaters with rock	0.1	Km	187,202.00
7	2008	Manifold 1 - drainage system hydraulic section recovery - Pueblo Nuevo de Colan (Contingency)	Piura	Paita	Colan	Pueblo Nuevo de Colan	Drain hydraulic section recovery	4.9	Km	217,414.00
8	2008	Mambre-La Bocana-Marcavelica drain hydraulic section recovery (Contingency)	Piura	Sullana	Marcavelica	Mallares	Drain hydraulic section recovery	7.02	Km	183,863.15
9	2008	Monte-Mallares-Marcavelica drain hydraulic section recovery (Contingency)	Piura	Sullana	Marcavelica	Mallares	Drain hydraulic section recovery	6.64	Km	167,832.88
10	2008	La Huaca II, La Huaca-Paita stage, rockfilling rehabilitation (Contingency)	Piura	Sullana	La Huaca	La Polvareda	Wet slope rehabilitation with rock acommodation	0.33	Km	258,772.00
11	2008	Viviate and Chira Palma - La Huaca drains hydraulic section recovery (Contingency)	Piura	Paita	La Huaca	Viviate	Drain hydraulic section recovery of Viviate and Chira Palma	3.9	Km	50,074.00
12	2008	Chira river coastal defense building on left bank, Santa Marcela – Viviate – La Huaca – Paita – Piura Areas (Contingency)	Piura	Paita	La Huaca	Viviate	Drain hydraulic section recovery	3900	Km	245,956.00
13	2008	Channel 4219C rehabilitation in Cieneguillo, centro de Sullana, Piura (Contingency)	Piura	Sullana	Sullana	Cineguillo	Coated channel rehabilitation	680	ml	146,993.00
14	2008	Chira river coastal defense building on right bank, La Polvadera, San Isidro, Pucusula - La Huaca - Paita - Piura Areas (Prevention)	Piura	Paita	La Huaca	La Polvadera, San Isidro, Pucusula-La Huaca	Building of 04 units of rock breakwaters	0.206	km	470,816.00
15	2008	Saman ravine coastal defense building, Mallares area, Marcavelica district, Sullana province (Prevention)	Piura	Sullana	Marcavelica	Mallares	Rock breakwater building	2	km	465,266.00

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	people	373,459	118,433	53,370	21,473	115,648	64,535
Housing loss victims	people	50,767	29,433	8,041	2,448	6,328	4,517
Decesased individuals	people	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	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 Piura region, to which this study belongs to.

Table 3.1.5-3 Disasters in Piura 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									6	1	2	1		1			11	
LANDSLIDE		1		2		1	4		5		1	6	5	7	5	3	40	
AVALANCHE				1				1	1			1					4	
TOTAL DESASTRES DE SEDIMENTOS	0	1	0	3	0	1	4	1	12	1	3	8	5	8	5	3	55	3
TOTAL FLOODING	0	0	5	51	9	3	5	14	3	5	6	14	8	22	0	1	146	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） Interviews

Only Critical points

- Special Project Chira-Piura was elaborated 40 years ago
- Poechos dam is being operated for hydraulic generation, drinking water supply, irrigation water and for tilapia farming
- One of the objectives of the dam is to protect Chira and Piura communities against floods
- Communities were affected in 1983 due to floods caused by El Niño and as solution dikes have been built. In 1998 floods, also caused by El Niño, communities almost did not suffered any damage, but the dikes were erosioned by a total of 5km. There are works that are still “provisional” due to the lack of economic resources
- The design flow was modified from 5.000m^3/s to 7.600m^3/s (return period of 100 years)
- The discharge valve of the Poechos dam is deteriorated by flow effects that drop from the floodgate and is one of the critical points

(Current site conditions: at the moment of the technical visit)

○ Section of the erosioned dike caused by El Niño (D1011～D1013)

- In the technical visit it was noted that the affected section had been totally built and repaired

○ Section of the erosioned dike caused by El Niño (D1020)

- In the technical visit it was noted that the affected section had been almost totally repaired but some banks were not protected
- Protected elements are agriculture lands (vegetables and cotton) and natural gas production areas. This natural gas installations are part of the private sector, but this resource is used in the near thermal power generation plant
- The bed of the area has reduced 2 meters due to 1998 floods
- For floods it is important to take measures not only to bear peak flow but also for a 3.000m^3/s flow because the river has this flow for a pretty long time
- The tide causes a variation between 1 and 1.2 meters

○ Section of the erosioned dike caused by El Niño (D2040)

- During the technical visit it was noted that the affected section had been almost totally built and repaired, but some banks were not protected

○ Section of the erosioned dike caused by El Niño (D2052)

- During the technical visit it was noted that there is a section (km 24.5 – 27) which dike is still provisional and that the banks were not protected enough

○ Section of the erosioned dike caused by El Niño (D3110, D4130)
- During the technical visit it was noted that the affected section had been almost totally built and repaired, but some banks were not protected

○ Erosioned bank (km 11.5 – 12.5, right bank)
- The erosioned area extended due to 2008 floods. There is a road along the river that connects communities of the lower watershed (Vichayal, Miramar and Vista Florida) and this will be damaged in future floods

○ Erosioned bank 2 (km 73, right bank)
- Great banana plantations are along the river in this area
- There is an approx 5km path where crops lands have been lost due to the banks erosion

○ Erosioned bank 3 (km 98, right bank)
- Miguel Checa Channel is built along the river in this area for irrigation purposes, with a 70m^3/s flow
- Erosion continues and it is probable that the channel is erosioned by future floods

○ Sullana Intake (km 64)
- During field recognizance it was noted that on the right bank, between the fixed dams for flood control the sediments were gathering and that there was dense vegetation too. If no adequate measures are taken, the water will not flow through the fixed dams and may overload the mobile dam (intake) of sand and damage it

○ Erosion under Poechos dam (km 99.5)
- During field recognizance it was noted that on the left bank immediately below the discharge mouth the area was severely erosioned, with the risk of collapsing if no measures are taken. Currently, the immediate affected areas under the dam have been repaired provisionally (bank protection, etc)

(Others)

○ Poechos Dam interview
- There are 3 floodgates. The maximum discharge flow is between 5.000 and 5.500m^3/s. Power dissipation is done through ski jumps. Immediately under the discharge mouth there is an eroded area of 25 meters
- During El Niño floods 3800m^3/s were discharged. The flow in Sullana downstream was between 6.000 and 6.5000m^3/s
- For electrical power, 200 m^3/s are being discharged and this same amount of water is used for irrigation of the lower watershed
- 80m^3/s are being discharged to Piura for agriculture, industrial and human consumption use
- Previously, there were breakwaters immediately downstream the dam, which were destroyed by water discharge
- It is the biggest dam of the country, with a storage capacity of 800 million MT

- 50% of the Poechos dam has sediments, reaching a critical level (400 million MT according to a total of 800 million MT), and there is no concrete measure for its solution
- Periodic sediment lifting is being done

○ Interview results on dike construction works

- The sub-base crown materials have been obtained from Macacara. The rest of materials were obtained from agricultural lands of both banks
- Protection stones from the dike were obtained from Cabo Mesa

○ Interview results on early alert system

- There is an early alert system for Piura River. However, for Chira River there is not even a plan

(Next, we present data collected through interviews about the Piura River System)

- There are 12 stations within Piura River (7.500km^2)
- These 12 stations have automatic pluviometers with satellite telemetry
- Apart from the 12 mentioned stations, there are 30 manual type stations with radio communication system
- Data will be analyzed with NAXOS program
- The current system emits an alert within the 48 hours, it has been used since 2002
- Until 2008 a radio communication system was used, but in 2008 the solar panels were stolen from the central station, in which data from other stations was gathered, being inoperative. That is how the satellite telemetry system was installed
- Currently, station’s data is transmitted by satellite
- The precipitated water of the Piura River upper watershed delays its arriving, due to which the system predicts the water level in the lower watershed 48 hours after rain occurs. In case of 2.000m^3/s, the arrival time is approximately 12 hours
- The alert is emitted when the flow surpasses 1.500m^3/s
- The system divides the Piura River Watershed in 720 segments
- On the floods of 2002, with a flow of 3.800m^3/s, the foreseen flow was about 3.600m^3/s
- Floods data are transmitted from the Chira-Piura Special Project to Civil Defense
- Half the watershed belongs to Ecuador, so the pluviometer has to be installed there too
- The major problem right now is the constant stealing of solar panels. Currently, surveillance has been hired in the two affected stations, also the panels have been secured properly against robbery

(2) Description of the visit to the study sites

Figure 3.1.6-1 shows pictures of main sites visited.

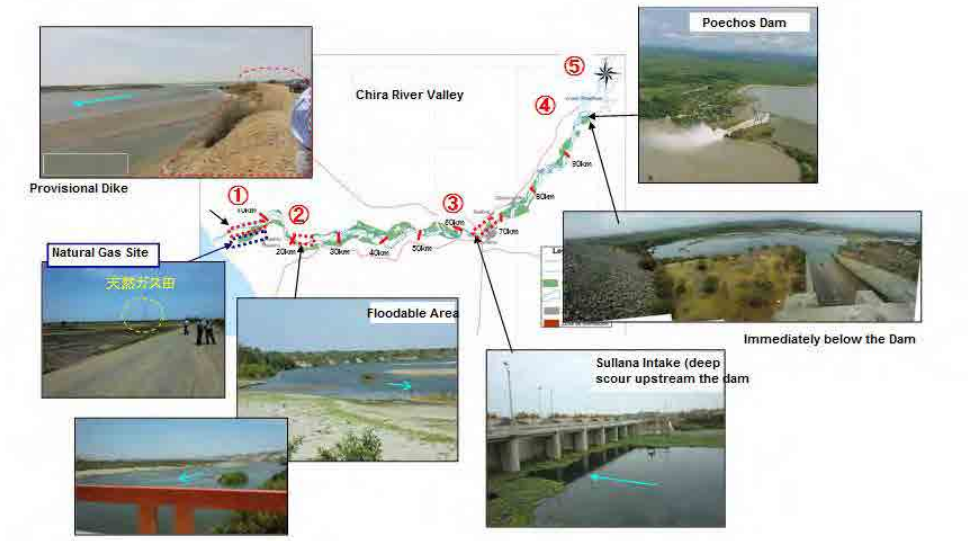


Figure 3.1.6-1 Visit to the Study Site (Chira River)

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: Frequent banks erosion for floods caused by El Niño

Current situation and challenges	・Necessary measures were taken on the affected area due to 1983 El Niño. In 1998 event, also by El Niño, no floods occur but the dike was erosioned ・Currently, the flow design with modified design is being reviewed, but due to the lack of economic resources, the situation is being controlled by a provisional dike ・There are only 8 sections of the affected dike that have been studied and their metering is a great challenge
Main elements to be conserved	・Agricultural lands (main product: cotton and banana) ・Natural gas fields (12 currently exploited fields which resources are used to generate electricity in the area)
Basic measures	・Elevate the provisional dike's height and execute bank protection works ・Protect the floor (measure against bed height reduction)

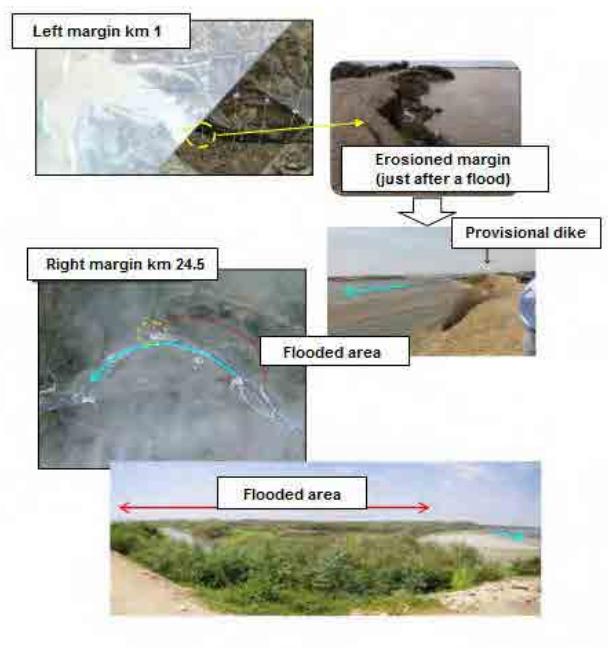


Figure 3.1.6-2 Local conditions related with Challenge 1 (Chira River)

2) Challenge 2: Frequent bank erosion due to El Niño floods

Current situation and challenges	・Several bank erosion damages occurred in the floods of 1998 due to El Niño ・There are several crops fields, roads and irrigation channels that are un-protected, and susceptible to be severely damaged if erosion continues
Main elements to be conserved	・Crop lands (main product: bananas) ・Main regional road ・Main irrigation channels
Basic measures	・Execute bank protection works to control erosion expansion

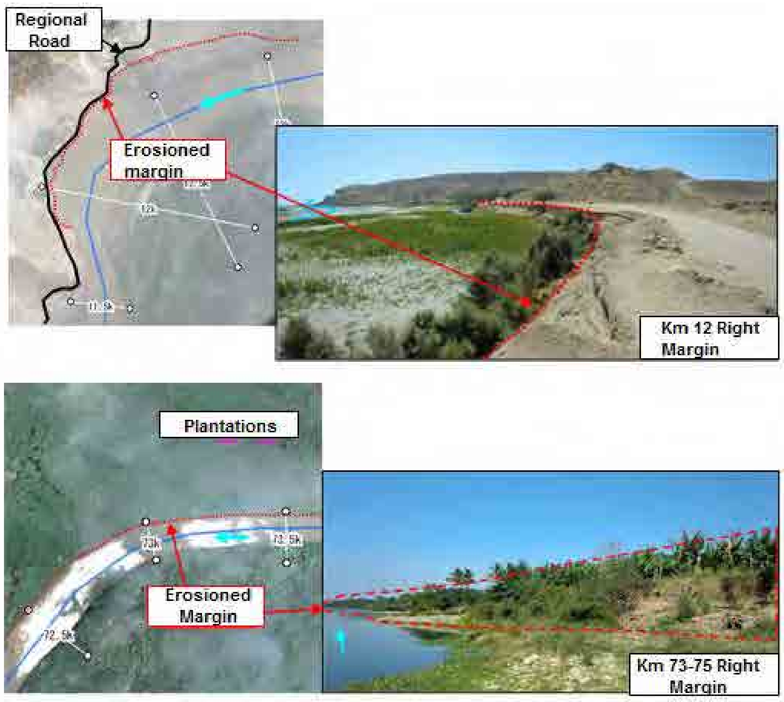


Figure 3.1.6-3 Local conditions related with Challenge 2 (Chira River)

3) Challenge 3: Direct dike erosion due to the water's discharge

Current situation and challenges	・The left margin immediately downwards the dam has been erosioned during floods water discharges ・It is probable that the dam is affected if floods of the same magnitude occur ・Currently, the immediate eroded sector under the dam is being provisionally repaired (margin protection works)
Main elements to be conserved	・Dam's body
Basic measures	・Built retarding reservoirs (to reduce floods peak stream) ・Built an intake (to integrate the existing small works)

Figure 3.1.6-4 Local conditions related with Challenge 3 (Chira River)

3.1.7 Current situation of vegetation and reforestation

(1) Current Vegetation

According to 1995 forestry map and its explanations, this area has a lot of dry forest. There are three types of forests in this watershed: i) Dry Forest Savanna Type (Bs, Sa), ii) Hills dry forest (Bs co) and iii) Mountain dry forest (Bs, mo) which distributes according altitudes (see Table 3.1.7-1). The main specie that constitutes dry forest savanna type is Algarrobo (*Prospis pallida*). In general, these forests have tall trees and short bushes. Species that form hill and mountain dry forest are very similar; being predominant the deciduous trees of approx 12 meters height. On the river shore, evergreen trees also grow with more than 10cm of DAP, due to the existence of the freatic water table near the surface. Once the dry forest is destroyed it is very difficult to recover it by a natural process, due to the unfavorable conditions. Mountain humid forest is characterized by the variety of species that are part of it, mostly are less than 10mt height.

Table 3.1.7-1 List of representative vegetable forming in the Chira watersheds

Code	Names	Altitudes	Precipitations	Representative Vegetation
1)Bs sa	Dry forest savanna type	0 and 500 m.a.s.l	160 and 240mm	Algarrobo forest (evergreen). In heights deciduous trees, bushes and cactus also appear
2)Bs co	Hill dry forest	400 and 700 m.a.s.l	230 and 1,000mm	Similar to mountain dry forest
3)Bs mo	Mountains dry forest	500 and 1,200 m.a.s.l	230 and 1,000mm	Mainly trees with leaves forming approx 12m height forests
4)Bh mo	Mountain humid forest	From the higher Amazon regions to the northern part of the country, up to 3200m.a.s.l In the south-center region of Peru: Andes east side up to 3.800m.a.s.l	Frequent mist cause cloud forests	Lots of vegetations including high trees (10mt approx), palm trees of 2 to 4 meters and herbaceous species
Also, coastal desert is observed (DC, Cu), sub-humid bush (Msh -Mh).				

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 3.7.2-1). Then, the addition of each ecologic life zone's surface, outstanding the coastal desert (Cu, Pj), dry grass (Ms), bushes (Msh, Mh), dry forest (Bs-sa, Bs-co, Bs-mo), humid mountain forest (Bh-mo) and puna grass (C-A, Pj). Table 3.1.7-3 shows the percentage of each ecologic area.

Table 3.1.7-2 Vegetation formation surface of the watershed's surface (Chira River)

	Vegetation											
	Cu	Dc	Ms	Msh	Mh	Bs-sa	Bs-co	Bs-mo	Bh-mo	C-A*	Pj	Total
(Surface: hectares)												
High Watershed	714,92	105,81	59,34	142,28	139,47	2.668,16	185,40	222,87	0,00	0,00	0,00	4.238,25
Low Watershed	31,70	0,00	0,00	1.205,16	1.021,28	1.889,54	473,16	1.164,53	401,54	90,25	112,57	6.389,73
Total	746,62	105,81	59,34	1.347,44	1.160,75	4.557,70	658,56	1.387,40	401,54	90,25	112,57	10.627,98
(Percentage %)												
High Watershed	16,9	2,5	1,4	3,4	3,3	63,0	4,4	5,3	0,0	0,0	0,0	100,2
Low Watershed	0,5	0,0	0,0	18,9	16,0	29,6	7,4	18,2	6,3	1,4	1,8	100,1
Total	7,0	1,0	0,6	12,7	10,9	42,9	6,2	13,1	3,8	0,8	1,1	100,1

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

Table 3.1.7-3 Ecologic Life Areas Percentage (Chira River)

Zones	Ecologic Life Zones							
	Deserts (Cu, Dc)	Dry bushes (Ms)	Bushes (Msh, Mh)	Dry Forests (Bs-sa, -co, -mo)	Mountain Humid Forests (Bh-mo)	Water bodies (C-A)	Grasslands (Pj)	Total
(Percentage: %)								
High Watershed	19,4	1,4	6,6	72,6	0,0	0,0	0,0	100,0
Low Watershed	0,5	0,0	34,8	55,2	6,3	1,4	1,8	100,0
Total	8,0	0,6	23,6	62,1	3,8	0,8	1,1	100,0

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

In the previous Table the coastal desert occupies a low percentage (approx 10%) and dry bushes do not even reach 1%. The other bushes occupy approx 20%. The dry forest represents 60% and this is what characterizes the vegetation of the Piura River Watershed

(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. Table 3.1.7-4 shows the disappeared deforested areas (total gathered) in Piura region.

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)
Piura	3.580.750	9.958 (0,3 %)	5.223	4.735

Source: National Reforestation Plan, INRENA, 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 3.1.7-5). It is observed that the reforested area increased in 1994, drastically decreasing later.

Table 3.1.7-5 History registry of forestation 1994-2003

(Units: ha)

Department	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Piura	7.449	971	2.407	3.144	19.070	2.358	270	1.134	789	48	37.640

Source: National Reforestation Plan, INRENA, 2005

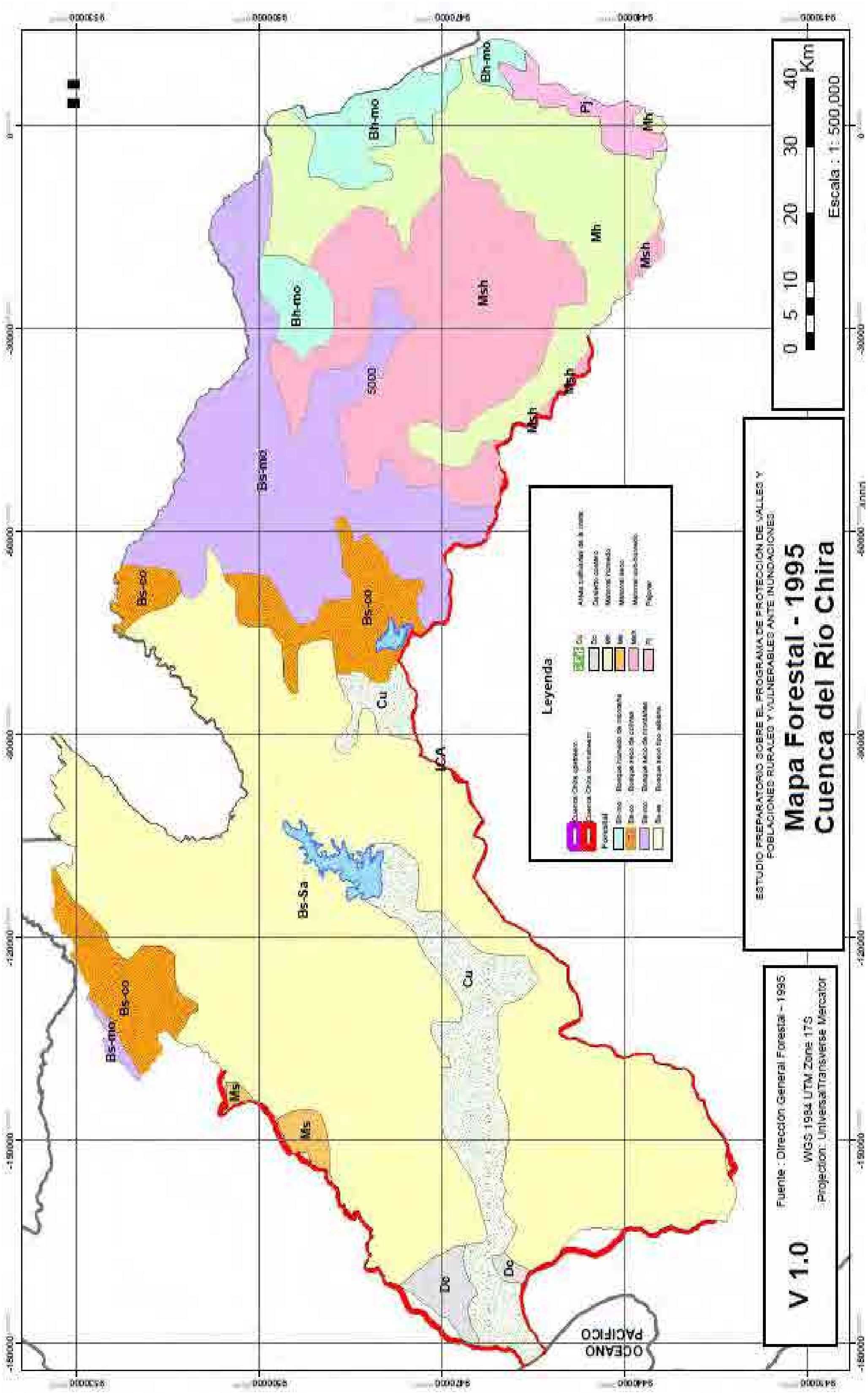


Figure 3.1.7-1 Forestry map of Chira River Watershed

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 Chira River. Here the most percentage is occupied by altitudes between o and 1000m.a.s.l. In Table 3.1.8-2 “Upstream Chira” means upstream Poechos Dam and “Downstream Chira” means downstream the same dam.

Table 3.1.8-2 Surface according to altitude

Altitude (m.a.s.l)	Area (Km^2)	
	Upstream Chira	Downstream Chira
0 – 1000	3262,43	3861,54
1000 – 2000	1629,48	207,62
2000 – 3000	1153,61	43,24
3000 – 4000	313,74	156,11
4000 – 5000	0,22	0,00
5000 – More	0,00	0,00
TOTAL	6359,48	4268,51
Maximum Altitude	4110,00	

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

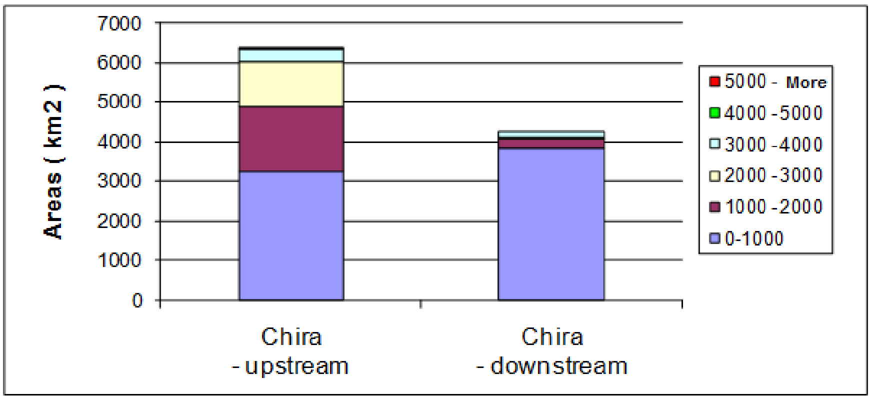


Figure 3.1.8-1 Surface according to altitude

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

Slope (%)	Upstream Chira		Downstream Chira	
	Area (km^2)	Percentage	Area (km^2)	Percentage
0 – 2	131,62	2%	651,28	15%
2 – 15	2167,69	34%	2859,35	67%
15 - 35	1852,79	29%	465,86	11%
More than 35	2237,64	35%	261,76	6%
TOTAL	6389,74	100%	4238,25	100%

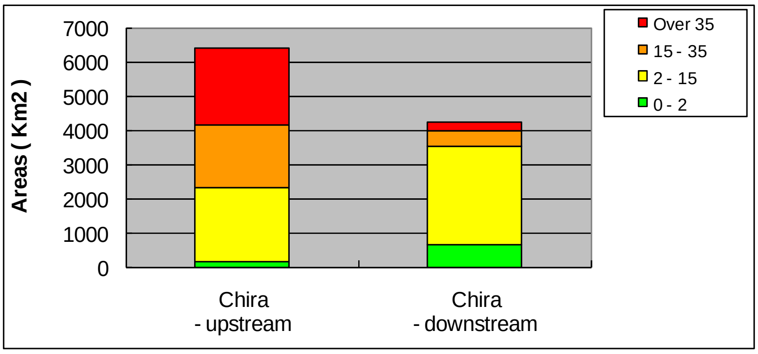


Figure 3.1.8-2 Slopes and surface

iii) River-bed slope

Table 3.1.8-4 and Figure 3.1.8-3 show the slope in Chira 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

Bed slope (%)	Upstream Chira	Downstream Chira
0,00 - 1,00	6,00	233,34
1,00 - 3,33	345,77	471,67
3,33 - 16,67	2534,14	1751,16
16,67 - 25,00	435,46	97,84
25,00 - 33,33	201,72	37,51
33,33 - More	318,46	42,72
TOTAL	3841,55	2634,24

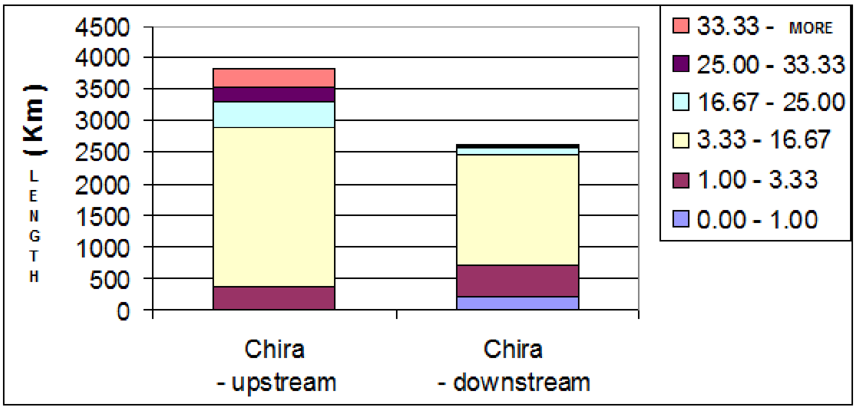


Figure 3.1.8-3 River-bed Slope and total length of streams

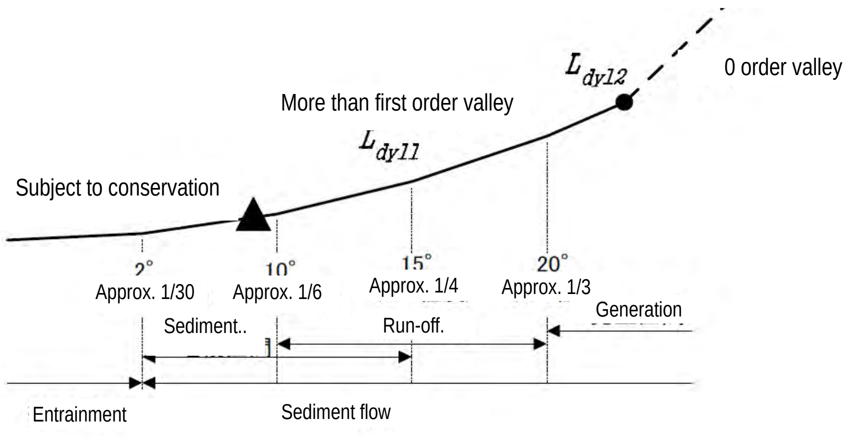


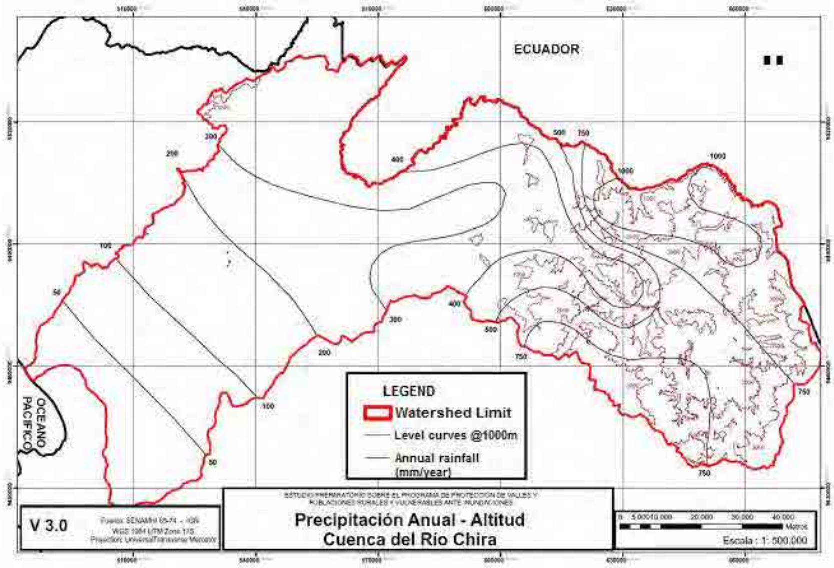
Figure 3.1.8-4 River-bed slope and sediment movement pattern

2) 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 Chira River Watershed.



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

Figure 3.1.8-5 Isohyet Map of the Chira 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 is between 750 and 1.000m.a.s.l.

3) 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.

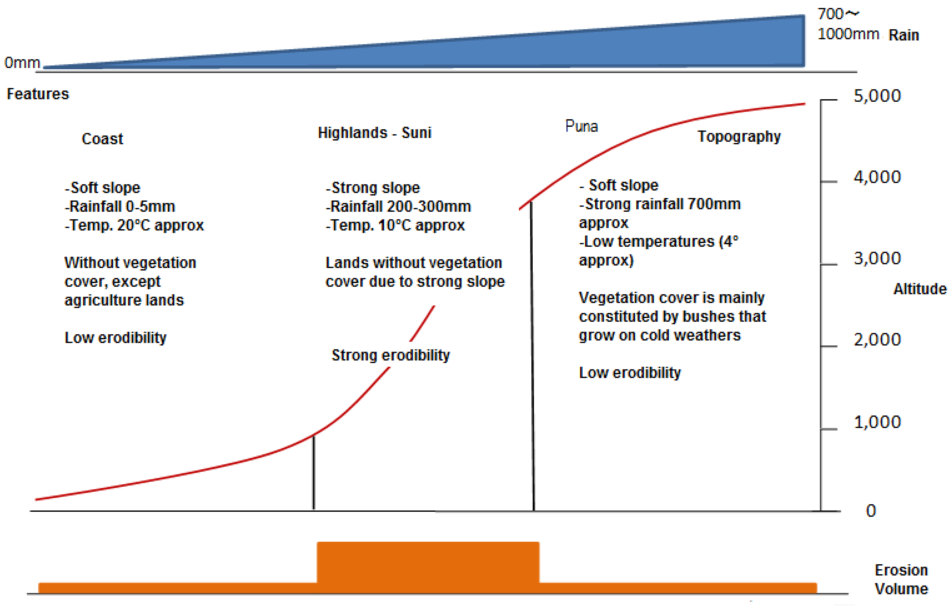


Figure 3.1.8-6 Relation between the erosion volume and the different causes

(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.

In Table 3.1.8-5 and 3.1.8-6 and Figures 3.1.8-7 and 3.1.8-8 the slope percentage distribution according to the altitudes of Chira River is shown. Upstream Poechos dam, between 1000 and 3000m.a.s.l there are several slopes with more than 35° of inclination. This matches with the highest watershed of the Chira River. On the contrary, downstream Poechos dam, slopes are less accentuated with inclinations between 2 and 15°, not very susceptible to erosion.

Table 3.1.8-5 Slopes according to altitudes upstream Chira river watershed

Altitude	SLOPES				Total
	0-2	2 - 15	15 - 35	More than 35	
0 - 1000	647.61	2777.68	300.77	100.13	3826.19
Ratio	17%	73%	8%	3%	100%
1000 - 2000	0.21	12.58	87.38	108.92	209.09
Ratio	0%	6%	42%	52%	100%
2000 - 3000	0.13	6.7	10.34	31.86	49.03
Ratio	0%	14%	21%	65%	100%
3000 - 4000	3.33	62.39	67.37	20.85	153.94
Ratio	2%	41%	44%	14%	100%
4000 - 5000	0	0	0	0	0
Ratio					
5000 - More	0	0	0	0	0
Ratio					
Total	651.28	2859.35	465.86	261.76	4238.25
Ratio	15%	67%	11%	6%	100%

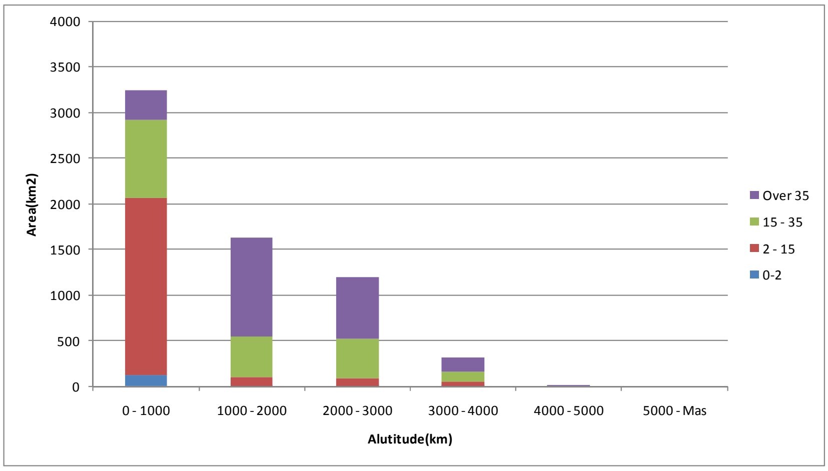


Figure 3.1.8-7 Slopes according to altitudes of Chira River

Table 3.1.8-6 Slopes according to altitudes Downstream Chira River Watershed

Altitude	SLOPES				Total
	0-2	2 - 15	15 - 35	More than 35	
0 - 1000	647.61	2777.68	300.77	100.13	3826.19
Ratio	17%	73%	8%	3%	100%
1000 - 2000	0.21	12.58	87.38	108.92	209.09
Ratio	0%	6%	42%	52%	100%
2000 - 3000	0.13	6.7	10.34	31.86	49.03
Ratio	0%	14%	21%	65%	100%
3000 - 4000	3.33	62.39	67.37	20.85	153.94
Ratio	2%	41%	44%	14%	100%
4000 - 5000	0	0	0	0	0
Ratio					
5000 - More	0	0	0	0	0
Ratio					
Total	651.28	2859.35	465.86	261.76	4238.25
Ratio	15%	67%	11%	6%	100%

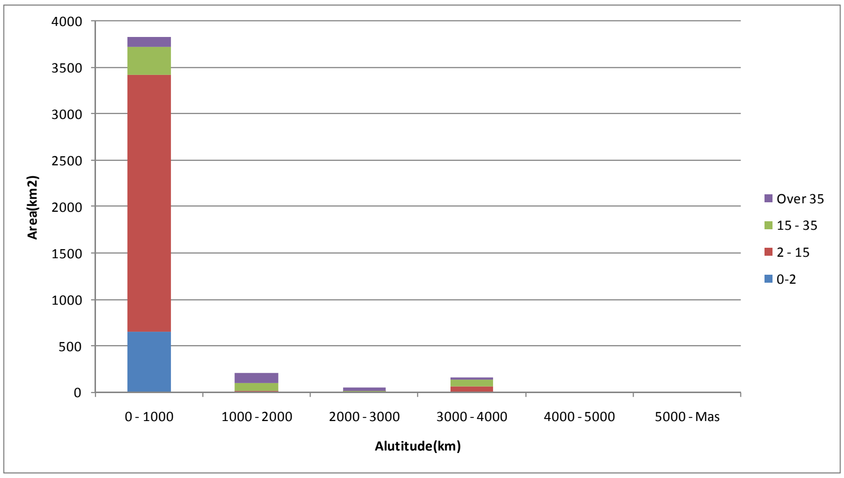


Figure 3.1.8-8 Slopes according altitudes Downstream Poechos dam of Chira River

(4) Production of sediments

1) Results of the geological study

Poechos dam is located on the Chira River Watershed, in which sediments gather, so there is no sediment input downstream. The following are the study results:

- 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 3.1.8-9 and 3.1.8-10)
- There is no rooted vegetation (Figure 3.1.8-11) 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 3.1.8-12)
- 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 3.1.8-9 Andesitic and Basaltic lands collapse

Figure 3.1.8-10 Sediment production of the sedimentary rocks

Figure 3.1.8-11 Cactus Invasion

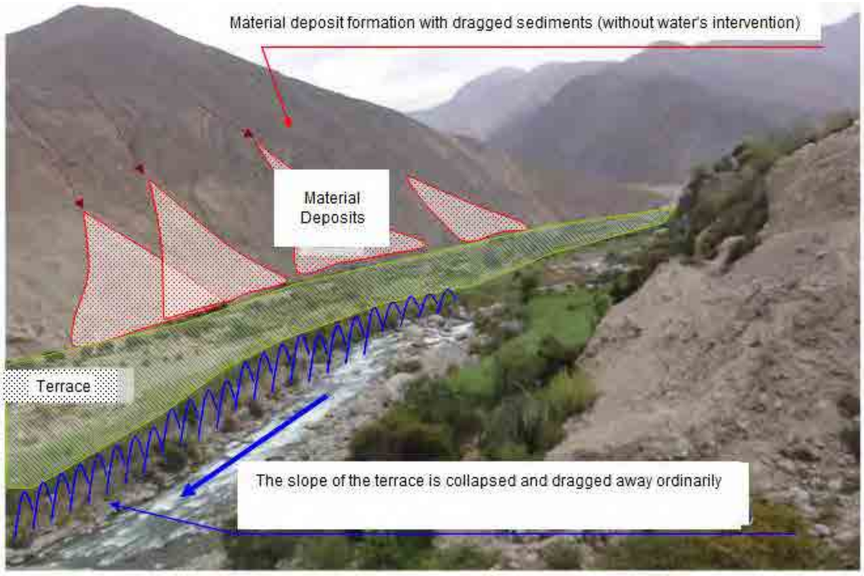


Figure 3.1.8-12 Movement of the sediment in the stream

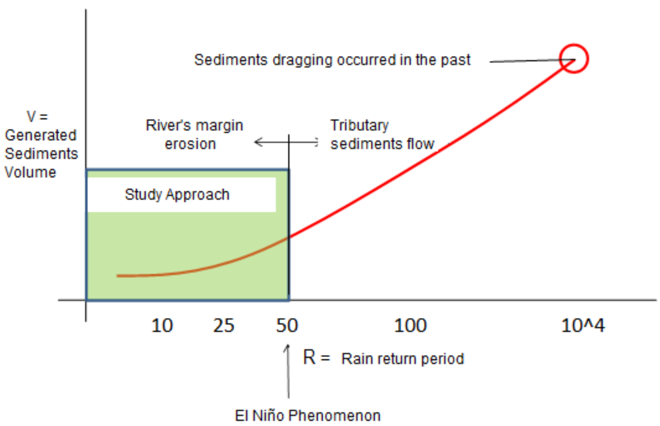
2） Sediments movement (in the stream)

In ravines terraces are developed. 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 wa ... posit detached from the hillsides and deposited at the bot
- 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 3.1.8-13)

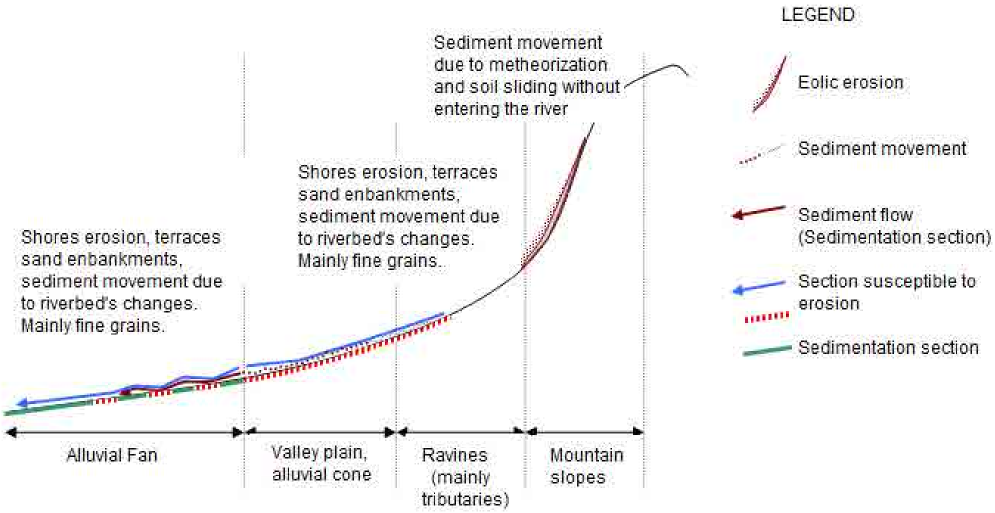


Figure 3.1.8-13 Production and entrainment of sediments in an ordinary year

(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

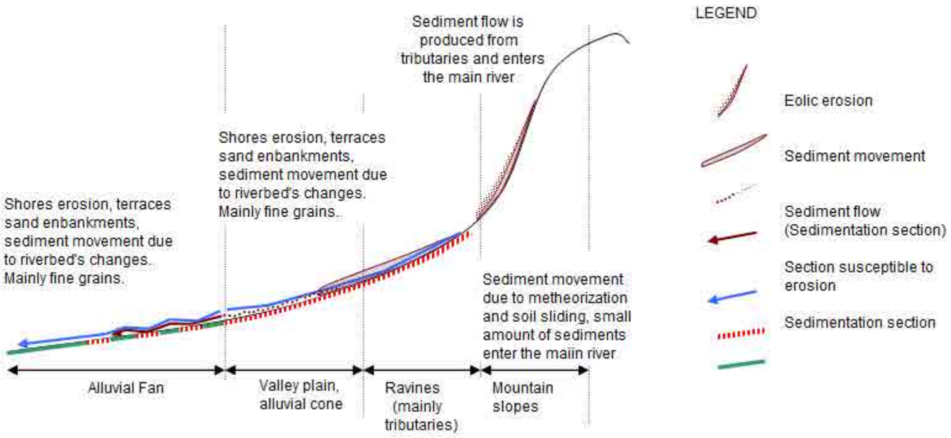


Figure 3.1.8-14 Production and entrainment of sediments during the torrential rainfall of magnitude similar to that of El Niño (1:50 year return period)

(iii) Large magnitude overflows (which may cause the formation of terraces similar to those existing now), with once a few thousand years return period

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, once a few thousand years , we estimate that the following situation would happen (see Figure 3.1.8-15).

- 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.

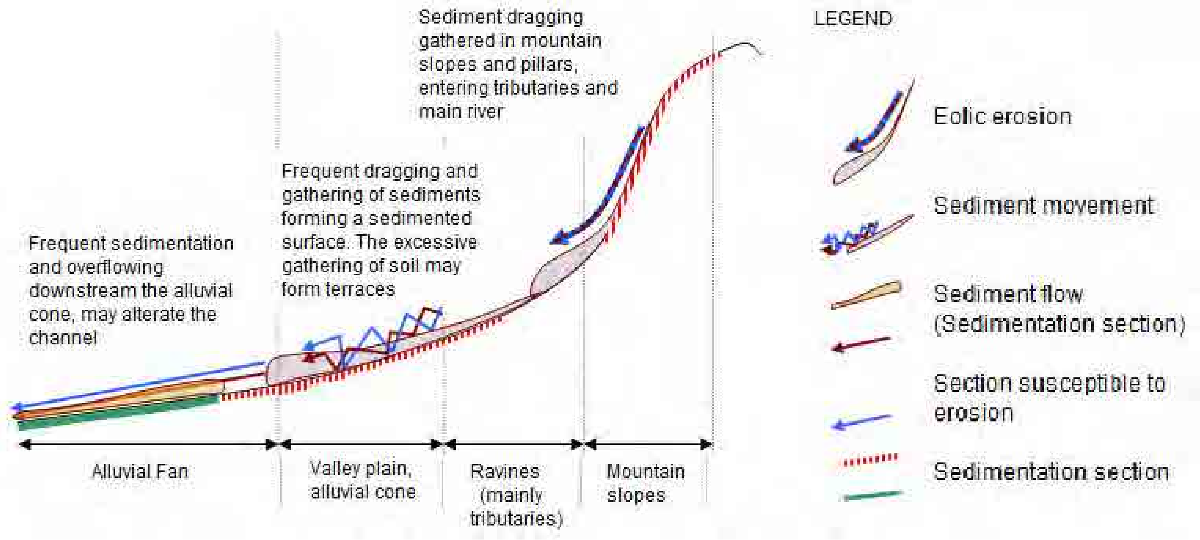


Figure 3.1.8-15 Production of sediments in large overflowing (geologic scale)

3.1.9 Run off analysis

(1) Rainfall data

1) Current rainfall monitoring system

The current rainfall data collection system used for the discharge analysis was reviewed; besides, the necessary rainfall data was collected and processed for such analysis. Rainfall data was obtained from SENAMHI and ELECT.PERU.

Tables 3.1.9-1~2 and Figure 3.1.9-1 indicate the rainfall monitoring points and the data collected according to the period.

In Chira river watershed rainfall monitoring is performed in 14 stations (including those currently non-operative), for a maximum period of 47 years since 1964 until 2010.

Table 3.1.9-1 List of rainfall monitoring stations (Chira river watershed)

CODE	STATION	DEPARTMENT	LENGTH	LATITUDE
152202	ARDILLA (SOLANA BAJA)	PIURA	80° 26'1	04° 31'1
150003	EL CIRUELO	PIURA	80° 09'1	04° 18'1
152108	FRIAS	PIURA	79° 51'1	04° 56'1
230	LA ESPERANZA	PIURA	81° 04'4	04° 55'55
152125	LAGUNA SECA	PIURA	79° 29'1	04° 53'1
152104	LAS LOMAS 1	PIURA	80° 15'1	04° 38'1
140	LAS LOMAS 2	PIURA	80° 15'1	04° 38'1
208	MALLARES	PIURA	80° 44'44	04° 51'51
152144	MONTERO	PIURA	79° 50'1	04° 38'1
152101	PANANGA	PIURA	80° 53'53	04° 33'33
152135	SAN JUAN DE LOS ALISOS	PIURA	79° 32'1	04° 58'1
203	SALALA	PIURA	79° 27'27	05° 06'6
152110	SANTO DOMINGO	PIURA	79° 53'1	05° 02'1

Table 3.1.9-2 Period of rainfall data collection (Chira river watershed)

PERIODO Y LONGITUD DE LA INFORMACION DISPONIBLE DE LAS ESTACIONES PLUVIALES

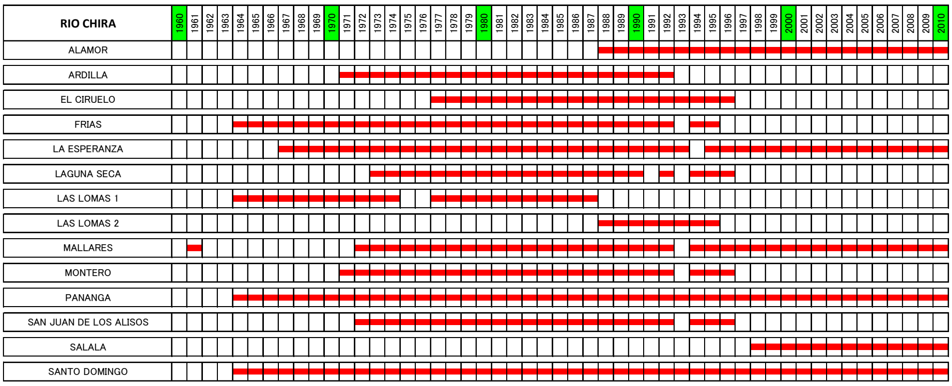


Figure 3.1.9-1 Monitoring stations location map (Chira River watershed)

2) Isohyet map

Annual rain isohyets maps are described next (average of 10 years) elaborated by SENAMHI using data recovered in the period 1965-1974.

Figure 3.1.9-2 shows a map of the isohyet of Chira River watershed.

In the Chira River Watershed is observed that the considerable variation of the annual rainfall depending on the zones, with a minimum of 50mm and a maximum of 1000 mm approximately. The rainfall is lower on the lower watershed and it increases as the altitudes gets near the upper watershed, increasing the altitudes.

The annual rainfall in the lower watershed, subject to the control of floods, is not so intense, with a variation of 50 to 200mm. However, it is the watershed with the lowest watershed rainfall among the 5 selected watersheds.

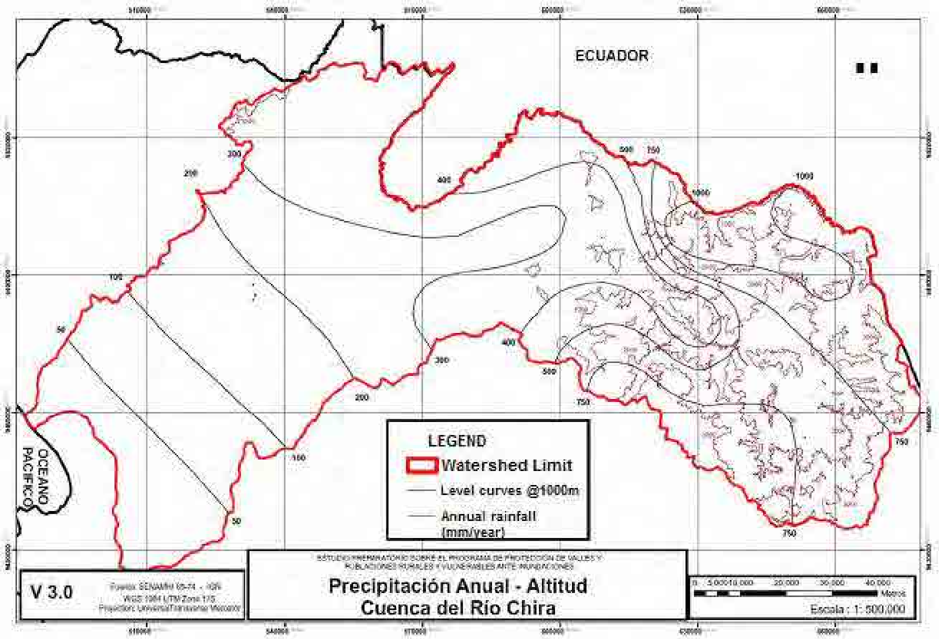


Figure 3.1.9-2 Isohyet Map (Chira River watershed)

(5) Rainfall analysis

1) Methodology

The statistic hydrologic calculation was made using the rainfall data collected from several stations, to determine the rainfall with 24 hour return period in every station.

Several models of distribution of return periods were tested and the most adequate one was adopted. Thus, the precipitation with 24 hours return period was determined with this model.

The statistic hydrologic models were:

- Normal o Gaussian distribution
- Log-Normal of 3 parameters distribution
- Log-Normal of 2-parameters distribution
- Gamma distribution of 2 or 3 parameters
- Log Pearson Type III distribution
- Gumbel distribution
- General distribution of extreme value

2) Results of the rainfall analysis of return period– t

The rainfall of several stations are shown below and the reference point of each watershed, according to return periods.

Rain observed in Chira River stations has been greater than 100mm with a maximum of 339mm.

Table 3.1.9-3 shows the monitoring points and the rainfall with 24 hour return period in each station. Figure 3.1.9-3 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-3 Rainfall with 24 hour return period
(Chira river watershed)

Nº	Station	Elevation (m.a.s.l.)	No. of Records	Return period (in years) 25	50	100	500	Registered	Assumed Distribution
1	Morropón	172	10	134,81	158,52	178,27	228,53	90,40 (*)	Gumbel
2	Malacasi	128	9	287,08	339,22	390,99	510,83	251,20	Gumbel
3	Virrey	230	27	231,55	290,51	347,08	484,48	230,70	Log Pearson III
4	Chignia	360	19	148,24	170,47	194,53	250,12	184,40	Gumbel
5	Barrios	310	19	135,34	153,85	172,23	214,89	119,70	Gumbel
6	Huarmaca	2180	43	112,54	128,58	140,48	172,84	111,40	Gumbel
7	Canchaque	1200	19	164,58	189,45	214,18	271,24	137,30	Gumbel

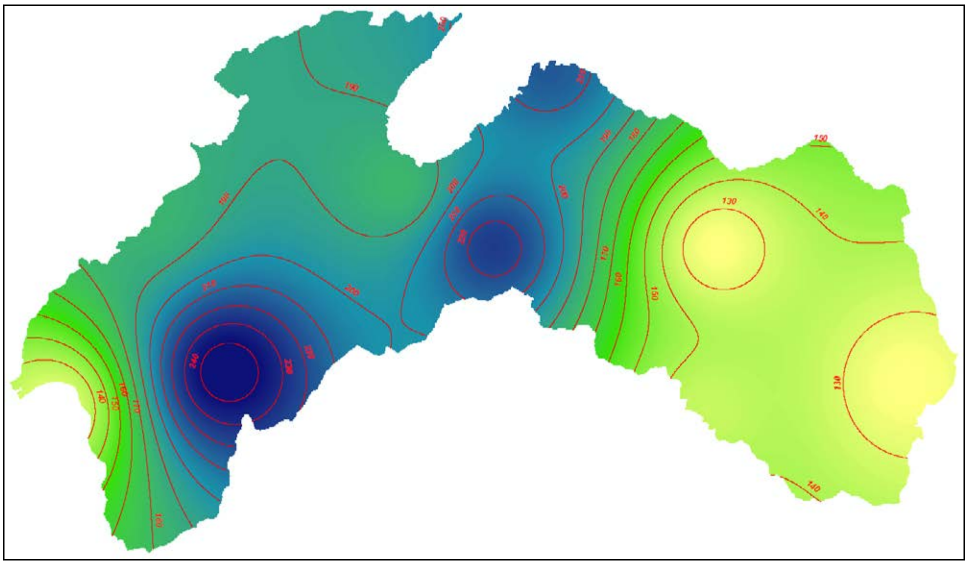


Figure 3.1.9-3 Map of isohyets of a 50 years period rainfall (Chira river watershed)

(6) Discharge flow analysis

1) Flow monitoring

The current flow data collection system used in the discharge analysis was reviewed, and the necessary flow monitoring data were collected and processed for such analysis. The flow data have been obtained mainly from the DGIH, irrigation commissions, Water National Authority (ANA) and the Chira-Piura Special Project.

2) Analysis of discharge flow

The statistic hydrological calculation was made using the data of the maximum annual discharge collected and processed in the reference points, to determine the flow with different probabilities. Table 3.1.9-4 shows the probable flow with return periods between 2 and 100 years.

Table 3.1.9-4 Probable flow in control points

(m^3/s)

Rivers	Return periods 2 years	5 years	10 years	25 years	60 years	100 years
Chira Puente Sullana	888	1.726	2.281	2.983	3.503	4.019

3) Analysis of flooding flow with t-years return periods

(a) Methodology

The probable flooding flow was analysed using the HEC-HMS model, with which the hyetograph or return periods was prepared, and the peak flow was calculated.

For the rainfall used in the analysis, the hyetograph of several periods prepared in the rainfall analysis was used. Hyetography was determined taking as reference the estimated peak point in the discharge analysis.

For Chira River, the flood regulator effect was taken into account from the Poechos Dam located on the upper watershed.

(b) Analysis results

Table 3.1.9-5 shows the flow of flooding with return periods between 2 and 100 years of the Chira river watershed.

Likewise, Figure 3.1.9-4 shows the hydrographical map of probable flood in the Chira river watershed.

It can be noticed that the numbers in Tables 3.1.9-4 and 3.1.9-5 are pretty similar. So, for the following flood analysis the figures of Table 3.1.9-5 were decided to be used because they match the hydrograph.

Table 3.1.9-5 Flood flow according to the return periods
(Peak flow: Reference point)

(m^3/s)

	Return period					
Rivers	2 years	5 years	10 years	25 years	50 years	100 years
Río Chira Puente Sullana	890	1.727	2.276	2.995	3.540	4.058

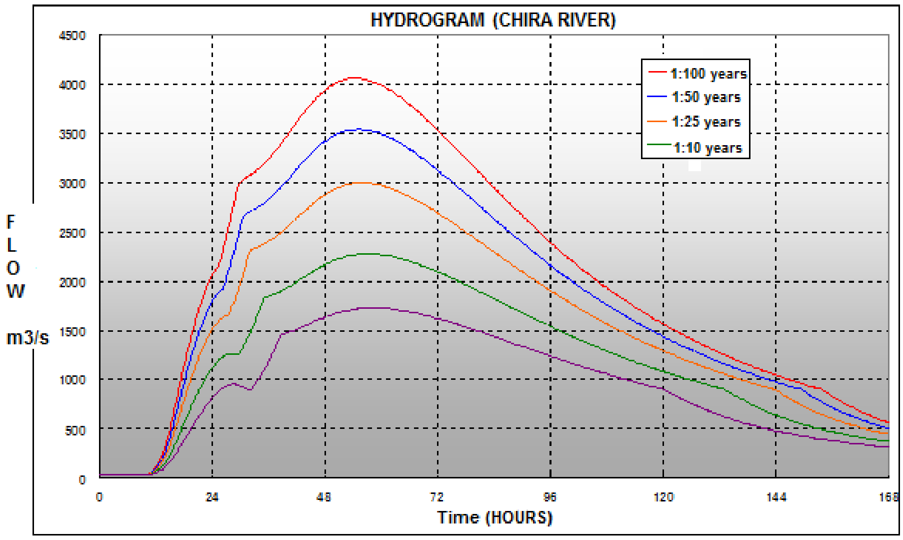


Figure 3.1.9-4 Hydrogram of Chira river

3.1.10 Analysis of inundation

(1) River surveys

Prior to the inundation analysis, the transversal survey of Chira 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			
Chira river	No.	10	
2. Dikes transversal survey			250m Interval, only one bank
Chira river	km	100	
3. River transversal survey			500m Interval
Chira river	km	120.0	200 lines x 0.60km
4. Benchmarks			
Type A	No.	10	Every control point
Type B	No.	100	273km x one point/km

(2) Flood analysis methods

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 bi-dimensional model

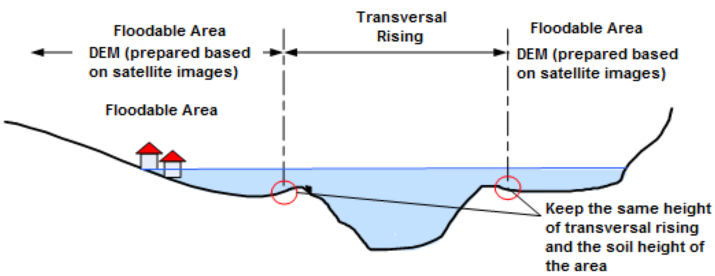
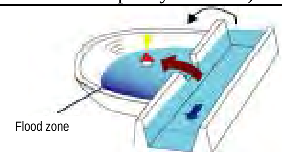
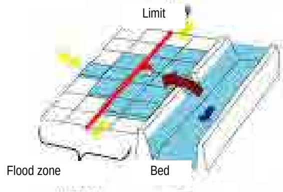


Figure 3.1.10-1 Idea of unidimensional model

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.

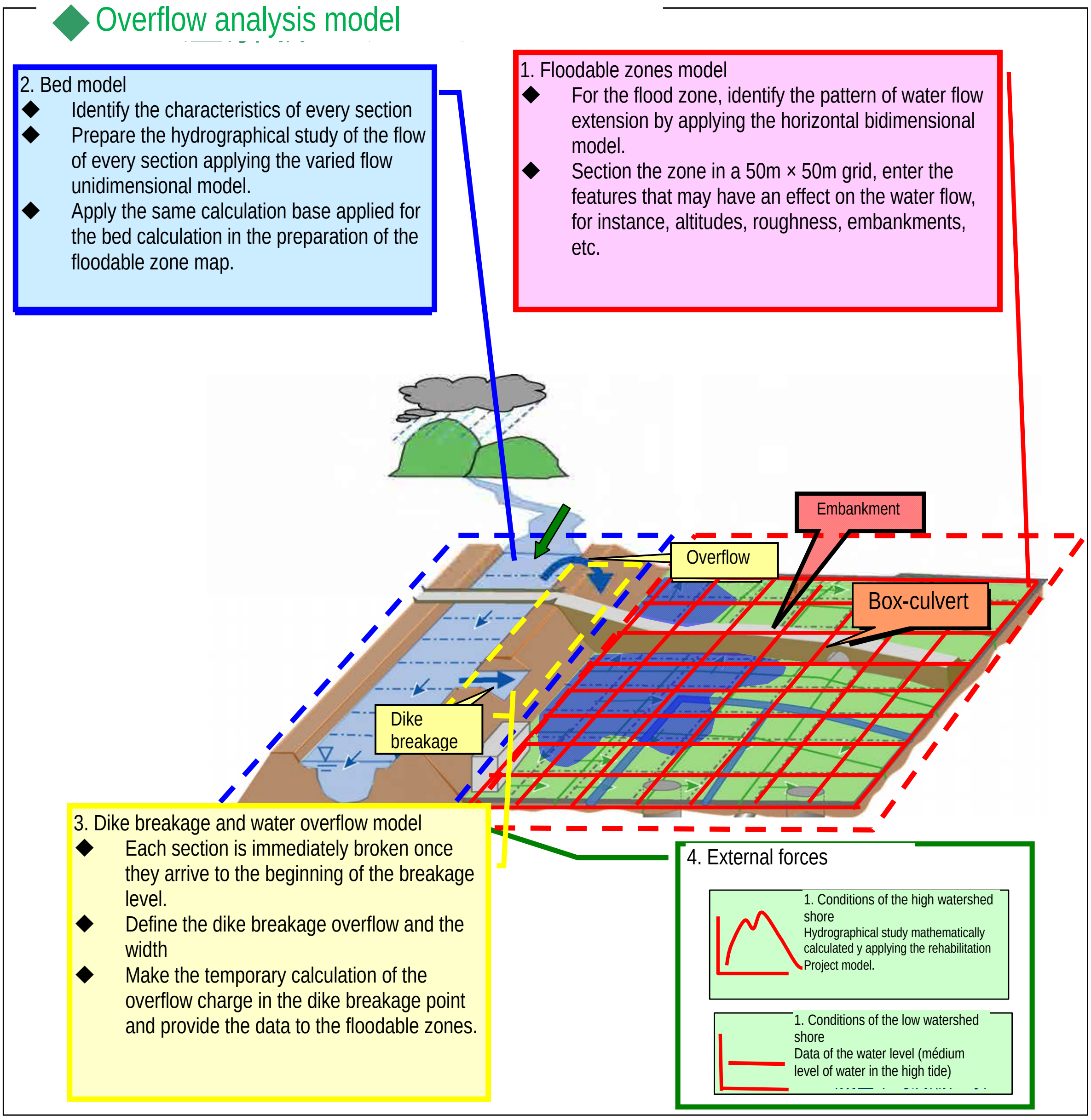


Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge capacity analysis

The current discharge capacity of the river channel 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, which allow evaluating in what points of the Chira river watershed flood may happen and what magnitude of flood flow may they have.

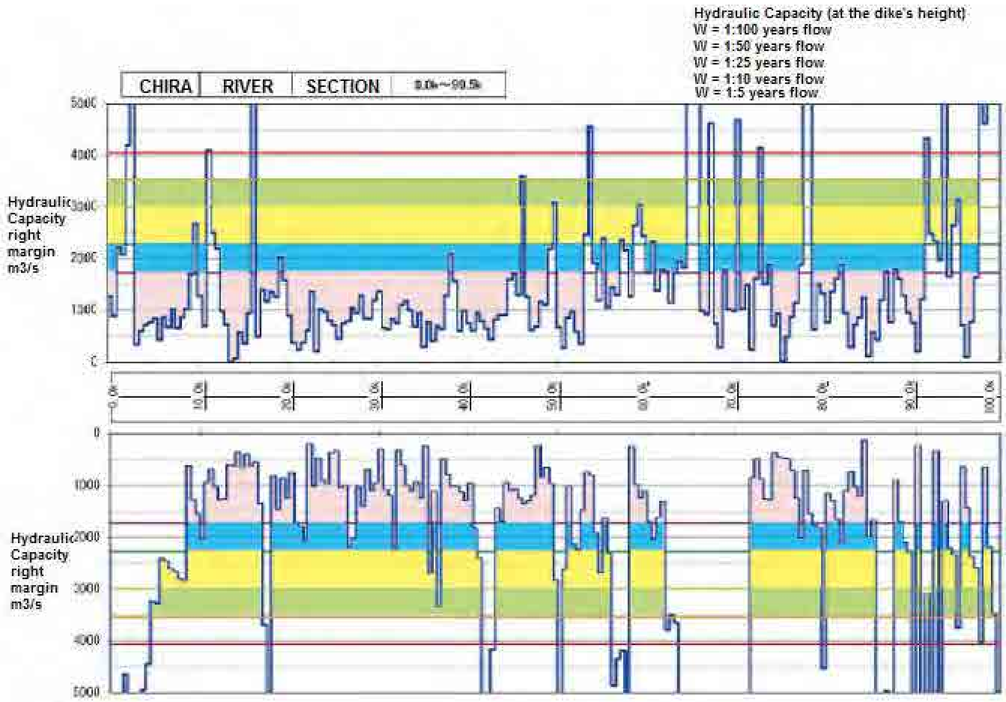


Figure 3.1.10-3(1) Current discharge capacity of Chira River

（4）**Inundation area**

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

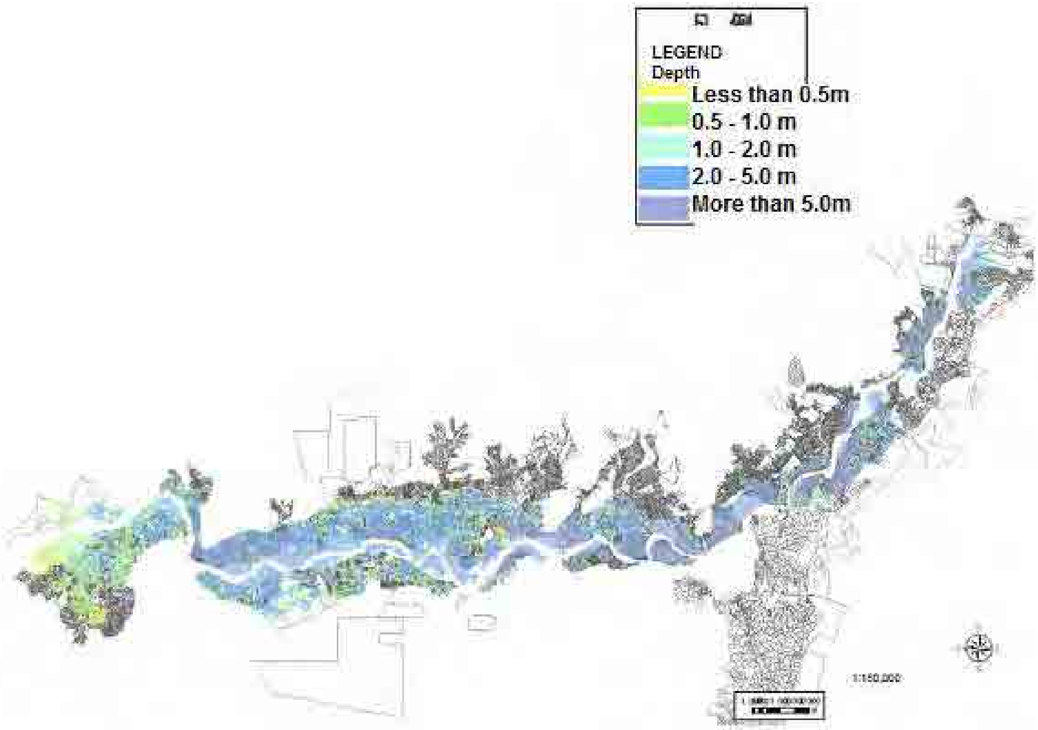


Figure 3.1.10-4(1) Overflow scope of Chira River (50 year period floods)

3.1.11 Early Alert Information System

(1) Piura River Watershed

There is an early alert system called **SIAT** (for its acronym in Spanish), for the Piura River Watershed. This was developed in the Reconstruction Definitive Study and Rehabilitation System for Flood Defense in Bajo Piura, which was installed in 2001 with financing of the German Government trough GTZ and Piura Regional Administration Council CTAR-Piura.

The objectives of this project are:

- Plan and organize institutions work linked to the Early Alert System
- Install strategic points telemetry network of Piura River
- Implement and function Hydrologic Model NAXOS as base for flood forecast
- Investigation on the pluvial behavior of El Niño phenomenon of Piura River Watershed
- Technical and support assistance on the elaboration of Contingency Plans and Vulnerability Reduction at district level and on Health and Agriculture sectors

SIAT system operation and its functioning are done throughout a total of 30 Pluviometric and Hydrometric stations that operate together with SENAMHI, PECH and DIRESA. Data is sent in real time to the Operation Center installed in the Piura-Chira Project.
Rainfall data is received, analyzed and processed by NAXOS hydrologic model.
The results of this model allow Piura River flood forecasts. The alert is transmitted on time to the CIR (Regional Information Center) in CTAR – Piura, so their organisms and Civil Defense take decisions to mitigate the negative impact in most vulnerable areas.

SIAT execution is done throughout an inter-institutional agreement and the following take part in this agreement:

- Regional Government of Piura (GRP)
- Development German Cooperation (GTZ)
- National Service of Meteorology and Hydrology (SENAMHI)
- Regional Health Direction of Piura (DIRESA)
- University of Piura (UDEP)
- Scientific and Technologic Consultant Council of the Regional Government of Piura (CCCTEP)
- Especial Project Chira-Piura (PECHP)

SIAT network works throughout a communication system, which initially was telemetric and now is via satellite. In map N° 4, the Early Alert System installed in Piura River Watershed is shown, as its operation connections.

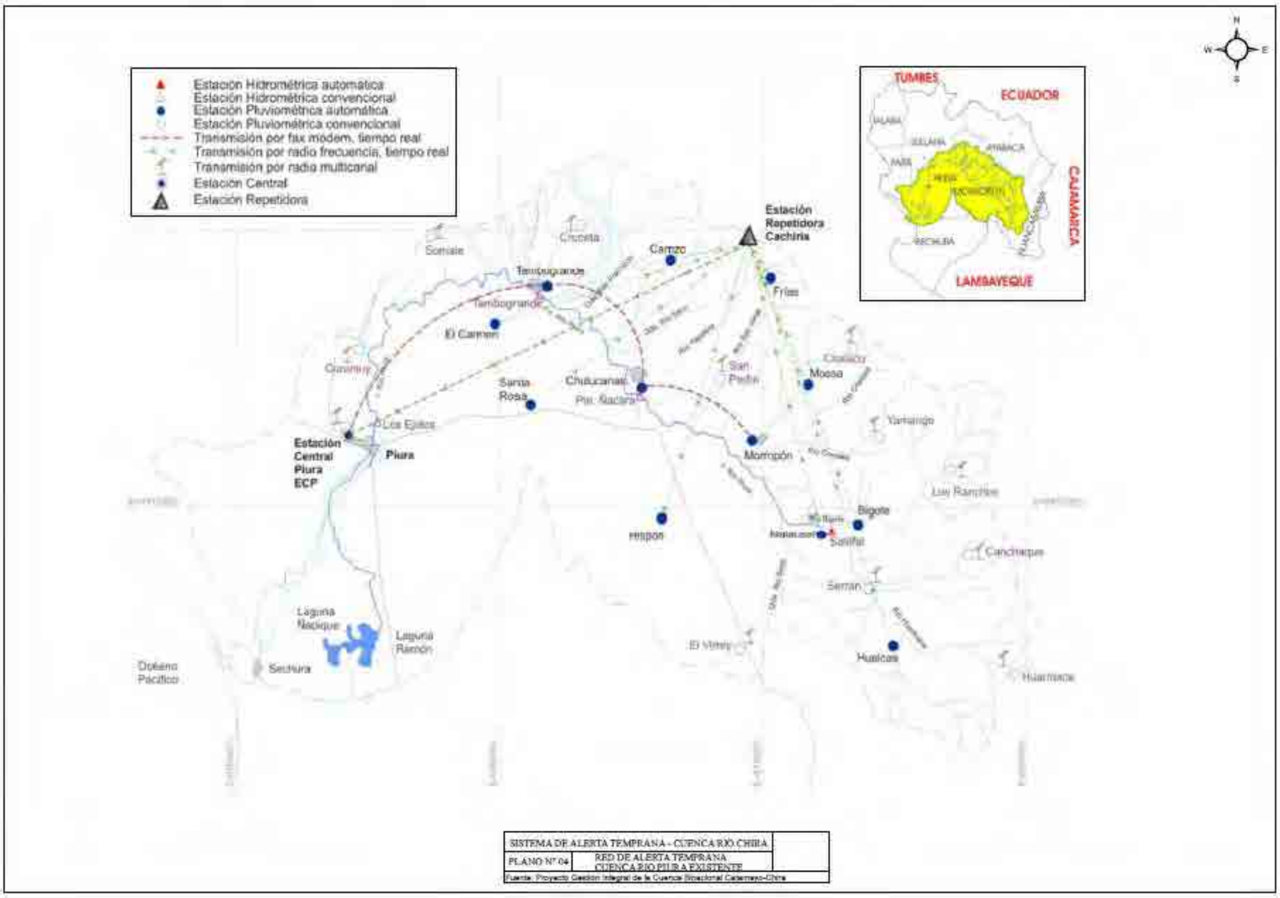


Figure 3.1.11-1 Early alert system of Piura River

(2) **Chira River Watershed**

Chira-Piura Project has a system to obtain information for the operation of the Chira-Piura system and especially for operating Poechos Dam. This is done based on a net built since 1971, which has 8 meteorological and 7 hydrometrical stations, all of them communicate through multi-channel radio and telephones; in Tables N° 6 and 7 stations are indicated and on map N|5 the location of each station is detailed. This procedure of information gathering and data transfer is used since the first stage of the project's building process.

It is a preliminary process of the early alert information system that is currently being used. This transmits data through a daily multi-channel radial system at 7:00 and 19:00 hours to the Piura base station, which gathers all the Chira-Piura system's information and at the same time re-transmits to Poechos dam and Puente Sullana. The transmission sequence is as follows:

- Radio transceiver – Hydrometeorological Station
- Radio transceiver – Base Station
- Information entering to the PC – Data base

It does not have a rainfall run-off model for the watershed, but they use isochronous information for the upper watershed discharge values transfer and at the same time for the lower areas and sporadically they are using satellite information.

Table 3.1.11-1 Hydrometrical Stations currently operating in Chira-Piura Watershed

Nº	Station	Coordinates UTM		RIVER	Condition
		N	E		
1	Paraje Grande	9488151	620548	Quiroz	Existent
2	Pte. Internacional	9515414	616512	Macara	Existent
3	Alamor	9529244	589330	Alamor	Existent
4	El Ciruelo	9524654	594327	Chira	Existent
5	Ardilla	9503620	567918	Chira	Existent
6	Poechos	9482714	552473	Chira	Existent
7	Pte. Sullana	9459530	534271	Chira	Existent

Table 3.1.11-2 Meteorological Stations currently operating in Chira River Watershed

N°	STATION	PROV	DIST	SUB BASIN	Coordinates UTM		ALTITUD	CATEGORY	INSTITUCION QUE OPERA
					N	E			
1	Ayabaca	Ayabaca	Ayabaca	Quiroz	9487823	642699	2700	MAO	SENAMHI
2	Chilaco	Sullana	Sullana	Chira	9480963	554900	90	MAO	PECHP
3	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	PV-PG	PECHP
4	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	PV-PG	PECHP
5	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	PV	PECHP
6	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	PV	SENAMHI
7	El Partidor	Piura	Las Lomas	Chipillico	9477296	580134	255	CO	SENAMHI
8	Alamor	Sullana	Lancones	Chira	9505457	566997	125	PV	SENAMHI

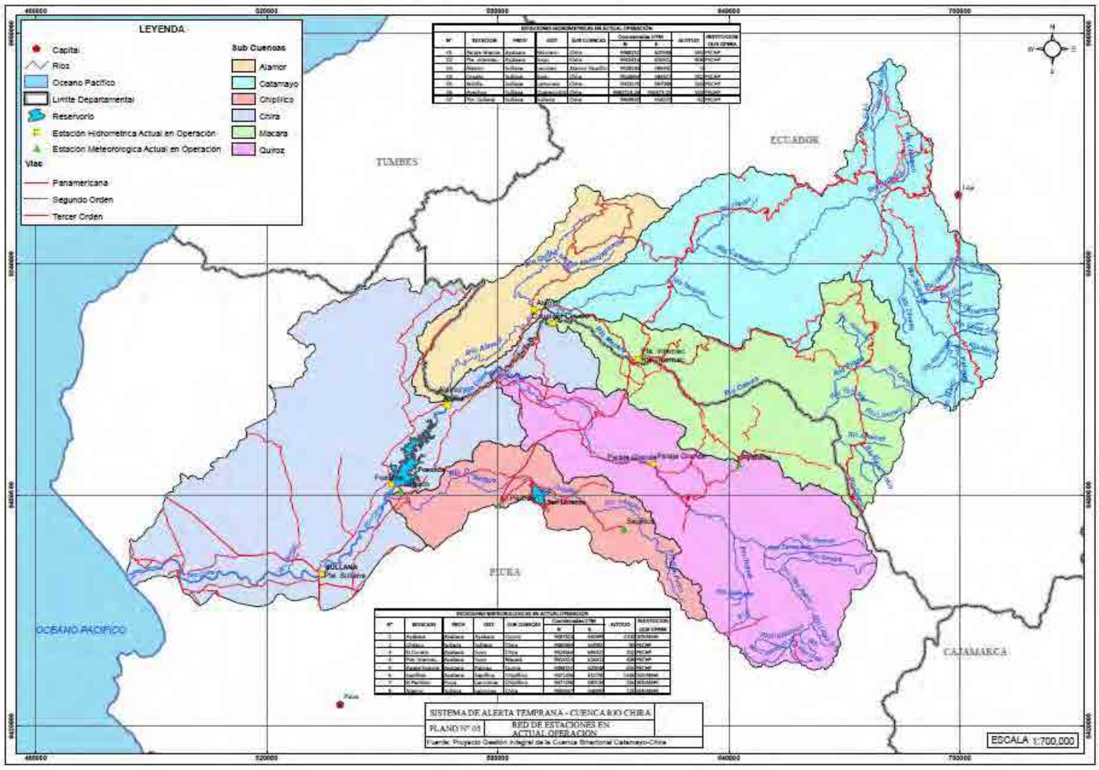


Figure 3.1.11-2 Location of monitoring stations of the Chira River Watershed

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 Chira 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	Banks 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		○					
	Dam Dikes					○		
	Natural gas deposit				○			

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 banks repair	4.3 Lack of early warning system
	1.4 Excessive sediment	2.4 Lack of dikes	3.4 Lack of repair	4.4 Lack of monitoring

	dragging from the upper and middle river levee		works and referral making	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 banks		
		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 banks 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.

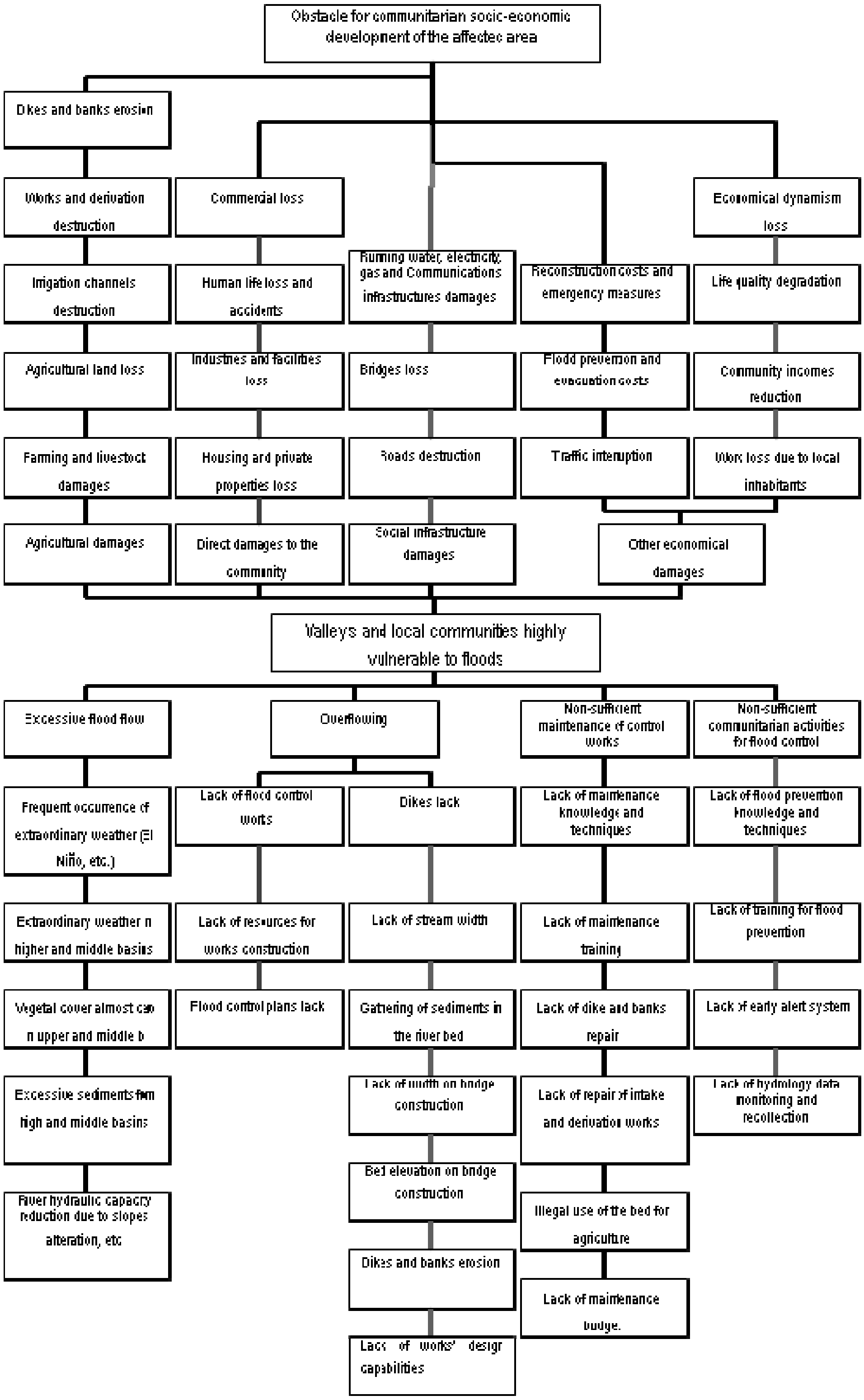


Figure 3.2.4-1 Causes and effects diagram

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 banks	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 banks 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 banks 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.

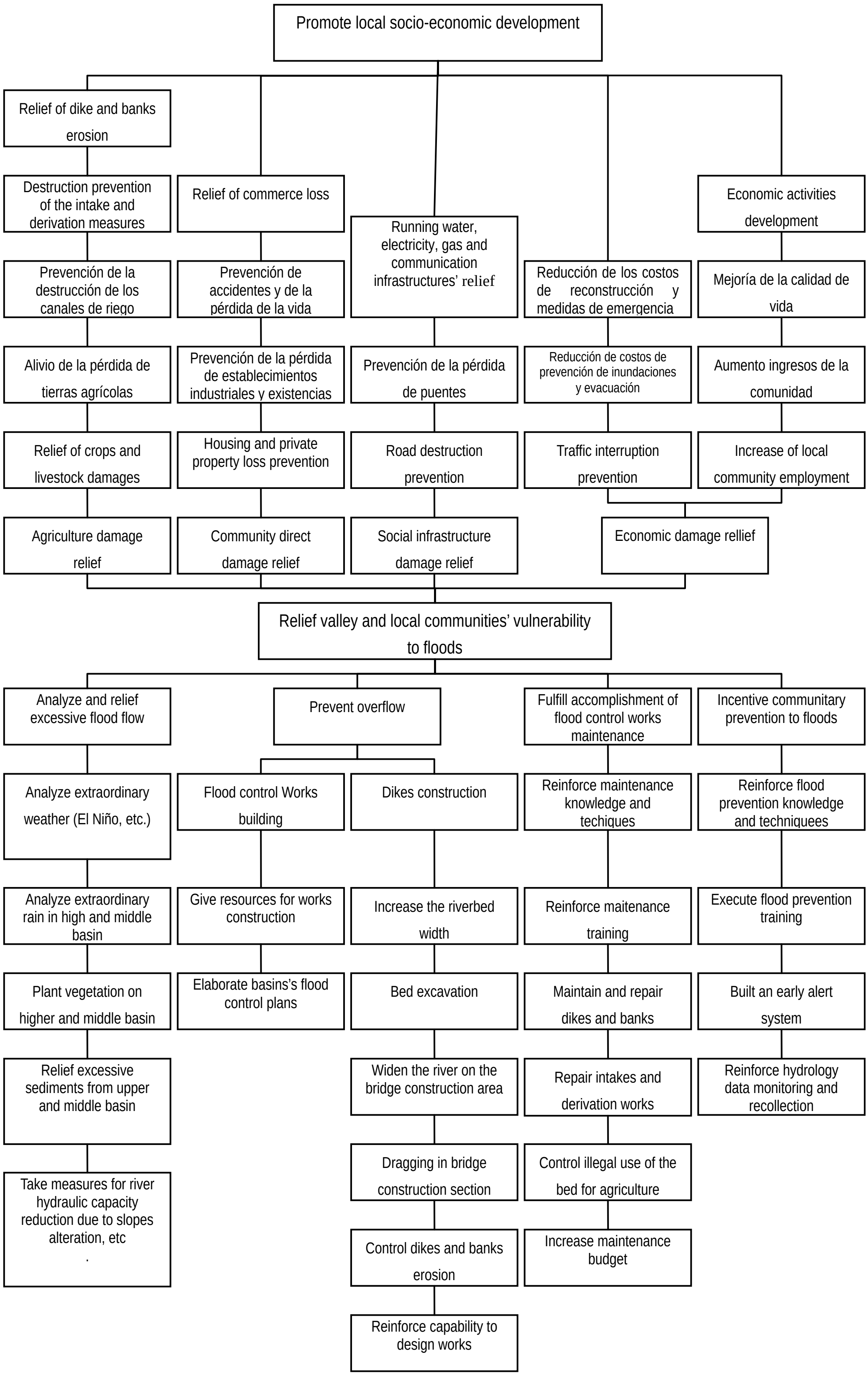


Figure 3.3.3-1 Measures - objectives – impacts diagram

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 values of each point in Chira 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	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
Chira	31.85	29.27	31.38	1.20	32.58	2.71	3.53

Table 4.2-2 Demand and Supply according to the calculation

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
0.0	1.43	0.48	2.10	1.20	3.30	1.88	2.82
0.5	3.78	1.37	2.34	1.20	3.54	0.00	2.17
1.0	4.16	1.44	2.60	1.20	3.80	0.00	2.36
1.5	4.70	2.58	2.85	1.20	4.05	0.00	1.47
2.0	3.94	2.68	3.14	1.20	4.34	0.40	1.66
2.5	4.40	3.95	3.36	1.20	4.56	0.16	0.61
3.0	4.48	5.77	3.65	1.20	4.85	0.36	0.00
3.5	5.18	2.02	3.90	1.20	5.10	0.00	3.08
4.0	5.58	2.73	4.27	1.20	5.47	0.00	2.75
4.5	5.98	3.30	4.70	1.20	5.90	0.00	2.60
5.0	6.17	3.46	5.15	1.20	6.35	0.18	2.89
5.5	6.47	3.84	5.74	1.20	6.94	0.47	3.10
6.0	6.92	3.31	6.52	1.20	7.72	0.80	4.41
6.5	7.29	4.66	7.24	1.20	8.44	1.15	3.78
7.0	7.52	4.40	7.29	1.20	8.49	0.98	4.09
7.5	7.79	5.37	7.70	1.20	8.90	1.11	3.54
8.0	8.08	4.73	7.95	1.20	9.15	1.07	4.43
8.5	8.21	5.28	8.10	1.20	9.30	1.08	4.02
9.0	4.85	5.67	8.15	1.20	9.35	4.50	3.68
9.5	6.23	6.84	8.30	1.20	9.50	3.27	2.66
10.0	6.78	8.22	8.40	1.20	9.60	2.82	1.38
10.5	7.71	6.69	8.44	1.20	9.64	1.94	2.95
11.0	6.39	5.90	8.78	1.20	9.98	3.60	4.08
11.5	6.48	10.02	9.00	1.20	10.20	3.72	0.18
12.0	7.21	8.85	9.22	1.20	10.42	3.21	1.57
12.5	7.62	8.62	9.30	1.20	10.50	2.88	1.88
13.0	7.65	7.25	9.36	1.20	10.56	2.91	3.31
13.5	6.89	7.10	9.36	1.20	10.56	3.67	3.46
14.0	7.16	4.67	9.76	1.20	10.96	3.80	6.29
14.5	6.53	5.20	9.95	1.20	11.15	4.62	5.95
15.0	7.82	7.57	10.49	1.20	11.69	3.87	4.12
15.5	7.32	7.17	10.93	1.20	12.13	4.81	4.96
16.0	8.19	8.78	11.17	1.20	12.37	4.17	3.59
16.5	8.35	15.27	11.31	1.20	12.51	4.16	0.00
17.0	10.28	8.03	11.66	1.20	12.86	2.58	4.84
17.5	14.24	10.59	12.33	1.20	13.53	0.00	2.94
18.0	34.72	10.34	12.84	1.20	14.04	0.00	3.70
18.5	9.67	10.89	12.97	1.20	14.17	4.50	3.27
19.0	11.28	10.86	13.14	1.20	14.34	3.06	3.48
19.5	10.21	12.41	13.27	1.20	14.47	4.26	2.06
20.0	11.30	11.88	13.62	1.20	14.82	3.53	2.94

20.5	11.00	11.31	13.86	1.20	15.06	4.07	3.75
21.0	13.85	10.33	14.69	1.20	15.89	2.04	5.56
21.5	14.24	9.88	15.42	1.20	16.62	2.39	6.74
22.0	14.82	10.66	15.60	1.20	16.80	1.98	6.14
22.5	10.06	11.63	15.66	1.20	16.86	6.80	5.24
23.0	12.96	13.73	16.06	1.20	17.26	4.30	3.54
23.5	11.55	10.33	16.26	1.20	17.46	5.91	7.13
24.0	13.59	13.89	16.15	1.20	17.35	3.75	3.45
24.5	14.03	13.98	16.95	1.20	18.15	4.12	4.17
25.0	12.22	13.66	17.31	1.20	18.51	6.29	4.85
25.5	12.14	13.49	17.37	1.20	18.57	6.43	5.08
26.0	14.51	12.67	17.40	1.20	18.60	4.09	5.94
26.5	14.53	13.79	17.42	1.20	18.62	4.09	4.83
27.0	17.09	14.09	17.46	1.20	18.66	1.57	4.57
27.5	16.97	14.95	17.49	1.20	18.69	1.72	3.75
28.0	15.03	14.79	17.56	1.20	18.76	3.72	3.97
28.5	16.01	15.74	17.53	1.20	18.73	2.72	2.99
29.0	14.75	15.11	17.65	1.20	18.85	4.10	3.74
29.5	15.95	15.33	18.20	1.20	19.40	3.45	4.07
30.0	15.81	16.33	18.49	1.20	19.69	3.88	3.37
30.5	14.10	16.91	19.02	1.20	20.22	6.12	3.31
31.0	16.48	15.29	19.01	1.20	20.21	3.73	4.92
31.5	16.94	15.38	19.57	1.20	20.77	3.83	5.39
32.0	19.58	16.29	19.63	1.20	20.83	1.25	4.54
32.5	14.61	16.28	20.29	1.20	21.49	6.88	5.21
33.0	16.00	17.47	20.65	1.20	21.85	5.85	4.38
33.5	17.31	17.76	20.77	1.20	21.97	4.66	4.21
34.0	17.93	17.63	20.83	1.20	22.03	4.10	4.40
34.5	17.70	16.95	21.14	1.20	22.34	4.64	5.39
35.0	18.56	17.79	21.30	1.20	22.50	3.94	4.71
35.5	15.47	15.63	21.32	1.20	22.52	7.05	6.89
36.0	21.32	17.51	21.32	1.20	22.52	1.20	5.01
36.5	19.34	16.99	21.55	1.20	22.75	3.40	5.76
37.0	23.95	18.53	22.19	1.20	23.39	0.00	4.86
37.5	18.08	18.56	22.65	1.20	23.85	5.78	5.29
38.0	19.29	20.59	23.15	1.20	24.35	5.06	3.76
38.5	20.13	22.45	23.35	1.20	24.55	4.42	2.10
39.0	20.34	21.60	23.74	1.20	24.94	4.60	3.35
39.5	20.69	19.15	23.77	1.20	24.97	4.28	5.82
40.0	21.32	20.54	24.01	1.20	25.21	3.88	4.67
40.5	21.20	20.54	23.90	1.20	25.10	3.91	4.56
41.0	23.56	20.27	24.66	1.20	25.86	2.30	5.59
41.5	24.89	21.57	25.02	1.20	26.22	1.33	4.65
42.0	31.86	21.40	25.09	1.20	26.29	0.00	4.89
42.5	37.02	21.16	25.47	1.20	26.67	0.00	5.51
43.0	27.98	20.48	25.73	1.20	26.93	0.00	6.45
43.5	23.52	21.90	25.85	1.20	27.05	3.53	5.15
44.0	24.10	22.25	25.87	1.20	27.07	2.97	4.82

44.5	22.56	22.45	26.17	1.20	27.37	4.81	4.92
45.0	23.08	24.17	26.36	1.20	27.56	4.48	3.39
45.5	23.18	24.53	26.38	1.20	27.58	4.40	3.05
46.0	24.00	24.07	26.55	1.20	27.75	3.75	3.68
46.5	24.59	27.88	26.82	1.20	28.02	3.43	0.14
47.0	24.69	24.60	27.03	1.20	28.23	3.54	3.63
47.5	25.00	23.54	27.09	1.20	28.29	3.29	4.75
48.0	22.35	24.08	27.46	1.20	28.66	6.31	4.58
48.5	24.80	25.61	28.05	1.20	29.25	4.45	3.64
49.0	24.46	25.71	28.58	1.20	29.78	5.32	4.07
49.5	25.58	28.08	28.72	1.20	29.92	4.34	1.84
50.0	29.39	29.77	29.19	1.20	30.39	1.00	0.62
50.5	41.99	25.10	29.33	1.20	30.53	0.00	5.43
51.0	29.20	23.78	29.40	1.20	30.60	1.40	6.82
51.5	26.38	25.91	29.58	1.20	30.78	4.40	4.87
52.0	28.69	26.32	29.81	1.20	31.01	2.32	4.69
52.5	29.06	25.39	30.13	1.20	31.33	2.27	5.94
53.0	27.82	24.56	30.28	1.20	31.48	3.66	6.92
53.5	26.29	30.30	30.50	1.20	31.70	5.41	1.40
54.0	26.71	33.91	31.05	1.20	32.25	5.54	0.00
54.5	29.67	29.65	31.26	1.20	32.46	2.79	2.81
55.0	31.29	28.20	31.43	1.20	32.63	1.34	4.43
55.5	30.31	31.63	31.77	1.20	32.97	2.66	1.34
56.0	31.64	29.27	32.09	1.20	33.29	1.65	4.02
56.5	35.26	30.28	32.57	1.20	33.77	0.00	3.50
57.0	34.64	30.04	32.61	1.20	33.81	0.00	3.77
57.5	36.39	33.42	33.70	1.20	34.90	0.00	1.48
58.0	58.58	34.00	34.42	1.20	35.62	0.00	1.62
58.5	28.33	32.15	35.15	1.20	36.35	8.02	4.20
59.0	31.38	35.27	35.27	1.20	36.47	5.09	1.20
59.5	32.22	36.10	35.45	1.20	36.65	4.43	0.56
60.0	32.00	34.99	35.38	1.20	36.58	4.58	1.59
60.5	33.67	33.70	35.77	1.20	36.97	3.30	3.27
61.0	34.42	35.01	35.82	1.20	37.02	2.60	2.01
61.5	33.54	32.93	35.85	1.20	37.05	3.51	4.12
62.0	32.88	34.00	36.03	1.20	37.23	4.35	3.23
62.5	37.71	34.00	36.18	1.20	37.38	0.00	3.38
63.0	37.27	32.51	36.21	1.20	37.41	0.14	4.90
63.5	37.55	34.05	36.32	1.20	37.52	0.00	3.47
64.0	60.11	36.40	38.32	1.20	39.52	0.00	3.12
64.5	60.11	37.30	39.12	1.20	40.32	0.00	3.02
65.0	51.58	41.61	39.46	1.20	40.66	0.00	0.00
65.5	51.58	41.75	39.97	1.20	41.17	0.00	0.00
66.0	51.58	44.00	40.22	1.20	41.42	0.00	0.00
66.5	51.58	37.56	40.39	1.20	41.59	0.00	4.03
67.0	51.58	38.19	40.84	1.20	42.04	0.00	3.85
67.5	55.36	42.37	41.52	1.20	42.72	0.00	0.36
68.0	55.36	38.72	41.75	1.20	42.95	0.00	4.23

68.5	55.36	37.76	41.91	1.20	43.11	0.00	5.35
69.0	55.36	40.42	42.02	1.20	43.22	0.00	2.80
69.5	70.76	39.82	42.43	1.20	43.63	0.00	3.80
70.0	70.76	39.82	42.50	1.20	43.70	0.00	3.87
70.5	70.76	43.43	42.58	1.20	43.78	0.00	0.35
71.0	67.10	40.21	42.74	1.20	43.94	0.00	3.73
71.5	67.10	41.06	43.27	1.20	44.47	0.00	3.41
72.0	40.21	38.70	43.40	1.20	44.60	4.39	5.90
72.5	39.42	41.65	44.07	1.20	45.27	5.85	3.62
73.0	40.46	44.78	44.17	1.20	45.37	4.91	0.58
73.5	41.35	41.75	44.38	1.20	45.58	4.23	3.83
74.0	41.81	42.85	45.06	1.20	46.26	4.45	3.41
74.5	42.27	42.84	45.47	1.20	46.67	4.41	3.83
75.0	42.85	43.61	46.02	1.20	47.22	4.37	3.61
75.5	42.85	41.22	46.16	1.20	47.36	4.51	6.14
76.0	42.90	42.85	46.19	1.20	47.39	4.49	4.54
76.5	43.41	43.66	46.36	1.20	47.56	4.16	3.90
77.0	44.33	44.17	46.57	1.20	47.77	3.44	3.60
77.5	45.28	45.12	46.63	1.20	47.83	2.55	2.71
78.0	43.59	48.49	46.70	1.20	47.90	4.31	0.00
78.5	44.89	49.89	46.77	1.20	47.97	3.08	0.00
79.0	45.47	43.72	47.22	1.20	48.42	2.96	4.70
79.5	45.66	45.28	47.29	1.20	48.49	2.83	3.21
80.0	48.26	45.32	47.50	1.20	48.70	0.44	3.38
80.5	45.56	44.82	48.38	1.20	49.58	4.02	4.76
81.0	46.31	46.40	49.17	1.20	50.37	4.06	3.97
81.5	47.01	46.93	49.27	1.20	50.47	3.46	3.54
82.0	48.12	47.87	49.35	1.20	50.55	2.42	2.68
82.5	47.49	47.13	50.93	1.20	52.13	4.64	5.00
83.0	47.63	46.29	51.60	1.20	52.80	5.17	6.51
83.5	48.82	48.12	52.30	1.20	53.50	4.68	5.38
84.0	49.54	48.83	52.60	1.20	53.80	4.26	4.97
84.5	47.57	50.20	52.82	1.20	54.02	6.45	3.82
85.0	51.69	48.16	53.21	1.20	54.41	2.72	6.25
85.5	51.82	49.96	53.81	1.20	55.01	3.19	5.05
86.0	63.61	50.00	54.19	1.20	55.39	0.00	5.39
86.5	69.13	51.94	54.60	1.20	55.80	0.00	3.86
87.0	56.61	53.49	55.37	1.20	56.57	0.00	3.08
87.5	70.38	53.01	56.75	1.20	57.95	0.00	4.94
88.0	53.86	55.45	57.62	1.20	58.82	4.96	3.37
88.5	55.92	55.78	57.72	1.20	58.92	3.00	3.14
89.0	56.71	55.79	57.87	1.20	59.07	2.36	3.28
89.5	57.20	55.74	58.09	1.20	59.29	2.09	3.55
90.0	63.07	56.69	59.78	1.20	60.98	0.00	4.29
90.5	55.90	55.77	60.55	1.20	61.75	5.85	5.98
91.0	76.15	58.17	60.60	1.20	61.80	0.00	3.63
91.5	60.48	61.40	60.79	1.20	61.99	1.51	0.59
92.0	63.03	60.76	61.57	1.20	62.77	0.00	2.01

92.5	58.64	61.19	62.11	1.20	63.31	4.67	2.12
93.0	64.36	61.35	62.73	1.20	63.93	0.00	2.58
93.5	61.19	63.94	62.99	1.20	64.19	3.00	0.25
94.0	62.54	62.02	63.56	1.20	64.76	2.22	2.73
94.5	63.79	63.98	64.48	1.20	65.68	1.89	1.70
95.0	65.13	64.80	65.00	1.20	66.20	1.07	1.40
95.5	64.58	64.65	66.74	1.20	67.94	3.36	3.29
96.0	65.68	63.40	67.32	1.20	68.52	2.83	5.12
96.5	67.11	65.02	68.08	1.20	69.28	2.17	4.26
97.0	67.67	66.58	68.47	1.20	69.67	2.00	3.09
97.5	69.14	77.54	68.67	1.20	69.87	0.73	0.00
98.0	65.73	69.83	68.95	1.20	70.15	4.41	0.31
98.5	68.48	71.57	69.64	1.20	70.84	2.36	0.00
99.0	70.30	80.96	70.32	1.20	71.52	1.22	0.00
99.5	71.59	85.56	70.58	1.20	71.78	0.19	0.00
Average	31.85	29.27	31.38	1.20	32.58	2.71	3.53

4.3 Technical Planning

4.3.1 Structural Measures

As structural measures it is necessary to prepare a flood control plan for the whole Watershed. The later section 4.12 “Medium and Long Term Plan” and 4.12.1 “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 each watershed, a big project needs to be set up investing very high costs, far beyond those considered in the budget of the present Project, which makes it difficult to take this proposal. Therefore, supposing the flood control dikes in the whole watershed are to be built progressively within a medium and long term plan, hereinafter they would be focused on the study of more urgent and priority works for flood prevention.

(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) 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 each watershed is as shown in Figure-4.3.1~ Figure-4.3.1-2. Based on the figures, 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 the watershed occurred one to two times of which scale is same as the flood discharge with return period of 50-year. And it is true that the flood discharges of same scale as the flood discharge with return period of 50-year caused large damages in the past. The maximum flood in the past is same as or less than the flood discharge with return period of 50-year.

Since the flood control facilities in Peru not well developed, it is not necessary to construct the facilities for more than the maximum discharge in the past, however it is true that the past floods caused much disaster so that the facilities should be safe for the same scale of flood, therefore the design flood discharge in this Project is to be the discharge with return period of 50-year.

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 Past
Chira	890	2,276	2,995	3,540	4,058	3,595

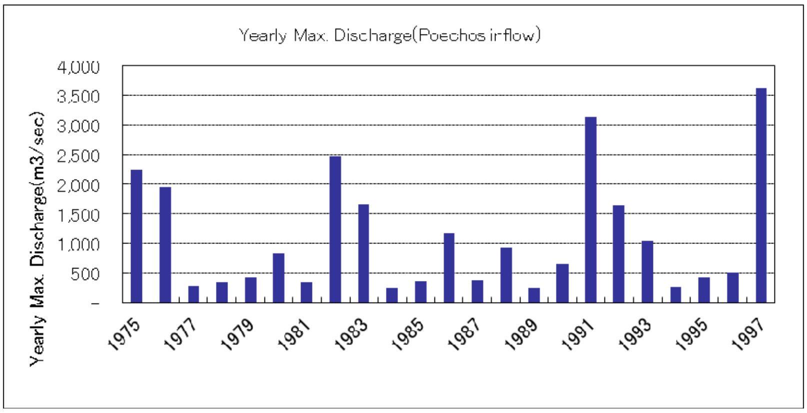


Figure- 4.3.1-1 Yearly Max. Discharge (Chira, Poechos Dam Inflow)

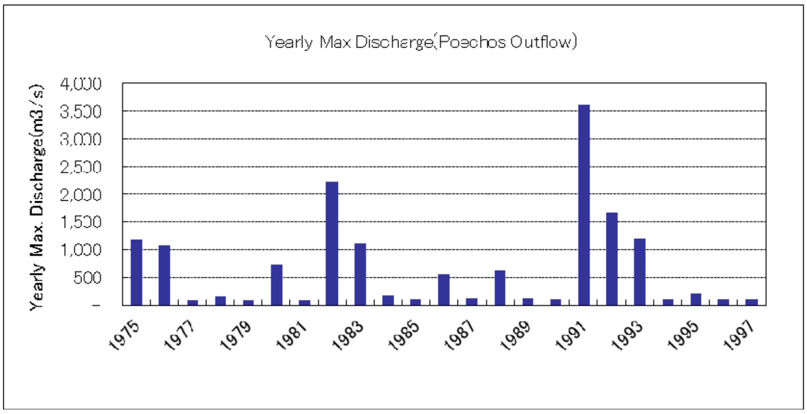
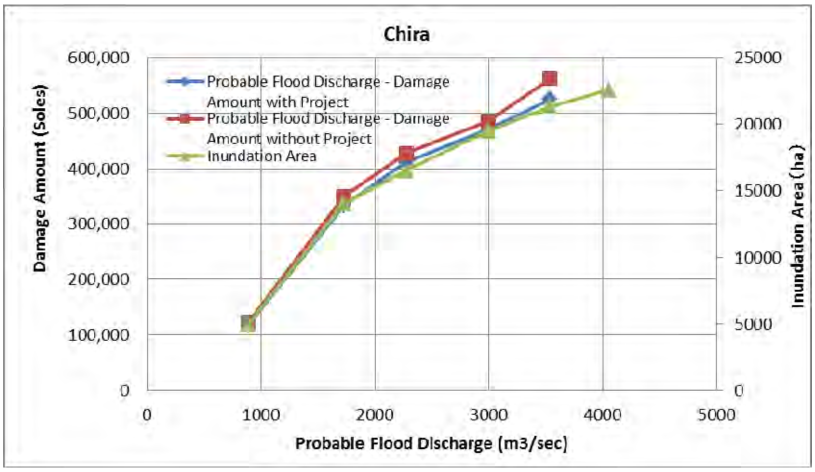


Figure- 4.3.1-2 Yearly Max. Discharge (Chira, Poechos Dam Outflow)

3) Relation among probable flood, Damage and inundation area

The relation among probable flood, Damage and inundation area in the watershed is shown in the Figure-4.3.1-3.

In the Chira watershed the three lines go up on the same line, namely the effect of damage reduction is almost nil. The project in Chira watershed are excluded due to low economical effect as described in 4.5 Social Evaluation.



Figure－4.3.1-3 Probable Flood Discharge, Damage Amount and Inundation Area (Chira 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 Quantities of Topographical Survey

Watershed	Topographiclal survey (S=1/1000～1/2000) (ha)	Cross sectional Survey (S=1/200, interval100m) (km)
Chira	234.5	23.8

(3) Selection of flood protection works with high priority

1) Basic Guidelines

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

- 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 four (4) 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

Table 4.3.1-3 details evaluated aspects and assessment criteria.

Table 4.3.1-3 Assessment Aspects and Criteria

Assessment Aspects	Description	Assessment Criteria
Demand of local population	● Flood damages in the past ● Demand of local population and producers	・Flooding area with big floods in the past and with great demand from local community (2 points) ・Demand of local population (1 point)
Lack of discharge capacity (bank scouring)	● Possibility of river overflow given the lack of discharge capacity ● Possibility of dike and bank collapse due to scouring	・Extremely low discharge capacity (discharge capacity with return period of 10 years or less) (2 points) ・Low discharge capacity (with 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.	・Area with large arable lands (2 points) ・Area with arable lands mixed with towns, or big urban area (2 points) ・Same configuration as the previous one, with shorter scale (1 point)
Inundation conditions	● Inundation 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 4.3.1-4 details assessment results of the river, as well as the selection results of flood protection priority works.

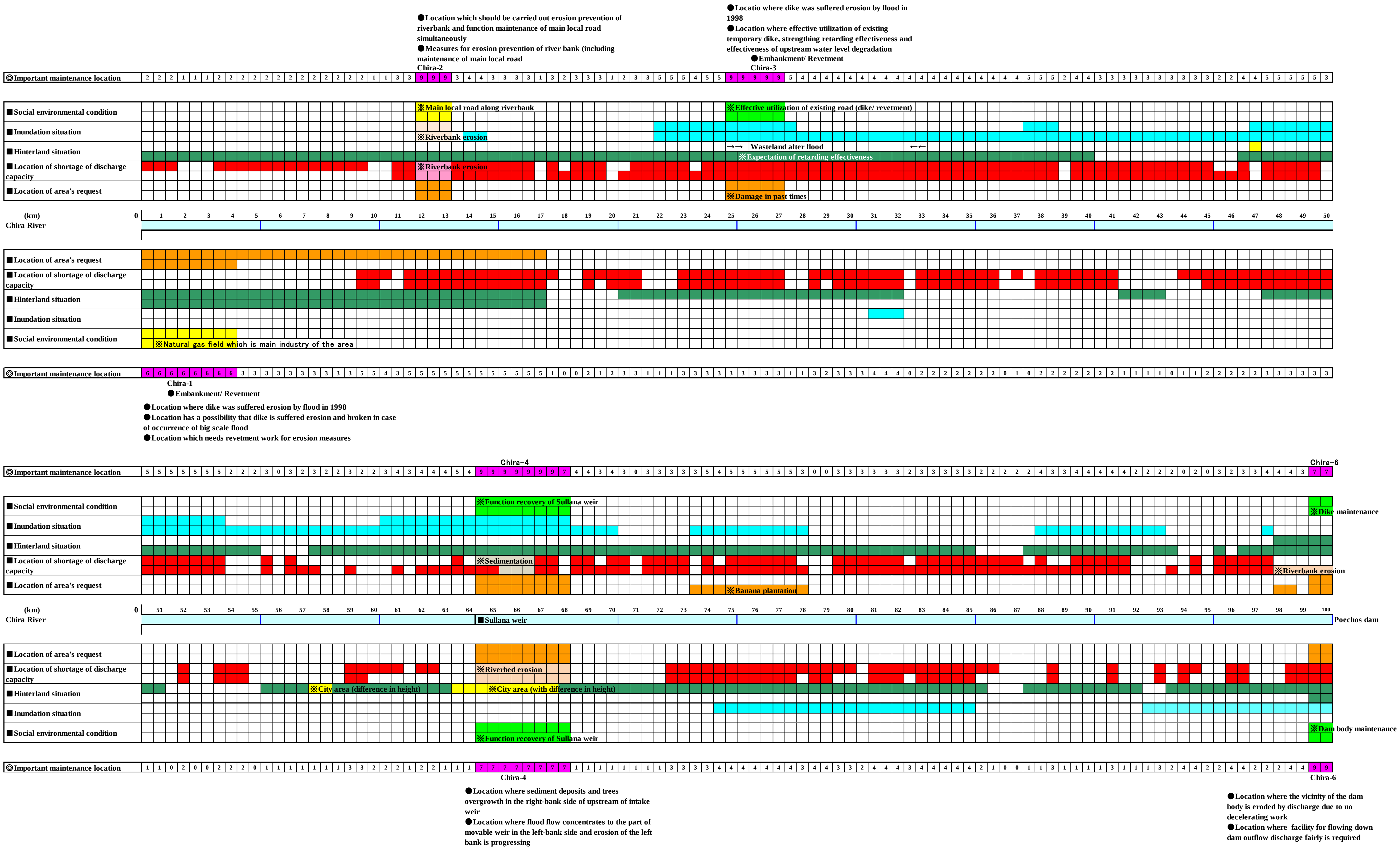


Figure 4.3.1-4 Selection of High Priority Improvement Facilities in the Chira River

3) Basis of Selection

Chira River is characterized due to the lack of discharge capacity, causing overflowing in all sections. Water flow reaches low lands and plain lands along the river. However, in Chira River case, the presence of Poechos dam may contribute to solve problems in case middle and small floods take place. Therefore, in case a flood with magnitudes that are bigger than the dam's capacity it is probable that serious damage is caused.

In order to control floods in this river, it is important to build dikes, beginning from the lower watershed to upper watershed, however this time the flood protection works with high priority are to be selected considering importance of facilities for adjacent area and heavily damaged areas in the past.

Table-4.3.1-4 Basis of Selection for Flood Protection Work (Chira river)

No	Location	Basis of Selection
①	0.0km～4.0km (Left Bank)	In this section there are dikes built but the banks are not protected. Floods of 1998 caused dike erosion. So, in case floods last for a long period causing erosion and dikes destruction, great damage to near infrastructures will happen (gas production field, crop lands, etc.). This section has groins instead of bank protection works. It is true that groin may stop waves, but it is necessary to execute bank protection works considering the existence of important infrastructure (natural gas field, crop land, etc.) that must be protected [Characteristics of the Section] ●Section where dike was scoured and eroded by 1998 floods. ●Section in which the dike will be eroded and may collapse in case a big flood occurs ●Section in which bank must be protected against erosion [Elements to Protect] ○Big crop fields, natural gas field, etc of the left bank [Method of Protection] ▼Implementation of embankment and bank protection utilizing the existing dike to increase discharge capacity and durability for bank erosion. ▼To protect the wide farmland and gas production field, the objective flood discharge should be 3,600m3/sec, which is equal to the flood in El niño disaster and to the flood discharge with return period of 50-year.
②	11.75km ～ 12.75km (Right Bank)	This section forms a big curve, causing strong erosion of the right bank, giving the current river's course section. If no adequate measure is taken, it is probable that the rural road located on the right bank is destroyed. It is considered important to execute bank protection works keeping as possible the current river course section to maintain the storage effect of the current river channel and at the same time, protect the road (since its destruction will have a strong impact for regional economy) [Characteristics of the Section] ●Section in which bank erosion during floods may cause destruction of the regional road ●Section in which bank erosion protection works and regional road functioning conservation works must be carried out simultaneously [Elements to Protect] ○Regional road of the right bank [Method of Protection]

		▼To keep the safety of the regional road of which destruction will have a strong impact for regional economy for the flood discharge which is equal to the flood in El niño disaster and to the flood discharge with return period of 50-year. ▼Bank protection work is implemented in the section basically damaged in the past disaster.
③	24.5km ～ 27.0km （Right Bank）	It is a section in which the right bank was strongly affected by the past floods damages. Currently, has a provisional dike which is also used as a road. It is considered important to effectively use this existing work. The provisional existing dike has been built with enough wide space of river and because of that it has a retardant effect when a flood occur. To have a better control of floods in the Chira River, it is important to create several sections as this that will be used as natural reservoirs, in order to reduce the water level along the whole river. The existing dike in this section is provisional and it does not have the sufficient height as to maximize the flood retarding effect. So, we are proposing to increase the height of the current dike in order to maximize the retarding effect [Characteristics of the Section] ●Section in which the dike was eroded by 1998 floods ●Section in which the water level must be reduced increasing the retardation effect by using the existing provisional dike [Elements to Protect] ○Agriculture lands of the right bank [Method of Protection] ▼In order to protect the wide area of farmland in the right bank side as well as to make maximum effect of flood retarding, the existing provisional dike will be utilized, and the protection work should be safe in the past El niño class disaster. ▼The dike with road constructed after the disaster will be raised for securing the discharge capacity of river and expecting the retarding effect.
④	64.0km ～ 68.0km	Sullana intake has sediments gathered on the right bank fixed weir section, which is being covered by vegetation. As consequence, left bank's erosion is produced. If no action is taken, the right bank's vegetation will grow its density increasing more its impact on the left bank Bearing in mind the importance of the intake and to maintain safety of the left bank, it is considered necessary to eliminate all vegetation and gathered sediments of the right bank fixed weir section to stabilize flowing condition during floods. This measure is also important for the maintenance of existing structures [Characteristics of the Section] ●Section in which sediments have gathered on the right bank side of the intake and is covered of dense vegetation ●Section in which overflows are focused on the movable weir of the left bank, causing bank erosion [Elements to Protect] ○Intake (Sullana) [Method of Protection] ▼Sullana intake is the most important facility in this river. If the function

		of this intake occur, the influence on the region is very heavy, therefore it should be safe in the case of El niño. ▼To keep the discharge capacity of the upstream of Sullana intake,the dense vegetation at right bank side of upstream of the weir and sediment deposit should be removed.

(4) Location of priority works on flood control

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

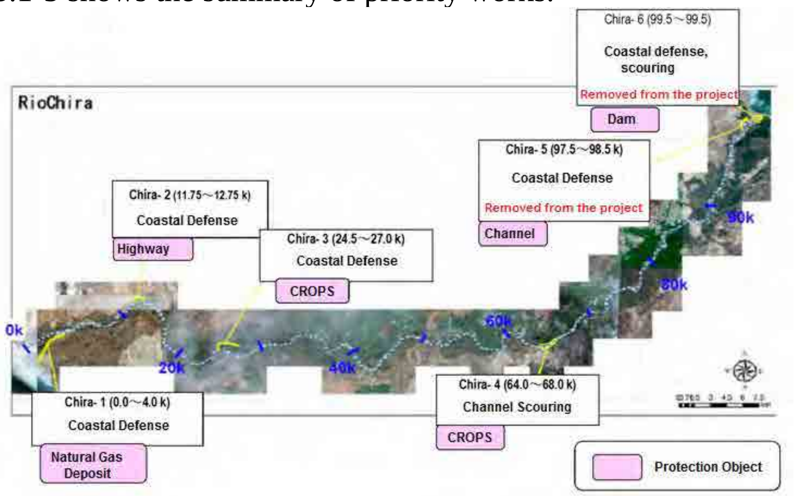


Figure 4.3.1-5 Priority Works on flood control in the Chira River

Table－4.3.1-5 Summary of Flood Prevention Facilities

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Chira	1	0.0k-4.0k	Revetment	Crop land/ natural gas	Revetment	H;2.0m Slope;1:3 L;4000m	0.0km～4.0km(left bank)
	2	11.75k-12.75k	Erosion	Road		H;2.0m Slope;1:3 L;1,000m	11.75km～12.75km(right bank)
	3	24.5k-27.0k	Revetment	Crop land		H;2.0m Slope;1:3 L;2,500m	24.5km～27.0km(right bank)
	4	64.0k-68.0k	Riverbed Excavation	Crop land	Riverbed excavation	Ex.width;100m Ex. depth;1.0m L;1,000m	64.0km～68.0km(total)

(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 zone to zone, 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.

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: $\tan\theta=\tan\varphi/n$ (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 ($\tan\theta=0.385$).

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.

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.

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 4.3.1-16 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

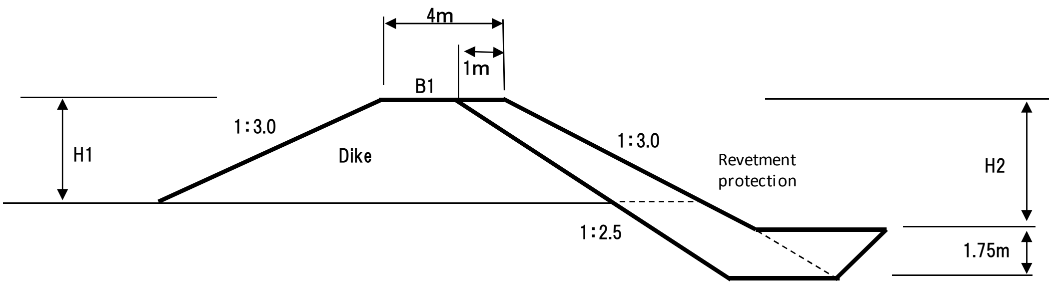


Figure 4.3.1-6 Standard dike section

4.1.2 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 4.12 "Medium and long term Plan", 4.12.2 "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 fluvial structures

This proposal consists in planting trees along river structures such as protection works of banks, dikes, etc.

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 along river structures.

c) Work execution: Plant vegetation at a side of the fluvial structures (dikes, etc.)

d) Maintenance post reforestation: The maintenance will be assumed by irrigator commissions by own initiative.

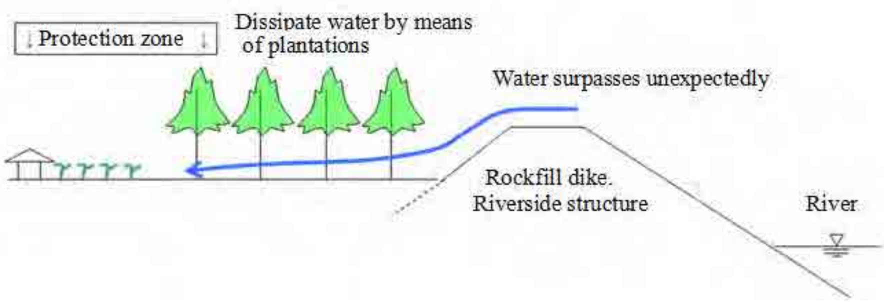
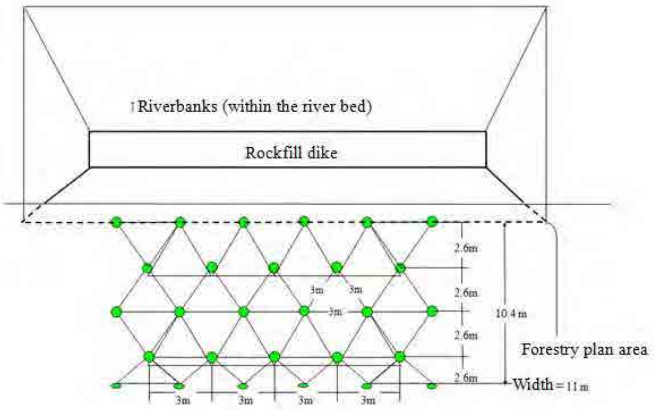


Figure 4.3.2.1-1 Conceptual Diagram Forestry in the Riverside structures (A Type)
(Source: JICA Study Team)

(3) Reforestation Plan Measure

1) Structure (forestry location)

In Peru the most common pattern for forestry is with equilateral triangles. This project also uses this model by planting trees with 3-meter intervals. If this method is used, it is expected that trees will act to stop and cushion even 1-meter diameter rocks, for what rows will be quadrupled, thus increasing their effectiveness. However, the main goal is to avoid overflow surpass the limit; in case floods strike directly with plants sowed, good results might not be expected.



(Source: JICA Study Team)

Figure 4.3.2.1-2 Location of the forestry design plan in the riverside structure

2) Species to be forested

Species to be planted along the river were selected applying the following criteria and submitted to an overall assessment.

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 land 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 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-4.3.2.1-2 shows a list of selected species applying this 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 4.3.2.1-2 Selection of forest species

Watershed	Forest species
Chira	Algarrobo (◎), Támarix (○), Casuarina (○)

In the Chira Watershed the main forestry specie is Algarrobo and also have more experience in forestry. This specie is a native specie form the northern coast of Peru. Because this plant exists in the area, farmers are used to it and know it very well. Tamarix has the same qualities as Algarrobo admits fruit can be eaten. Casuarinas specie requires little water and supports saline water, which is why is used in areas near the ocean.

3) Volume of the Reforestation Plan

The forestry plan has been selected as it is mentioned in the location and type of species plan, in the dikes and rockfill, sedimentation wells along the riverside. The width of the forest is 11 meters; and within sand reservoir, trees will be planted excepting on the normal water route.

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

Table 4.3.2.1-3 Construction estimating for the forestry and vegetation cover recovery plan (Along the river)

N°	Location (bank)	Length (m)	Width (m)	Area (ha)	Quantity (unit)	Distribution according to the specie (unit)			
						Algarrobo	Algarrobo	Algarrobo	Algarrobo
Chira-1	Izquierdo	4.000	11	4,4	13.024	2.605	1.302	9.117	13.024
Chira-2	Derecho	1.000	11	1,1	3.256	1.628	977	651	3.256
Chira-3	Derecho	2.500	1	0,3	888	444	266	178	888
Chira-4	ambos lados			0,0	0	–	–	–	–
Cuenca Chira Total		7.00 0		5,8	17.168	4.677	2.545	9.946	17.168

(Source: JICA Study Team)

4) Areas subject to the Reforestation and Vegetation Recovery Plan

In areas subject to the Reforestation/Vegetation Recovery Plan along river structures, the structure arrangement is similar everywhere. See Figure 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 4.3.2.1-4, based on information obtained through interviews to private providers. Given that seedling prices and transportation cost varies per provider, an average was applied.

Table 4.3.2.1-4 Unitary cost of plants

Watersheds	Species	Unitary cost (unitary price + transportation) (in Soles/plant)
Chira	Algarrobo	1,3
	Taray	5,4
	Casuarinaceae	1,9

ii) Labor cost

Reforestation work performance ratio was determined in 40 trees/person-day according to the information gathered through interviews to AGRORURAL and to irrigator commissions. As to riverside reforestation, the labor unitary cost will be 33.6 Soles/man-day. In the high Watershed 16,8 Soles/man-day, corresponding to half of the first one.

iii) Reforestation execution cost

Work costs for the forestry and vegetation cover recovery plan in the riverside structures are detailed in Table 4.3.2.1-5.

Table 4.3.2.1-5 Forestry work cost

Watershed	Code	Cost		
		Plants	Labor	Total
Chira	Cira-1	27.740	10.940	38.680
	Cira-2	8.629	2.735	11.364
	Cira-3	2.352	746	3.098
	Cira-4			0
Total Chira		38.721	14.421	53.142

(Source: JICA Study Team)

6) **Implementation process plan**

Since coastal forests are part of fluvial structures, its reforestation will be subjected to the same execution plan. The ideal is to begin planting immediately before or at the beginning of the rainy season, and finish a month earlier of this season to ensure the survival of these plants. However, since it almost does not rain in the coastal area, in this case there is no much difference between rainy and dry season. So, as it is true to perform a planting in those dates when the river water raises, it should not be a problem if this task is done when the water level is low, if for the fluvial structures execution schedule reasons requires this. Water is required only for three months after transplantation by using a simple gravity irrigation system (with hose), until the 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	Bank erosion and river bed change	Bank erosion and river bed change Sediment flow from ravines
Measures	Erosion control → Bank protection Control of riverbed variation → compaction of ground, bands (compaction of ground in the alluvial cone, bands)	Erosion control → bank protection Riverbed variation control →compaction of ground, bands (compaction of ground in the alluvial cone, bands) Sediment flow → protection of slopes, sediment control dams

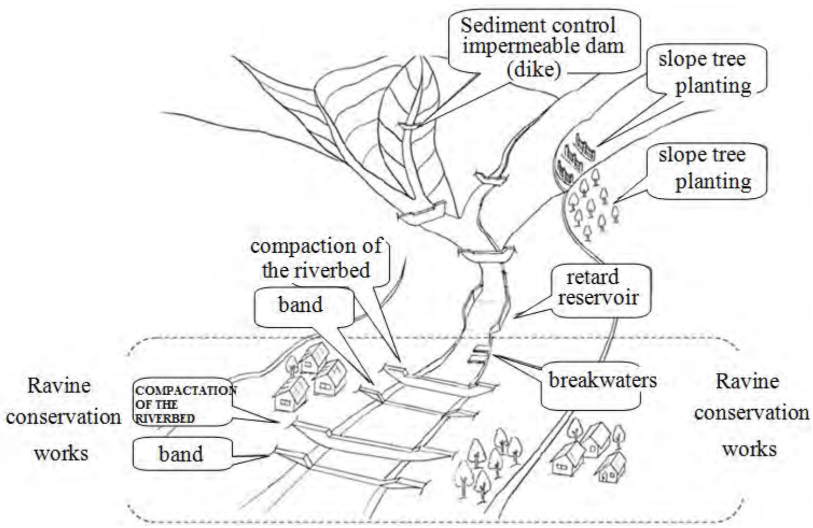


Figure 4.3.2.2-1 Sediment control works

1) Sediment control plan in the upper Watershed

The next section 4.12 "Medium and long term Plan" 4.12.3 "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.

Below are the analysis results on the riverbed variation in the Chira River.

Total volume of dragged sediment (in thousands of m^3)	5.000
Annual average of dragged sediment (in thousands of m^3)	100
Total volume of riverbed variation (in thousands of m^3)	- 1.648
Annual average of variation of riverbed height (m)	- 0,01

Since most of sediments are dragged to the upper watershed higher that the Poechos Dam and it will be retained there, not affecting the lower watershed bed. So it is considered not necessary to take special actions for sediment control.

4.3.2.3 Early Alarm System

(1) Objectives

The objectives of this study on the early alarm system are the following:

- Precipitation stations, flow stations, data transfer system, early alert center, community Communications system
- Forecast of floods, flow, flood wave shape, arrival time, etc on real timing based on monitoring and registering precipitations and flow
- Know hydrologic phenomenon in terms of location and time
- Emit forecasts and early alerts for flood risks to local communities
- Gather teams to evacuate the community and also for flood damage prevention
- Give entertainment and capability development for the early alarm center staff, on measures and responses to floods
- Training and education of the community in disaster prevention topics

(2) Rain and Flow Monitoring Stations

Currently in Chira-Piura watershed there are several observation stations of the Chira-Piura Special Project and SENAHMI, which have their proper operation conditions and that may be used in the early alarm system. Every Station of the Chira River is operating since 1972 or even before. The 7 monitoring stations and 8 meteorological stations that are part of this early alarm system are shown in Table 4.3.2.3-1 and 4.3.2.3-2 respectively. Also, on Figure 4.3.2.3-1 their location is shown.

These stations have been built after 1963 and also after 1972. The monitoring work is performed by experimented staff well trained in this field, due to which the data quality is good, precise and trustable. All information, including data of more than 30 years has been digitalized.

Table 4.3.2.3-1 Flow Monitoring Stations for Early Alert System

N°	STATION	PROV	DIST	SUB BASINS	Coordinates UTM		ALTITUDE	CATEGORY	INSTITUTION WHO WORKS
					N	E			
1	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	Hg	PECHP
2	Ardilla	Sullana	Sullana	Chira	9503270	567048	106	Hg	PECHP
3	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	Hg	PECHP
4	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	Hg	PECHP
5	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	Hg	SENAMHI
6	Alamor	Sullana	Lancones	Chira	9505457	566997	125	Hg	PECHP
7	El Arenal	Paita	El Arenal	Chira	9459524	529062	62	Hg	PECHP

Table 4.3.2.3-2 Meteorological Observation Stations for Early Alert System

N°	ESTACION	PROV	DIST	SUB CUENCAS	Coordenadas UTM		ALTITUD	CATEGORIA	INSTITUCION QUE OPERA
					N	E			
1	Ayabaca	Ayabaca	Ayabaca	Quiroz	9487823	642699	2700	MAO	SENAMHI
2	Chilaco	Sullana	Sullana	Chira	9480963	554900	90	MAO	PECHP
3	El Ciruelo	Ayabaca	Suyo	Chira	9524654	594327	202	PV-PG	PECHP
4	Pte.Internac.	Ayabaca	Suyo	Macará	9515414	616512	408	PV-PG	PECHP
5	Paraje Grande	Ayabaca	Paimas	Quiroz	9488151	620548	555	PV	PECHP
6	Sapillica	Ayabaca	Sapillica	Chipillico	9471196	612750	1446	PV	SENAMHI
7	El Partidor	Piura	Las Lomas	Chipillico	9477296	580134	255	CO	SENAMHI
8	Alamor	Sullana	Lancones	Chira	9505457	566997	125	PV	SENAMHI

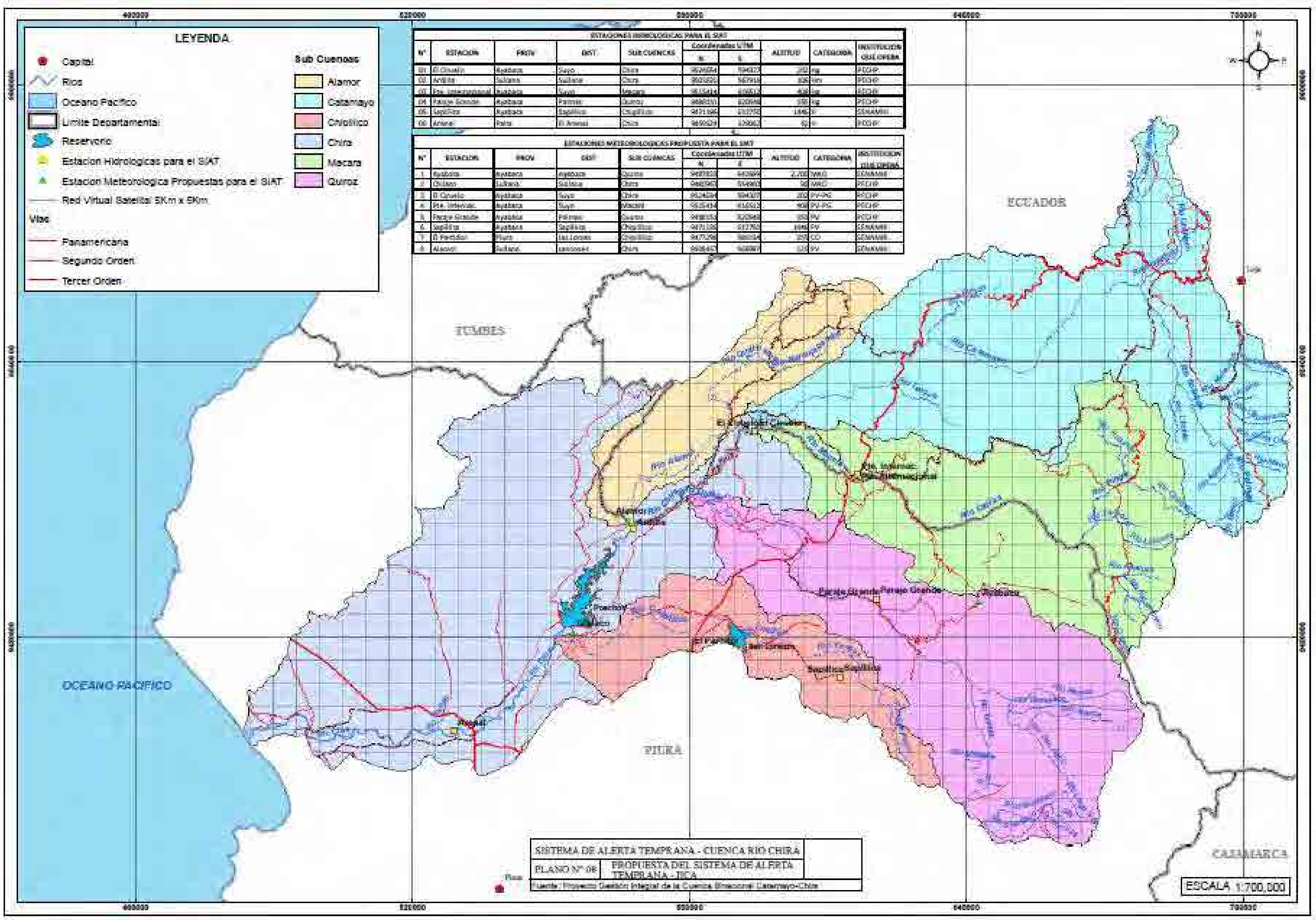


Figure 4.3.2.3-1 Location of the Early Alarm System

(3) Renewal of the monitoring equipment

1) Current conditions and renewal justification

The 7 observation stations and 8 meteorological stations equipment that are part of the Chira River early alert system are operative. However, these are obsolete, and may present capacity o functioning (maintenance) trouble any moment. We are recommending the renewal of these equipments taking advantage of the new early alert system installation, in order to standardize the equipment and reinforce their capacity.

2) Type of equipment to be renewal

i) Flow monitoring stations

We are proposing the equipment renewal of the 7 flow monitoring stations, that inlcude the following:

- Meteorological data sensors
- Water level sensors
- Digital storage system for the digital information transmission
- Satellite communication system
- Photovoltaic panels for energy storage
- Lightning rod
- Installation works and protective fences

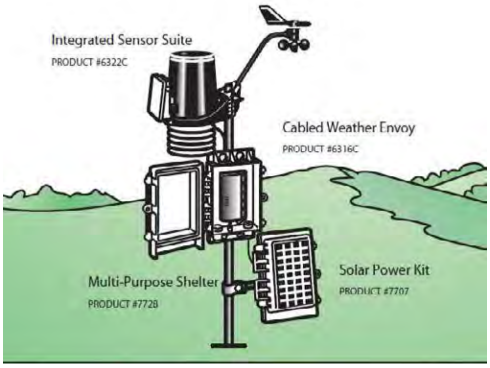
ii) Meteorological Stations

The following equipment for 8 meteorological stations is proposed to be renewal:

- Meteorological monitoring automatic equipment
- Data register

In Figure 4.3.2.3-2 some equipments are shown:

		
Water level sensor	Rain level sensor	Data register



Meteorological monitoring equipment

Figure 4.3.2.3-2 Some examples of monitoring equipment

(4) Data Transmission System

The early alert system must be operated in real time. So, for data transmission in real time the next procedures must be followed:

1) Register gathered data from automatic stations
2) Transmit registered and compiled data to the base station through satellite or telephone transmission
3) Transmit processed data of the base station to ministries and institutions throughout the early alert communication system

(5) Early Alert Center Creation

An early alert center is proposed to be created as base station, where all data gathered in the field will be received and precipitation and flow will be monitored to forecast floods flow, emitting alerts to the relevant institutions when necessary. The early alert center shall be located on a strategic point according to the other monitoring stations, for example, within the Chira-Piura Special Project Area, or in Poechos Dam site, or even in the Sullana dam Administration Office.

The early alert system of Piura River is being operated and maintained without any problem. Chira and Piura Rivers are near and are located in the same Piura region. So, from the organization and capacity point of view, it is positive to integrate the early alert system of Chira River with the Piura River so the Chira-Piura Special Project of the Regional Government takes control and operates both systems.

The base station will be equipped with data receptors, decoders, PC, information panel and other necessary equipment.

In Figure 4.3.2.3-3 the early alert system is shown

Figure 4.3.2.3-3 Early Alert System

(6) Software Provision for flood forecast

We are proposing to acquire the software to forecast maximum flow and floods wave shape from precipitation and flow data (for example: NAXOS) and up-dating this on time.

(7) Transmission System Construction to Alert the Community

We are proposing to acquire the system and transmission equipment to alert local governments, private disaster prevention system and local community, parallel to the implementation of this Project.

(8) Training and capacity development of the early alert center staff

(9) Disaster prevention education and practical training for local community and local government staff

(10) Costs

In Table 4.3.2.3-3 the necessary cost to build the early alert system is shown. This is estimated in US$ 550.000.

Table 4.3.2.3-3 Alarm System Cost

Item	Description	Unit	Quantity	UP	Partial Cost	Subtotal USD
1	**Hydrometeorological Equipment**					
1.1	Equipment					
	Hydrometric Equipment	Unit	7.00	10,000.00	70,000.00	
	Meteorological E. (New and repowered)	Unit	15.00	8,000.00	120,000.00	
1.2	Installation					
	Hydrometric Equipment	Unit	7.00	13,000.00	91,000.00	
	Meteorological E (repowered)	Unit	8.00	3,000.00	24,000.00	
2	**Data Transmission System**					
	Transmission Equipment H/M	Unit	7.00	7,000.00	49,000.00	
3	**Base Station**					
3.1	Equipment	Global	1.00	50,000.00	50,000.00	
3.2	Local (Pry. Chira-Piura)					
4	**Hydrologic Model**					
4.1	System Adaptation (Implementation)		1.00	20,000.00	20,000.00	
4.2	Software		1.00	30,000.00	30,000.00	
4.3	Adviser and Investigation	monthly	3.00	15,000.00	45,000.00	**499,000.00**
5	**Institutional management**					
5.1	Civil training	Global			2,500.00	
5.2	Poechos operation training	Global			2,500.00	**5,000.00**
5.3	**Maintenance (annual cost)**					
5.4	Hydrometeorological Station	monthly	2.00	1,000.00	2,000.00	
5.5	Base Station	monthly	2.00	1,000.00	2,000.00	
5.6	Satellite Connection (08 stations)	monthly	72.00	500.00	36,000.00	
5.7	Technical Assistance (contingency plans)	Global			4,000.00	
5.8	Prevention equipment and tools	Global			2,000.00	**46,000.00**
TOTAL usd						**550,000.00**

(11) Problems on installation of flood alert system

There are following problems on the installation of flood alert system:

1) Questionable points in the installation of flood alert system

a) The area expected to be inundated is almost farmland and scarcely urban area for which urgent evacuation is required.

b) Since the Poechos dam is located at the upstream end of the study area, and inflow to the reservoir is observed, the forecasting of flood occurrence and increase of flood discharge can be estimated with accuracy to same extent.

c) The flood alert system in Chira river has slightly meanings as model case since the sysytem in Piura river adjacent to Chira river is already mobilized.

d) The flood prevention project for Chira river is to be excluded due to its low economic viability. The flood alert system with small scale cost is not always implemented by Japanese Yen Loan but also can be done by the budget from the provincial government based on thestudy results by JICA Study Team.

e) The observation stations included in the system are under mobilization at present and data has been collected, however the conditions of observation equipment could not be collected, therefore the necessity of their renewal is unknown. If the renewal of equipment is not required, 64% of cost(2,640,000soles) is not necessary.

(12) Conclusion

In the meeting held on December 5,2011 among JICA Peru office, DGIH, OPI, DGPM and JICA Study Team, it was concluded that the flood alert system is exclude from Project, and if necessary, Piura provincial government will implement it (Minutes of Meetings on Main Points of Interim Report, Lima, December 5, 2011) .

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.

(1) 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”.

(2) Target area

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

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

(3) Target population

Target populations will represent irrigator associations and other community groups, provincial, district and local community governments in the Chira River 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.

(4) Activities

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

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) Communy activity planning in consideartion 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

Component 4: Information Networks on Flooding Risk management

Courses	a) Risk management and Forecasting and Warning Usefulness b) Workshop – Meeting with Local Authorities
Objectives	a) Local populations learn suitable technology on risk management and forecasting and warning usefulness. b) Cooperation preparedness between local Governments, Water Users Associations, communities, and local populations for flooding control purposes.
Participants	a-b) Engineers and / or technicians from local Governments and Water Users Associations, Community representatives
Times	a) 12 times in all (every five (5) hours b) 12 times in all (every five (5) hours
Lectures	a-b) Engineers from MINAG and / or the Regional Government, Forecasting and warning usefulness contractors and College professors (From universities, institutes, NGOs, etc.)
Contents	a-1) Disaster risk conditions and forecasting and warning usefulness a-2) Comprehensive risk management technology for flooding control a-3) Forecasting and warning usefulness technology a-4) Forecasting and warning usefulness control carried out by the local population's involvement b-1) Setting up an information network for Disaster risk conditions and forecasting and

	warning usefulness b-2) Local cooperation set up for forecasting and warning usefulness b-3) Preparation of a disaster risk plan that includes Forecasting and warning usefulness

(5) Costs and period of time

Costs of activities are detailed in Table 4.3.3-1. The total amount is S./ 158,930 Nuevo Soles.

The period is of approximately two years although the processes on structural and non-structural measures for flood prevention have to be considered in the program.

Table 4.3.3-1 Technical assistant cost

Item	Activities	Unit	Unit price(soles)	No.of basin	Amount(soles)
1.0	**Knowledge on river bank protection action in consideration of agriculture and natural environment**				
1.1	Workshop on operation and maintenance of facilites	event	9,300	1	9,300
1.2	Workshop on river bank plantation management	event	9,300	1	9,300
	Prevention and mitigation for erosion	event	9,300	1	9,300
	Natural resources management	event	9,300	1	9,300
2.0	**Preparation of community disaster management plan for flood control**				
2.1	Workshop on risk management plan	event	8,370	1	8,370
2.2	Details of 2.1	event			
	Community activity planning in consideration of ecological zoning	event	12,200	1	12,200
	Risk management	event	12,200	1	12,200
	Resource management	event	12,200	1	12,200
	Preparation of community disaster management plan	event	12,200	1	12,200
2.3	Preliminary flood forecasting and warning	event			
	Risk management and early warning system	event	9,300	1	9,300
	Joint activity with local government, users' association, etc.	event	5,580	1	5,580
3.0	**Hillside management for river sedimentation prevention**				
3.1	Field works for hillside conservation technique	event	7,500	1	7,500
	Forest seedling productions	event	7,900	1	7,900
	Forest planatation setting up	event	7,900	1	7,900
	Forest resource management and conservation	event	7,900	1	7,900
3.2	Difusion of posters and leaflet	event	3,600	1	3,600
4.0	**Risk Management Information and Instruments**				
4.1	Workshop on risk management and forecasting & warning system	event	9,300	1	9,300
4.2	Workshop with local authority	event	5,580	1	5,580
	Total				**158,930**

Source: JICA Study Team

(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 costs include the following:

① Work direct costs = total number of works by type × unit price
② Common provisional works = ① x 10%
③ Construction cost -1 = ① + ②
④ Miscellaneous = ③ x 15%
⑤ Benefits = ③ x 10%
⑥ Construction cost -2 = ③+④+⑤
⑦ Tax = ⑥ x 18% (IGV)
⑧ Construction cost = ⑥+⑦
⑨ Environmental measures cost = ⑧ x 1%
⑩ Detailed design cost = ⑧ x 5%
⑪ Works supervision cost = ⑧ x 10%
⑫ Project Cost = ⑧+⑨+⑩+⑪

(2) Work direct costs

On Table 4.4.1-1 a summary Table of direct costs for structural measures is presented for the Chira River Watershed. Structural measure Chira -5 consists in bank protection to protect irrigation channels. In the most recent field study it was seen that Chira-6 work execution implies change of the river course along the Chira-5 work, converging the current course downstream the coastal defense proposed for Chira-5. So, this last was decided to be discharged because it was unnecessary. Chira-6 has been excluded in the present Project because a similar project has been initiated by the Regional Government of Piura.

(3) Project Costs

The project cost is estimated in 64.0 million of soles as shown in Table 4.4.1-2. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance. The annual operation and maintenance cost of completed works is approximately 0.5% of the project's cost.

Table 4.4.1-1 Summary Table of the work's direct cost (at private prices)

WATERSHED 流域名	CRITICAL POINTS クリティカル・ポイント		MEASURES 対策		DIRECT COST 直接工事費計 (1)
Rio Chira	1	0.0K～4.0K	Coastal defense	築堤・護岸工	8,442,000
	2	11.75K～12.75K	Coastal defense	築堤・護岸工	15,480,000
	3	24.5K～27.0k	Coastal defense	築堤・護岸工	6,075,000
	4	64K～68K	Flow desilting	河床掘削	2,400,000
	5	97.5K～98.5K	Coastal defense	築堤・護岸工	0
	6	99K	Coastal defense + Desilting	築堤・護岸工・河床掘削	0
				SUB TOTAL	32,397,000

Table 4.4.1-2 Construction cost (at private prices) (In soles)

Watershed 流域名	PRIVATE PRICES COSTS															
	COMPONENT A														COMPONENT B	TOTAL COST OF THE PROGRAM 全体事業費
	STRUCTURAL MEASURES												NON STRUCTURAL MEASURES 非構造物対策		TECHNICAL ASSISTANCE 能力開発	
	DirectCost(直接工事費)			INDIRECT COST (間接工事費)												
	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical FIle 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	HYDRAULIC INFRASTRUCTURE Total Cost 構造物・事業費 (12) = (8)+(9)+(10)+(11)	REFORESTATION Total Cost 植林/植生回復 事業費 (13)	EARLY ALERT SYSTEM Total Cost 洪水予警報 事業費 (14)	TRAINING Total Cost 防災教育 事業費 (15)	(16) = (12)+(13)+(14)+(15)
CHIRA	32.397.000	3.239.700	35.636.700	5.345.505	3.563.670	44.545.875	8.018.258	52.564.133	527	2.628.207	5.256.413	60.974.394	102	2.640.213	314	64.030.772

4.4.2 Cost Estimation (at social prices)

(1) Work direct costs

In Table 4.4.2-1 a summary Table of direct costs for structural measures is presented for the Chira River watershed. The works' direct cost at private prices was turned into social prices applying the conversion factor.

(2) Project Costs

The project cost is estimated in 51.7 million of soles as shown in Table 4.4.2-2. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance, before converting from private prices.

Table 4.4.2-1 Summary Table of the work's direct cost (at social prices)

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Private Prices 民間価格 (PP)	Correction Factor 係数 (fs)	Social Price 社会価格 (PS) = (fs)*(PP)
Rio Chira	1	0.0K～4.0K	Coastal Defense	河床掘削	8.442.000	0.804	6.787.368
	2	11.75～12.75K	Coastal Defense	築堤・護岸工	15.480.000	0.804	12.445.920
	3	24.5K～27.0K	Coastal Defense	築堤・護岸工・河床掘削	6.075.000	0.804	4.884.300
	4	64K～68K	Flow desilting	導流壁・河床掘削・築堤・護岸工	2.400.000	0.804	1.929.600
	5	97.5K～98.5K	Coastal Defense	築堤・護岸工	0	0.804	0
	6	99K	tal Defense+Desilting		0	0.804	0
				SUB TOTAL	32.397.000		26.047.188

Table 4.4.2-2 Construction cost at (social prices)

Watershed	SOCIAL PRICES COSTS															
	COMPONENT A														COMPONENT B	TOTAL COST OF THE PROGRAM 全体事業費
	STRUCTURAL MEASURES												NON STRUCTURAL MEASURES 非構造物対策		TECHNICAL ASSISTANCE 能力開発	
	DIRECT COST(直接工事費)			INDIRECT COST (間接工事費)								HYDRAULIC INFRASTRUCTURE Total Cost	REFORESTATION Total Cost 植林/植生回復 事業費	EARLY ALERT SYSTEM Total Cost 洪水予警報 事業費	TRAINING Total Cost 防災教育 事業費	
	Direct Cost	Temporal works cost	Works Cost	Operative Expenses	Utility	Infrastructure total cost	TAX	Work's Total Cost	Environmental Impact	Technical File	Supervision					
流域名	直接工事費計	共通仮設費	工事費	諸経費	利益	構造物工事費	税金	建設費	環境影響	詳細設計	施工管理費	構造物･事業費				
	-1	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)	(13)	(14)	(15)	(16) = (12)+(13)+(14)+(15)
CHIRA	26.074.188	2.604.719	28.651.907	4.297.786	2.865.191	35.814.884	6.446.679	42.261.563	422..616	2.113.078	4.226.156	49.023.413	82	2.343.438	272..506	51.721.005

4.5 Social Assessment

4.5.1 Private prices

(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

- Determine 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)
- After, 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 (Chira 1 to 6, without including Chira-5 work).
- Determine the difference between ① and ②. Add the benefits of other works different than dikes (intakes, roads and dams 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 flood 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.

a. Dams damage

The loss amount due to dam damage is calculated by adding the direct loss (dam'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)

b. 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-trafficability (usually in Peru it takes five days to complete the rehabilitation of a temporary road)

2) Loss estimated amount according to disasters in different return periods

In Table 4.5.1-2 the amounts of loss with and without Project are shown. These are estimated for disasters of different return periods in the Chira River.

Table 4.5.1-2 Loss Estimated Value (at private prices)

(s./1,000)

Case	t	Chira
Without Project	2	0
	5	349,698
	10	427,001
	25	485,714
	50	562,385
	Total	1,824,798
With Project	2	0
	5	333,585
	10	411,472
	25	471,293
	50	525,002
	Total	1,741,352

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

The annual average loss amount that is expected to be reduced by the Project by the total annual average loss amount occurred as flow multiplying the amount of loss reduction occurred as flow for the corresponding flood probabilities.

Considering that floods happen probabilistically, the annual benefit is determined as the annual average amount of loss reduction. Next find the procedures of calculation.

Table 4.5.1-3 Loss reduction annual average 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	$D_1 = L_1-L_2$	$(D_1+D_2)/2$	(1/2)-(1/5) = 0,300	$d_2 = (D_1+D_2)/2$ x 0,300
1/5	L_3	L_4	$D_2 = L_3-L_4$	$(D_2+D_3)/2$	(1/5)-(1/10) = 0,100	$d_3 = (D_2+D_3)/2$ x 0,100
1/10	L_5	L_6	$D_3 = L_5-L_6$	$(D_3+D_4)/2$	(1/10)-(1/20) = 0,050	$d_4 = (D_3+D_4)/2$ x 0,050
1/20	L_7	L_8	$D_4 = L_7-L_8$	$(D_4+D_5)/2$	(1/20)-(1/30) = 0,017	$d_5 = (D_4+D_5)/2$ x 0,017
1/30	L_9	L_{10}	$D_5 = L_9-L_{10}$	$(D_5+D_6)/2$	(1/30)-(1/50) = 0,013	$d_6 = (D_5+D_6)/2$ x 0,013
1/50	L_{11}	L_{12}	$D_6 = L_{11}-L_{12}$	$(D_6+D_7)/2$	(1/50)-(1/100) = 0,010	$d_7 = (D_6+D_7)/2$ x 0,010
1/100	L_{13}	L_{14}	$D_7 = L_{13}-L_{14}$			
Foreseen average annual amount of loss reduction			$d_1+d_2+d_3+d_4+d_5+d_6+d_7$			

In Table 4.5.1-4 Results of loss amount calculus are presented (annual average), which are expected to be reduced when implementing the Project in the Chira River Watershed.

Table 4.5.1-4 Annual average of damage reduction (private prices)

s/1000

流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damage - thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①−② Mitigated damages ③=①−②	区間平均被害額 ④ Damage Avergare	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	349,698	333,585	16,113	8,056	0.300	2,417	2,417
	10	0.100	427,001	411,472	15,529	15,821	0.100	1,582	3,999
	25	0.040	485,714	471,293	14,421	14,975	0.060	898	4,897
	50	0.020	562,385	525,002	37,383	25,901	0.020	518	5,415

(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 4.5.1-5 Analysis assessment indicators of cost-benefit relation

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

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. In this Study the following SCF values were used:

Dams 0.804

Gabions 0.863

Intakes 0.863

TAX (Peruvians use IGV) is not taken into account in the conversion of market prices to socioeconomic prices.

iii) Other preliminary conditions

Price level: 2011

Social discount rate: 10%

Annual maintenance cost: 0.5% of construction cost

3) Cost-benefit relation analysis (C/B)

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 4.5.1-6 results of calculations C/B, NPV and IRR to private prices is shown.

Table 4.5.1-6 Social Assessment (C/B, NPV, IRR) (at private prices)

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Chira	70,400,707	31,791,564	64,303,772	3,416,669	0,55	negative 25662760	0,6%

4.5.2 Costs at social prices

(1) Benefits

1) Estimated loss amount according to different return periods

In Table 4.5.2-1 the amounts of loss with and without Project are shown. These are estimated for disaster of different return periods in the Chira River Watershed.

Table 4.5.2-1 Estimated loss amount (at social prices)

(s./1,000)

Case	t	Chira
Without Project	2	0
	5	407,180
	10	494,866
	25	563,929
	50	649,089
	Total	2,115,064
With Project	2	0
	5	384,769
	10	473,618
	25	544,283
	50	605,046
	Total	2,007,716

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

In Table 4.5.2-2 results of loss amount calculation (annual average) that are expected to reduce to implement the Project in the Chira River are shown.

Table 4.5.2-2 Annual average of damage reduction (at social prices)

s/1000

流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damage − thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①−② Mitigated damages ③=①−②	区間平均被害額 ④ Damage Avergare	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	407,180	384,796	22,410	11,205	0.300	3,362	3,362
	10	0.100	494,866	473,618	21,248	21,829	0.100	2,183	5,545
	25	0.040	563,929	544,283	19,646	20,447	0.060	1,227	6,772
	50	0.020	649,089	605,046	44,043	31,844	0.020	637	7,409

(2) Social Assessment

In Table 4.5.2-3 results of the calculation C/B, NPV and IRR at social prices are shown.

Table 4.5.2-3 Social Assessment (C/B, NPV, IRR) (at social prices)

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Chira	96,306,401	43,490,602	51,721,005	2,747,002	0,94	negative 2,911,709	9%

4.5.3 Social assessment conclusions

The social assessment shows that the Project in Chira River watershed has no economic impact on private and social prices. Also, the following economical non-quantifiable positive impacts are shown:

- 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

So, social assessment sets that the project will not show any economic impact, even when other non-quantifiable monetary impacts, this Project is considered not viable.

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-bank, 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 bank 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	Bank 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 bank	Bank 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 bank 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

	流域名	Item	Basic Case	Case 1 Cost increase 5%	Case 2 Cost increase 10%	Case 3 Benefit decrease 5%	Case 4 Benefit decrease 10%	Case 5 Discount rate increase 5%	Case 6 Discount rate decrease 5%
民間価格	CHIRA	IRR (%)	0.6%	–	-1%	–	–	0.6%	0.6%
		B/C	0.55	0.53	0.50	0.53	0.50	0.43	0.74
		NPV(s)	-25,662,760	-28,535,476	-31,408,193	-27,252,338	-28,841,917	-30,786,945	-15,812,908
社会価格	CHIRA	IRR (%)	9%	8%	7%	8%	7%	9%	9%
		B/C	0.94	0.89	0.85	0.89	0.84	0.72	1.26
		NPV(s)	-2,911,709	-5,231,797	-7,551,886	-5,086,212	-7,260,715	-12,054,326	13,085,346

(3) Assessment of the sensitivity analysis

The impact sensitivity analysis was made due to socioeconomic conditions changes, regarding private or social prices. According to this analysis, and because benefits fluctuate and discount rate too, the incidence on IRR, C/B and NPV values is much reduced. Also, the economic impact is not palpable. As exceptional case, Case 6 (decrease of discount rate = 5%) showed a determined economic impact in terms of social prices costs.

4.7 Sustainability Analysis

This project will be co-managed 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. Usually the central government (in this case, the DGIH) takes the 80%, irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both parties. 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.

Table 4.7-1 presents the data of the budget for irrigation committees in recent years.

Table 4.7-1 Project Budget of the irrigation commissions

River	Annual Budget				(In soles)
	2006	2007	2008	2009	Average in 4 years
Chira	30.369,84	78.201,40	1.705.302,40	8.037.887,44	2.463.008

(1) Profitability

The project in Chira River Watershed is estimated in 64,4 million soles. The economic impact in terms of social prices cost is C/B = 0.94, NPV is – 2.9 million soles and IIR is 9%. Therefore, it is concluded that the project's economic impact will not be positive.

(2) Cost of operation and maintenance

The annual cost of operation and maintenance required for the project, having as a base year 2008 is estimated at 263,000 soles, corresponding to 0.5% of the project construction cost. On the other hand, the average operating expenses for the last 4 years of the irrigation commissions was 2,463,008.

When considering that the annual operation and maintenance cost represents 10.75% of the annual irrigation commissions, the project would be sustainable enough according to the financial capacity of these committees to maintain and operate the constructed works.
As conclusion, this project is not economically viable; so, the project is not viable.

4.8 Environmental Impact

4.8.1 Procedure of Environmental Impact Assessment

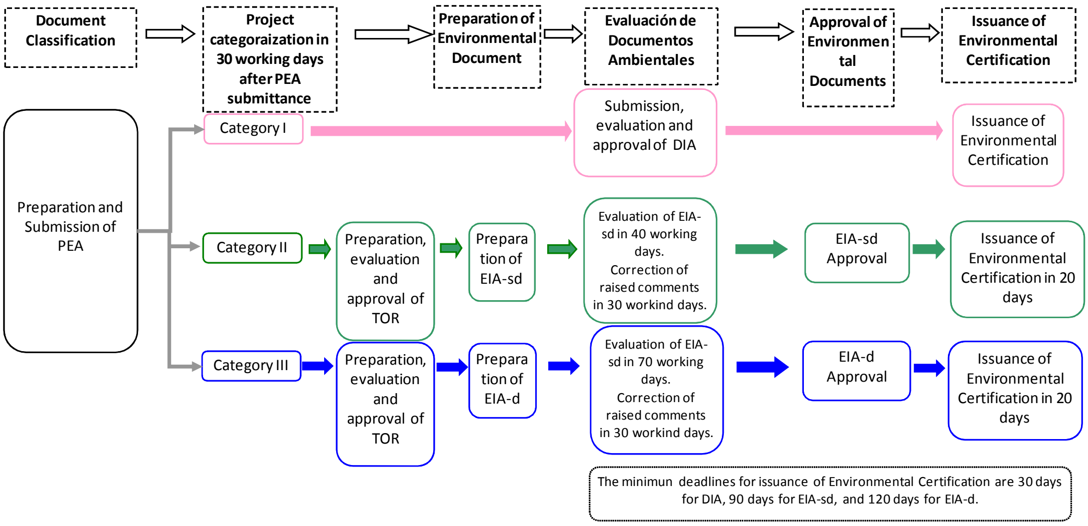
Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The following table shows the environmental management instruments that are required for each category. The Project holder 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 4.8.1-1 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 4.8.1-1 The 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 Chira river. EAP for the Chira river was submitted to DGIH from JICA on January 25, 2011. DGIH submitted it to DGAA on July 19, 2011.

EAP for Chira 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 Chira river in which DGAA classified Chira river into Category I. Therefore the additional environmental impact analysis for Chira 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. Table 4.9.1-2 described “working sites” to be considered in the Environmental Impact section for the 6 watersheds.

Table 4.8.1-2 Works Description

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Chira	1	0.0k-4.0k	Revetment	Crop land/ natural gas	Revetment	H; 2.0m Slope; 1:3 L; 4000m	0.0km～4.0km (left bank)
	2	11.75k-12.75k	Erosion	Road		H; 2.0m Slope; 1:3 L; 1,000m	11.75km～12.75km (right bank)
	3	24.5k-27.0k	Revetment	Crop land		H; 2.0m Slope; 1:3 L; 2,500m	24.5km～27.0km (right bank)
	4	64.0k-68.0k	Riverbed Excavation	Crop land	Riverbed excavation	Ex.width; 100m Ex. depth; 1.0m L; 1,000m	64.0km～68.0km (total)

Source: JICA Study Team

4.8.2 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 4.8.2-1 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 4.8.2-2 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

4.8.3 Identification, Description and Social Environmental Assessment

(1) Identification of social environmental impacts

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

Table 4.9.3-1 Impact Identification Matrix (Construction and Operation Stage) –Chira River Basin

Construction Stage			Work	1-4	1-4	1-4	4	1,4	1, 4	1-4	1-4	1-4	1-4	1-4		
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					4	0
		Cantidad de agua superficial							N			N			2	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 %

Operation Stage			Works	Dike Point 1,2,3	Riverbed without Silting Point 4	Total Negatives	Total Positives
Environment	Component	Environmental Factors					
Physique	Air	PM-10 (Particulate matter)				0	0
		Gas emissions				0	0
	Noise	Noise				0	0
	Soil	Soil fertility				0	0
		Land Use				0	0
	Water	Calidad del agua superficial				0	0
		Cantidad de agua superficial		P	P	0	2
	Physiography	Morfología fluvial		N	N	2	0
		Morfología terrestre				0	0
Biotic	Flora	Terrestrial flora				0	0
		Aquatic flora				0	0
	Fauna	Terrestrial fauna				0	0
		Aquatic fauna		N	N	2	0
Socio-economic	Esthetic	Visual landscape		P	P	0	2
	Social	Quality of life		P	P	0	2
		Vulnerability - Security		P	P	0	2
	Economic	PEA				0	0
		Current land use		P	P	0	2
Total				7	7	4	10
Percentage of positive and negative						29 %	71 %

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

In the Chira River watershed, according to the impact identification results for the building stage, a total of 64 interactions have been found, from which 62 (97%) correspond to impacts which effect will be perceived as negative and 2 (3%), which effects will be positive. We have to mention that from the 62 negative impacts, only 15 have been quantifiable as significant and

2 as very significant. To identify and obtain presented results of the impacts assessment in the construction stage of each one of the developed works of the Chira River the impact identification matrix was developed, where "P" means: Positive Impacts and N: Negative Impacts.

According to the results of impacts identification, in the operation stage a total of 14 interactions have been found, from which 4 (29%) correspond to impacts which effect is negative and 10 (79%), which effect is positive. It is worth mentioning that from the 4 negative impacts, only 2 have been significant and 2 as very significant. The calculation method is the same one as the applied for the construction phase, before mentioned.

During operation stage of hydraulic infrastructure that will cause that negative environment impacts that are more significant we can mention "riverbed excavation". This will cause a modification of river morphology and a reduction of the conditions of the river's habitability, which will directly impact the aquatic fauna.

More significant positive impacts are related to every building work in a river watershed and are directly related to improve the influence area population's life quality, improve the "current use of land" and improve the safety conditions and reduce vulnerability at social and environmental level.

(2) Environmental and Social Impact Assessments

In the next Table the environmental impact assessment results are presented, expressed in grades. The impact may be in building stage grouped according to type of works, and the impact after the operation entrance has been grouped according to areas.

In the Chira River Watershed 62 interaction were identified that may show negative impacts during construction stage, from which 15 are "strong" and 2 are "very strong." From the 6 interaction that may be negative impacts after being used, 2 are "strong" and 2 are "very strong."

During the construction stage, plot division, land leveling and other site preparation jobs may be negative to the local topography in all the project sites. After entering into service, it is foreseen that riverbed excavation that wants to be done in Chira-4 during construction will have a strong impact on river topography and aquatic fauna.

It is worth mentioning that in 4.8.5 "Monitoring and Control Management Plan" the prevention and mitigation measures will be analyzed as these interactions are "strong and very strong."

Table4.8.3-2 Environmental Impact Assessment Matrix – The Chira River Basin

			The Chira 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	Chi 1, 2 and 3	Chi 4
		Puntos de Obras: / Factores Ambientales	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1, 2, 3, 4	Chi 1, 2, 3	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4	Chi 1 - 4		
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
		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
	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
	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
		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
	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
		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	26.0	31.0
	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	-25.5	-30.5
		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
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
		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
	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
		Aquatic fauna	0.0	0.0	-12.0	-14.5	-22.5	0.0	-15.0	0.0	0.0	0.0	0.0	-25.5	-30.5
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
	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
		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
	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
		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

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

4.8.4 Socio-Environmental Management Plans

The objective of these plans is to internalize positive environmental impacts as significant and very significant negative impacts, linked to the project's building and operation stages. This in order to guarantee prevention and/or mitigation of significant and very significant negative impacts, environmental patrimony conservation and project's sustainability.

In the construction stage in all the Watersheds, the following measures have been set: "Local hiring Program", "Management and control of construction sites Program," "Channel deviation Program," "Management of excavation and fill banks", "Management of excavation and streams filling," "Quarry Management", "DME handling," "Camp rules and stay in work" and "Transportation activities' management." During the operation stages, the development of activities regarding "Management of streams and aquatic fauna" where conditioning to downstream of the intervention points actions to reduce erosion probability and provide habitability conditions for aquatic fauna species had been considered.

Next, the mitigation measures associated to the negative impacts that mitigate or the improving positive impacts. These environmental management plans for works points where significant or very significant negative impacts should be taken into account.

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

4.8.5 Monitoring and Control Plan

This plan has two types of activities:

1. Monitoring: are the verification activities of the set management measures
2. Control: Includes the monitoring and measurement activities for compliance of the environmental regulations like Environmental Quality Standards (ECA's) or Maximum Permissible Limits (LMA's). 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 5 watersheds, 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:

<u>Water Quality and Biological Parameters:</u>

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 4.8.5-1 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	°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

<u>Air Quality:</u>

During impact analysis, in the projects to be developed in the 5 watersheds 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 4.8.5-2 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

Noise Quality

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 4.9.4-3, the terms are described.

Table 4.8.5-3 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 4.8.5-4 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.

4.8.6 Budget for the environmental impact management

Next, direct costs for the environmental impact management measures previously mentioned according to watershed is detailed in the table.

Table 4.8.6-1 Direct costs of measures to manage environmental impact

Actions	Unit	Qty	Unitary price (S/.)	Subtotal (S/.)	Total (s/.)
Sign for vehicles entrance	Month	6	S/. 1.400,0	S/. 8.400,0	S/. 8.400,0
Industrial weaste transportation	Month	6	S/. 4.200,0	S/. 25.200,0	S/. 25.200,0
Project sites landscape protection measures	Month	6	S/. 2.800,0	S/. 16.800,0	S/. 16.800,0
Operation and maintenance of construction equipment	Month	6	S/. 1.960,0	S/. 11.760,0	S/. 11.760,0
Measures for staff noise protection	Month	6	S/. 1.120,0	S/. 6.720,0	S/. 6.720,0
Functioning expenses to implement environmental impact mitigation measures	Month	6	S/. 4.480,0	S/. 26.880,0	S/. 26.880,0
Soil and air contaminant prevention capacity development	Month	6	S/. 2.520,0	S/. 15.120,0	S/. 15.120,0
Bed and aquatic fauna monitoring					S/. 11.239,2
Diversity indicators monitoring	times	3	S/. 672,0	S/. 2.016,0	
Water flow monitoring	times	3	S/. 588,0	S/. 1.764,0	
Tº, pH, OD monitoring	times	3	S/. 571,2	S/. 1.713,6	
DBO monitoring	times	3	S/. 638,4	S/. 1.915,2	
Total solids dissolve monitoring (SDT)	times	3	S/. 638,4	S/. 1.915,2	
Total suspended solids monitoring (SST)	times	3	S/. 638,4	S/. 1.915,2	
Air and noise quality monitoring					S/. 37.500,0
Gas emissions monitoring	times	3	S/. 4.500,0	S/. 13.500,0	
Dust monitoring	times	3	S/. 5.000,0	S/. 15.000,0	
Noise monitoring	times	3	S/. 3.000,0	S/. 9.000,0	
Total					S/. 159.619,2

4.8.7 Conclusions and Recommendations

(1) Conclusions

According to the Preliminary Environmental Assessment regarding impacts on construction and operation stage, most of the identified impacts are characterized by mild significance. The ones with significant and very significant negative impacts are controllable or mitigated; always that the Environmental Management Plans are performed properly.

Also, significant positive impacts exist, especially in the operation stage. These are: safety improvement and vulnerability reduction of social and environmental levels, improvement of the life quality of the influence area population and enhancing the "current land use."

(2) Recommendations

1) Starting construction works in the dry season is recommended

Meanwhile, Chira River keeps its flow along the year (with season variations). It is important to develop the work's implementation schedule taking into account the area's agricultural cycle, since many of the sites are located near agricultural lands. In this way, the impact of local residents that have to transport agricultural machinery and crops can be minimized.

2) About ecosystem impact, it is important to take into account that to Chira River, during flood season between November until March, flamingos arrive, although in little amount. The impact on these birds may be mitigated by avoid performing works during this season.

3) About land topic, the following measures must be taken into consideration in case it is not clear in which parts the works will be executed. The DGIH of MINAG, as executor of the Project, shall: ① clearly define the stages of the project, immediately after E/F, and ② identify land and users included in these lands that will be used in the Project. Afterwards, the necessary lands will have to be obtained fulfilling the set procedures in the Expropriation General Regulation. In case the land is owned by the community, it must be negotiated with the correspondent local community and achieve consensus.

4) For procedures related to cultural heritage conservation, DGIH must obtain CIRA before starting the Project, fulfilling the procedures provided for such purpose, immediately after E/F is completed.

5) Regarding to gender, so far it has been noted that there has been a certain percentage of women participating in the activities of the irrigation commissions, but not in the capacity building workshops. Therefore, it is necessary to take some steps to promote women's participation within the components of this Project. For example, bearing in mind that there are several groups of women in the Project's Watersheds, women can be summoned in the workshops that are organized by these groups. It is also necessary to consider women's working hours and choose dates and times that they are easy for them to participate.

6) Finally, the actions to be taken in order to let DGIH obtain the necessary environmental license for the Project are indicated. On April 2011, DGAA-MINAG evaluates EAP report to determine the status of the Project. In case, it is classified as Category I, the environmental license shall be issued.

4.9 Execution Plan

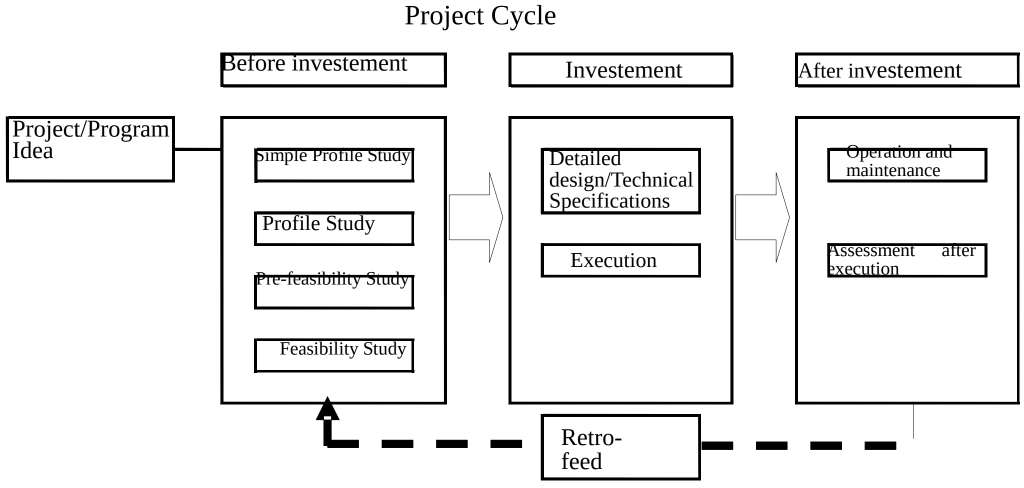
The Project's Execution Plan will review the preliminary schedule, which includes the following components. For pre-investment stage: ① full execution of pre-feasibility and feasibility studies to obtain SNIP's approval in the pre-investment stage; for the investment stage: ② signing of loans (L/A), 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.

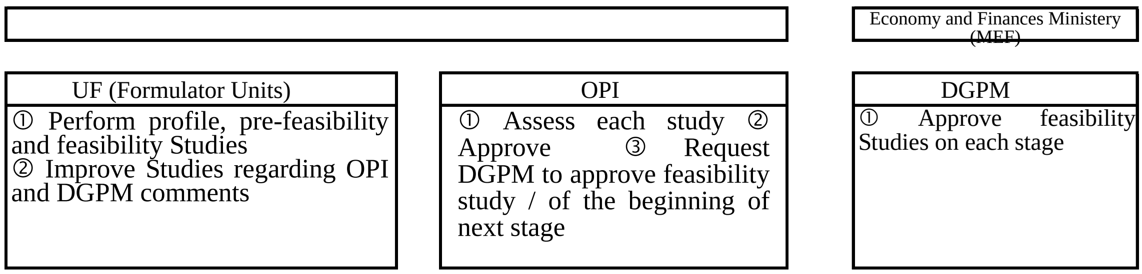


(Source: DGPM HP)

Figure 4.9-1 SNIP Cycle Project

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 quite different in each stage, in SNIP procedures, the project's training unit (UF) conducts studies of each stage, the Planning and Investment Office (OPI) assesses and approves the UF's presented studies and requests Public Sector Multi-Annual Programming General Direction (hereinafter referred DGPM) to approve feasibility studies and initiation of following studies. Finally DPGM evaluates, determines and approves the public investment's justification.



(See Regulation No.001-2009-EF/68.01.)

Figure 4.9-2 Related Institutions to SNIP

Due to the comments of examining authorities (OPI and DGPM) to FU, 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.

(2) Yen loan contract

Once the feasibility studies reports are submitted and examined in SNIP, discussions on the loan in yen will begin. It is estimated to be a period of 6 months for procedures.

(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 development of detailed design and technical specifications, the contractors' selection and the work's supervision. Table 4.9-1 presents the Project's overall schedule.

1) Consultant selection: 3 months, builder selection: 3 months
2) Develop detailed design and technical specifications of the work's period

① River and re-forestation works along these works

Detailed design and technical specifications elaboration: 6 months
Working Period: 2 years

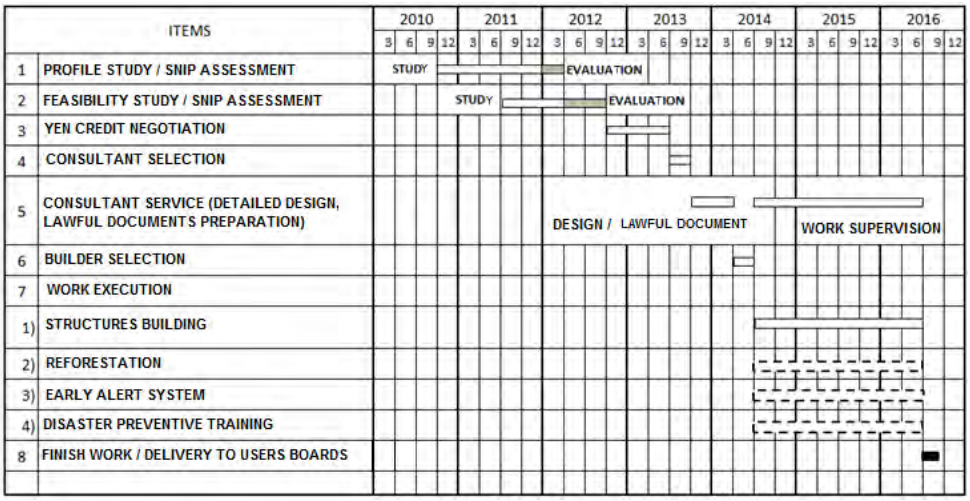
② Alarm system for Chira River

It will be executed in the same period of fluvial installation works
Detailed design and technical specifications elaboration: 6 months
Working Period: 2 years

②Capacity Building

It will be executed on the same work period of river facilities.
Detailed design and technical specifications elaboration: 6 months
Working Period: 2 years

Table 4.9-1 Implementation Plan



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:

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 DGIH project management is dedicated to calculate project costs, detail design and supervision of the works execution. The study direction conducts studies for projects and planning formation

＊ The Planning and Investment Office (IPO) 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 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 (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 DGPM 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 DNEP from the Economy and Finance Ministry and

OGA-MINAG

＊The Public Debt National Direction (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, the investment stage (Project execution) corresponds to PSI from MINAG. The PSI is currently performing JBIC projects, etc. and in case of beginning a new project, it forms the correspondent Project Management Unit (UGP), who is responsible of choosing the consulting firm, hire construction services, works supervision, etc. The following figure describes the structure of the different entities involved in the Project’s execution stage.

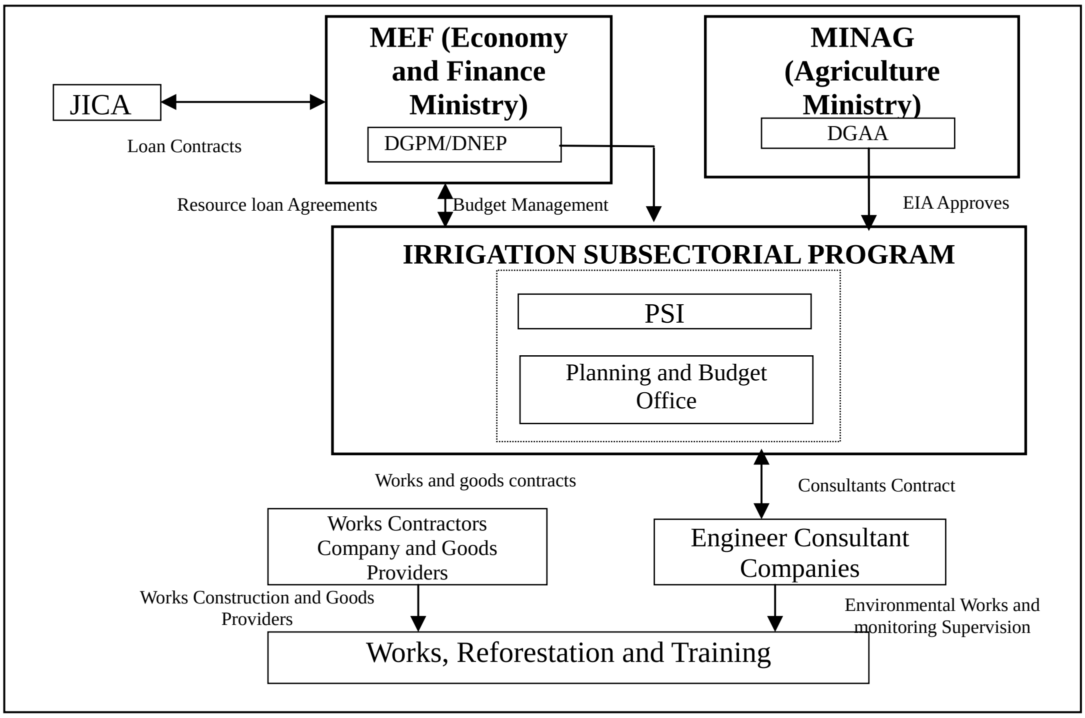


Figure 4.10-1 Related institutions to the Project's execution (investment stage)

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. Likewise, they should pay the construction costs in credits mode. Next, the relationship of different organizations involved in post-project implementation stage is detailed.

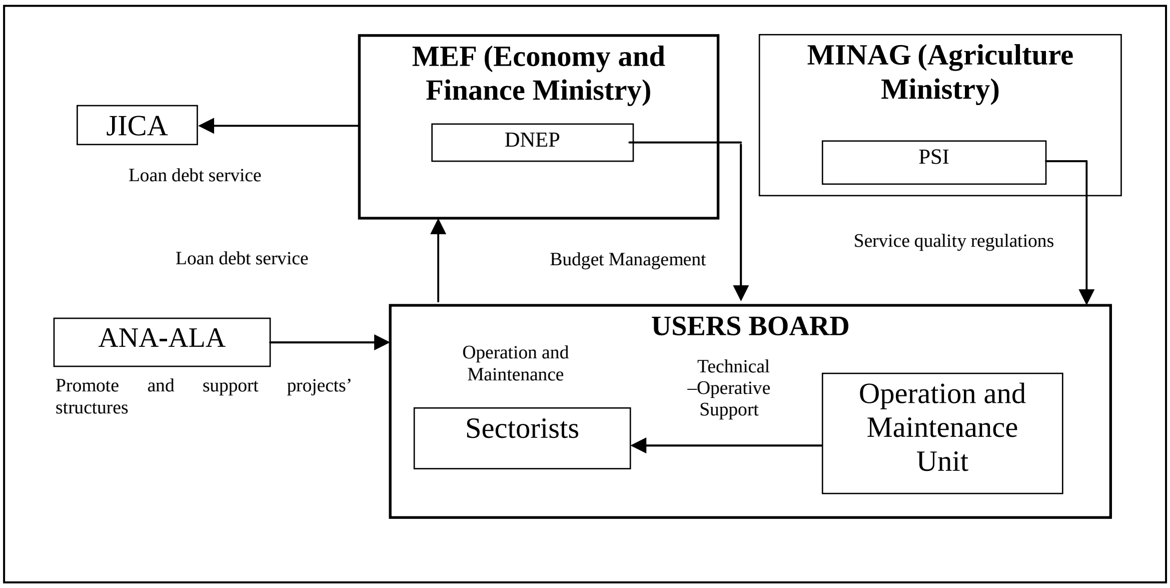


Figure 4.10-2 Institutions related to the Project (operation and maintenance stage)

(2) 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 conformed 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:

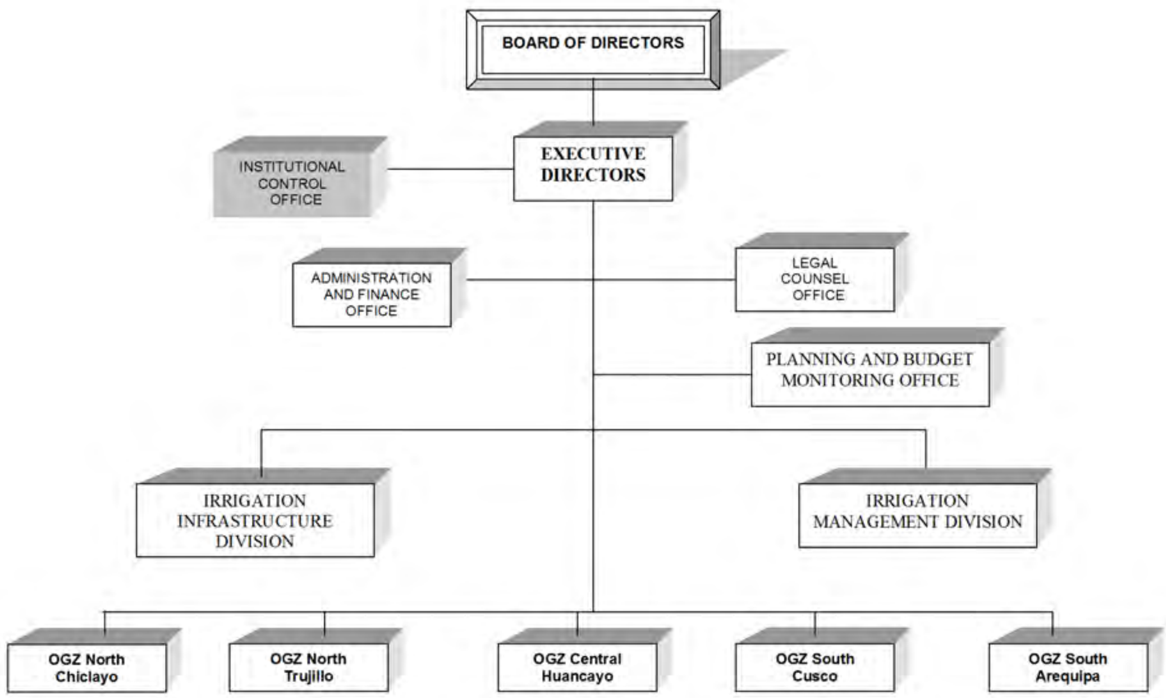


Figure 4.10-3 Organization of PSI

4.11 Logical framework of the eventually selected option

In Table 4.11-1 the logical framework of the definite selected option is shown.

Table 4.11-1 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	Scio-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 areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, bank erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, bank erosion progress and watershed's downstream erosion.	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, road damages prevention, construction of 28 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			
B-1 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

B-2 Early alert system	Installed equipments, operational state, emitted alerts state, emitted alerts frequency and information transmission state	Work advance reports, public entity and local community monitoring	Equipment adequate functioning, appropriate staff training, communication and promotion, equipment and programs O & M
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

4.12 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.

4.12.1 Flood Control General Plan

There are several ways to control floods in the entire watershed, for example building dams, retarding basins, dikes or a combination of these.

The option of building a dam is not viable, because there is one, Poechos Dam in the upper watershed of the Chira River and downstream of the dam a flooded plain spreads widely.

It is also not viable to build a retarding basin because in order to reduce the maximum flood flow with 50 years return period for 10 years, it is required a 1.5 million m^3 reservoir. Most of the area downstream Poechos dam is occupied by crops and there is no place to build a reservoir. So, we are discharging the idea of building a retarding basin.

Therefore, we will focus our study in the construction of dikes 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 transversal survey results of the river, which results are shown in Table 3.1.10 and Figure 3.1.10-3.

2) Overflowing characteristics

Overflowing analysis of each River was performed. In Table 3.1.10 and in Figure 3.1.10-9 the overflow condition for flows with probabilities of 50 years is shown. This River is characterized because of its lack of discharge capacity, water overflows in every section, flooding lower lands and flat lands along the river.

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, and the dike’s standard section will be determined as already mentioned in section 4.3.1,(5), 1). In Table 4.2-2, 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 4.12.1-1 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 slow water.

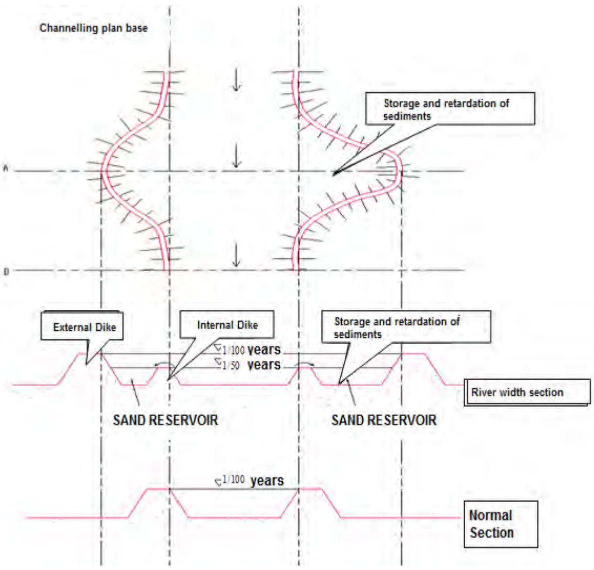


Figure 4.12.1-1 Definition of dike alignment

5) Plant map and River section

In Figures 4.12.1-2 and -4.12.1-3 the plan and longitudinal section of the Chira River is shown.

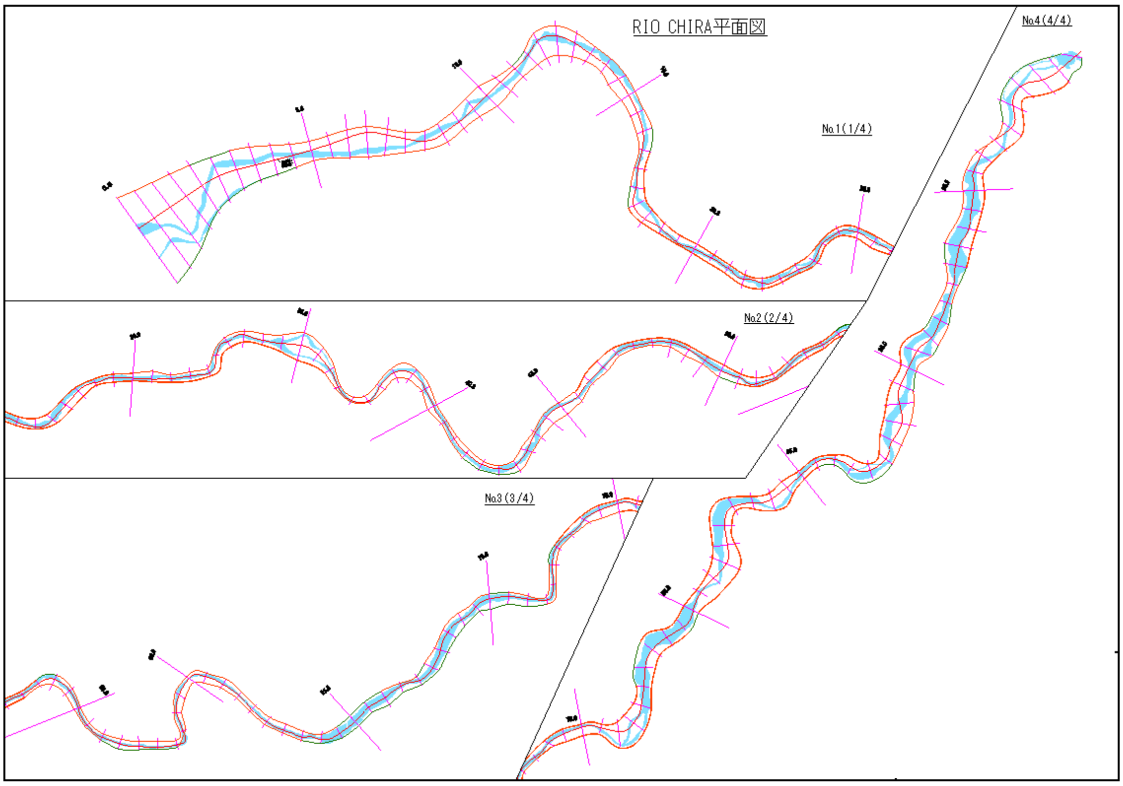


Figure 4.12.1-2 Plan of Chira River

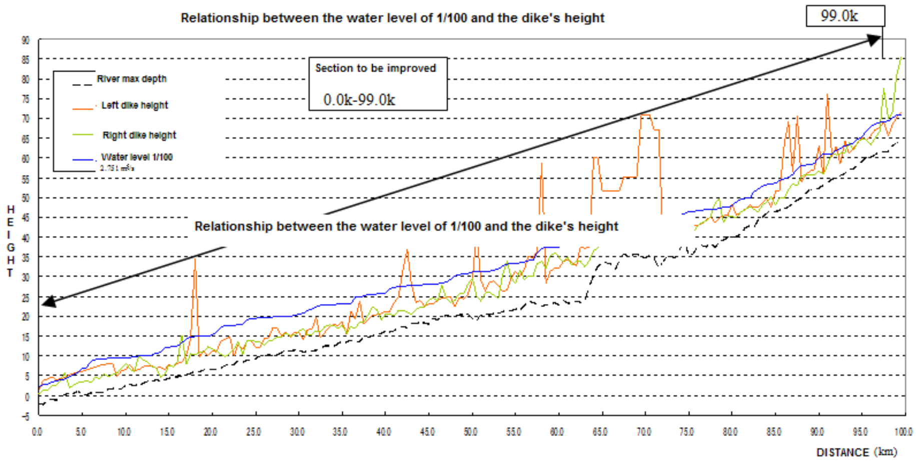


Figure 4.12.1-3 Chira River Longitudinal Profile

6) Dike's construction plan

Next, basic policies for the dike's construction plan on the Yauca 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 4.12.1-1 and Figure 4.12.1-4 show the dike's construction plan on the Chira River

Table 4.12.1-1 Dike's Construction Plan

River	Sections to be improved		Dike missing heigth average (m)	Dike proposed size	Dike length (km)
Chira	Left bank	0,0k-99,0k	3,80	Dike heigth = 4,0m Bank protection works heigth = 4,0m	77,5
	Right bank	0,0k-99,0k	4,17		89,5
	Total		4,00		167

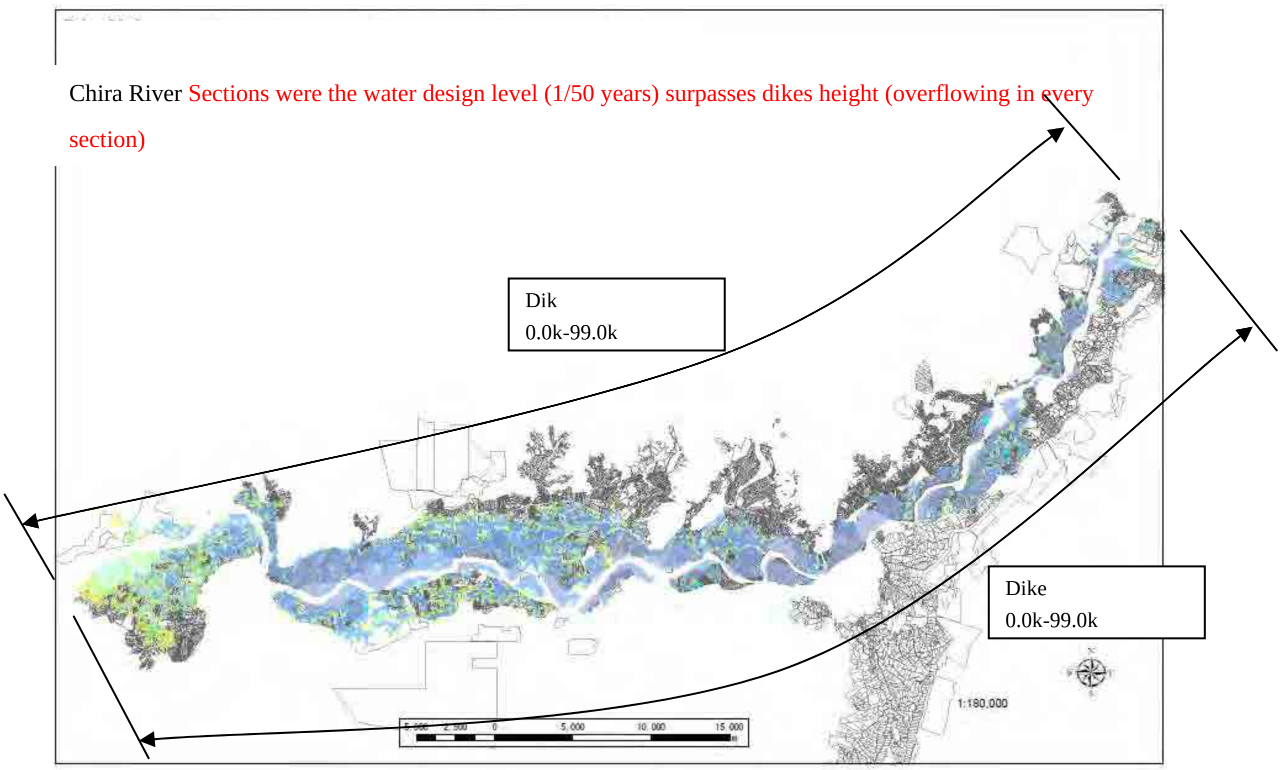


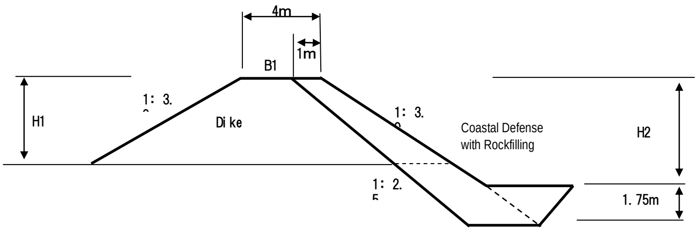
Figure 4.12.1-4 Chira River dike construction works approach

7) Project Cost

In Tables 4.12.1-2 and 4.12.1-3 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 4.12.1-4.

Table 4.12.1-2 Direct works' cost (at private prices)

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 (in soles)	Work direct cost/m (in soles)	Work direct cost/km (in thousand soles)	Dike length (km)	Work direct cost (in thousand soles)
Chira	Dikes	56.0	m3	10.0	560.0	560.0	167.0	93,520.00
	Margin Protection	20.1	m3	100.0	2014.1	2014.1		336,348.40
Total					2,574.10	2,574.10		429,868.40

Table 4.12.1-3 Projects' Cost (at private prices)

Nombre de la Cuenca 流域名	Direct Cost			Indirect Cost									Total Project Cost 構造物･事業費
	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)		(12) = (8)+(9)+(10)+(11)
CHIRA	429,868,400	42,986,840	472,855,240	70,928,286	47,285,524	591,069,050	106,392,429	697,461,479	6,974,615	34,873,074	69,746,148		809,055,316

Table 4.12.1-4 Projects' Cost (at social prices)

Watershed 流域名	SOCIAL PRICES COSTS											
	DirectCost(直接工事費)			INDIRECT COST (間接工事費)								HYDRAULIC INFRASTRUCTURE Total Cost
	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical FIle 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	構造物･事業費 (12) = (8)+(9)+(10)+(11)
CHIRA	345,614,194	34,561,419	380,175,613	57,026,342	38,017,561	475,219,516	85,539,513	560,759,029	5,607,590	28,037,951	56,075,903	650,480,474

2) Operation and Maintenance Plan

The operation and maintenance cost was calculated identifying the trend of the sedimentation and erosion bed 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 gathering 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) Bed variation analysis

Figure 4.12.1-5 shows the results of the Bed variation analysis of the Chira River for the next fifty years. From this figure a projection of the bed's sedimentation and erosion trend and its respective volume can be made.

2) Sections that need maintenance

In table 4.12.1-5 possible sections that require a process of long-term maintenance in the Chira River watershed is shown.

3) Operation and maintenance cost

Next the direct work cost at private prices for maintenance (bed excavation) required for each watershed in the next 50 years is shown.

Direct Work Cost

At private prices: 2,500.000 m^3 x 10 soles =25,000 soles

Tables 4.12.1-6 and 4.12.1-7 show a 50 year Project cost at private and social prices.

Table 4.12.1-5 Sections which bed must be excavated in a programmed way

River	Excavation extension		Maintenance method
Chira	1 section	Section：64,0km-68,0km Volume：2.500.000m^3	It is considered necessary to periodically eliminate sediments that gather upstream Sullana dam. Since it will be impossible to get rid of all sediments due to their large amount, we will be more focused on the immediate upper part of the dam because it is more important

* Volume of sediments that will gather in 50 years

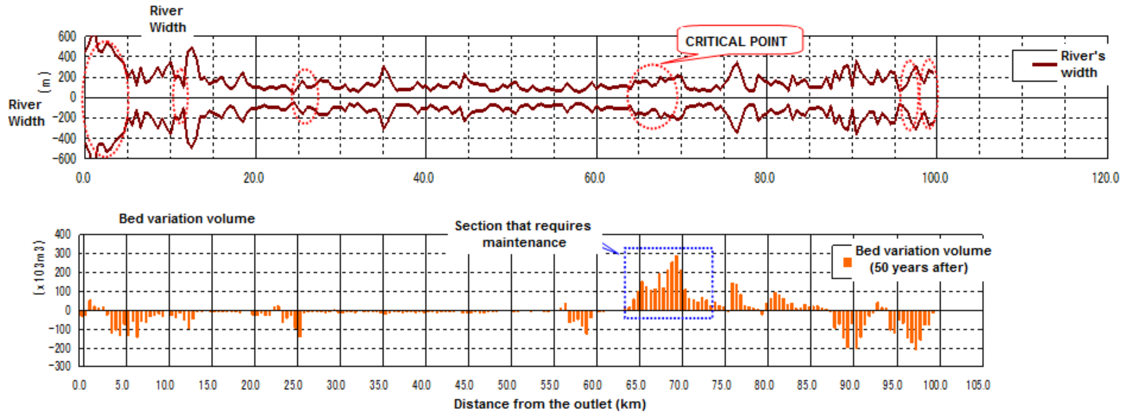


Figure 4.12.1-5 Section that requires maintenance (Chira River)

Table 4.12.1-6 Excavation Works cost for a 50 year bed (at private prices)

Watershed 流域名	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical FIle 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	Total Cost 事業費 (12) = (8)+(9)+(10)+(11)
CHIRA	25,000	2,500	27,500	4,125	2,750	34,375	6,188	40,563	406	2,028	4,056	47,053

Table 4.12.1-7 Excavation Works cost for a 50 year bed (at social prices)

Watershed 流域名	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Correction Factor 修正係数 fc	Works Total Cost 建設費 (9) = fc*(8)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical FIle 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	Total Cost 事業費 (13) = (9)+(10)+(11)+(12)
チラ川	25,000	2,500	27,500	4,125	2,750	34,375	6,188	40,563	0.804	32,612	326	1,631	3,261	37,830

(3) Social Assessment

1) Private prices cost

i) Damage amount

Table 4.12.1-8 shows the damage amount calculated analyzing the overflow caused by floods in the Chira River with return periods between 2 and 50 years.

Table 4.12.1-8 Amount of damage for floods of different return periods (at private prices)

Damage Amount (1,000 soles). 被害額（千ソーレス）	
year	Chira
2	0
5	349,698
10	427,001
25	485,714
50	562,385

ii) Damage reduction annual average

Table 4.12.1-9 shows the damage reduction annual average of each watershed calculated with the data of Table 4.12.1-8.

iii) Project's Cost and the operation and maintenance cost

Table 4.12.1-3 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 4.12.1-6.

iv) Economic evaluation

In Table 4.12.1-10 the results of economic assessment are shown.

Table 4.12.1-9 Damage Reduction Annual Average

民間価格:流域全体 (Precios Privados para las cuencas en su TOTALIDAD)

流域 Basin	流量規模 Return period	超過確率 Probability	被害額 (Total damage – miles de S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②	区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	349,698	0	349,698	174,849	0.300	52,455	52,455
	10	0.100	427,001	0	427,001	388,349	0.100	38,835	91,290
	25	0.040	485,714	0	485,714	456,357	0.060	27,381	118,671
	50	0.020	562,385	0	562,385	524,049	0.020	10,481	129,152

Table 4.12.1-10 Economic assessment results (private prices costs)

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
Chira	1,678,976,217	758,192,379	809,055,316	59,450,746	1.03	23,878,182	11%

2) Social prices cost

i) Damage amount

Table 4.12.1-11 shows the damage amount calculated analyzing the overflow caused by floods with return periods between 2 and 50 years in each watershed.

Table 4.12.1-11 Amount of damage for floods of different return periods (at social prices)

Damage Amount (1,000 soles). 被害額(千ソーレス)	
year	Chira
2	0
5	407,180
10	494,866
25	563,929
50	649,089

ii) Damage reduction annual average

Table 4.12.1-12 shows the damage reduction annual average of each watershed calculated with the data of Table 4.12.1-11.

iii) Project's Cost and the operation and maintenance cost

Table 4.12.1-4 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 4.12.1-7.

iv) Economic assessment

In Table 4.12.1-13 the results of economic assessment are shown.

Table 4.12.1-12 Damage Reduction Annual Average

社会価格									
流域 Basin	流量規模 Return period	超過確率 Probability	被害額 (Total damage – miles de S/.)			区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
			事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②				
CHIRA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	407,180	0	407,180	203,590	0.300	61,077	61,077
	10	0.100	494,866	0	494,866	451,023	0.100	45,102	106,179
	25	0.040	563,929	0	563,929	529,397	0.060	31,764	137,943
	50	0.020	649,089	0	649,089	606,509	0.020	12,130	150,073

Table 4.12.1-13 Economic assessment results (social prices costs)

流域名	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
Chira	1,950,952,864	881,011,642	650,480,474	47,798,400	1.49	290,623,028	18%

(4) Conclusions

The economic assessment result shows that the Project has positive economic impact in terms of cost on both private and social prices, but the required cost at private price is extremely high (809.1 million soles), so, this Project is not viable to be adopted for this Project.

4.12.2 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

① 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

② Forestry area: means forestry in areas with planting possibilities around watersheds with water sources or in areas where forest area has decreased.

③ Forestry method: local people plantations. Maintenance is done by promoters, supervision and advisory is leaded by NGOs.

④ 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

⑤ 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

(Existing Chira River Watershed Reforestation Project): Currently the Catamayo – Chira Binational Project is being held based on the cooperation study among Ecuador and Peru. This Project includes some actions on soil conservation and water reserve forests. It is being implemented with the financing support of Spain (70%), Peru (15%) and Ecuador (15%), which also includes a reforestation component. The selected area for reforestry and forest conservation of this project is mainly the important areas of water charge, which match the reforestation component of this Project and it is not considered pertinent to invest efforts where there are donors acting already.

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 11 years to reforest from the Chira River Watershed (upper and lower watersheds).

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 Chira River Watershed, as well as the execution cost, according to this estimate, the area to be reforested is approximately 35,000 hectares. The required period is 9 years, and the cost is calculated in 95.2 million nuevos soles. In other words, investing a great amount of time and money is required to reforest.

Table 4.12.2-1 Upstream Watershed Forest General Plan

Watershed	Surface to reforest (ha)	Time Required (years)	Cost required (soles)
Chira lower watershed	7,442	2	20,086
Chira upper watershed	27,835	9	75,130
Total	35,277	—	95,216

(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 9 years and invested 95.2 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.

4.12.3 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 4.12.3-1 the sediment control works disposition proposed to be executed throughout the watershed is shown. The cost of Chira 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. The results are shown in Table 4.12.3-1.

Due to the Chira 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 4.12.3-1 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/.)		
Chira	Toda la cuenca	0	S/.0	0	S/.0	272	S/.423	S/.423	S/.796
	Tramo prioritario	0	S/.0	0	S/.0	123	S/.192	S/.192	S/.361

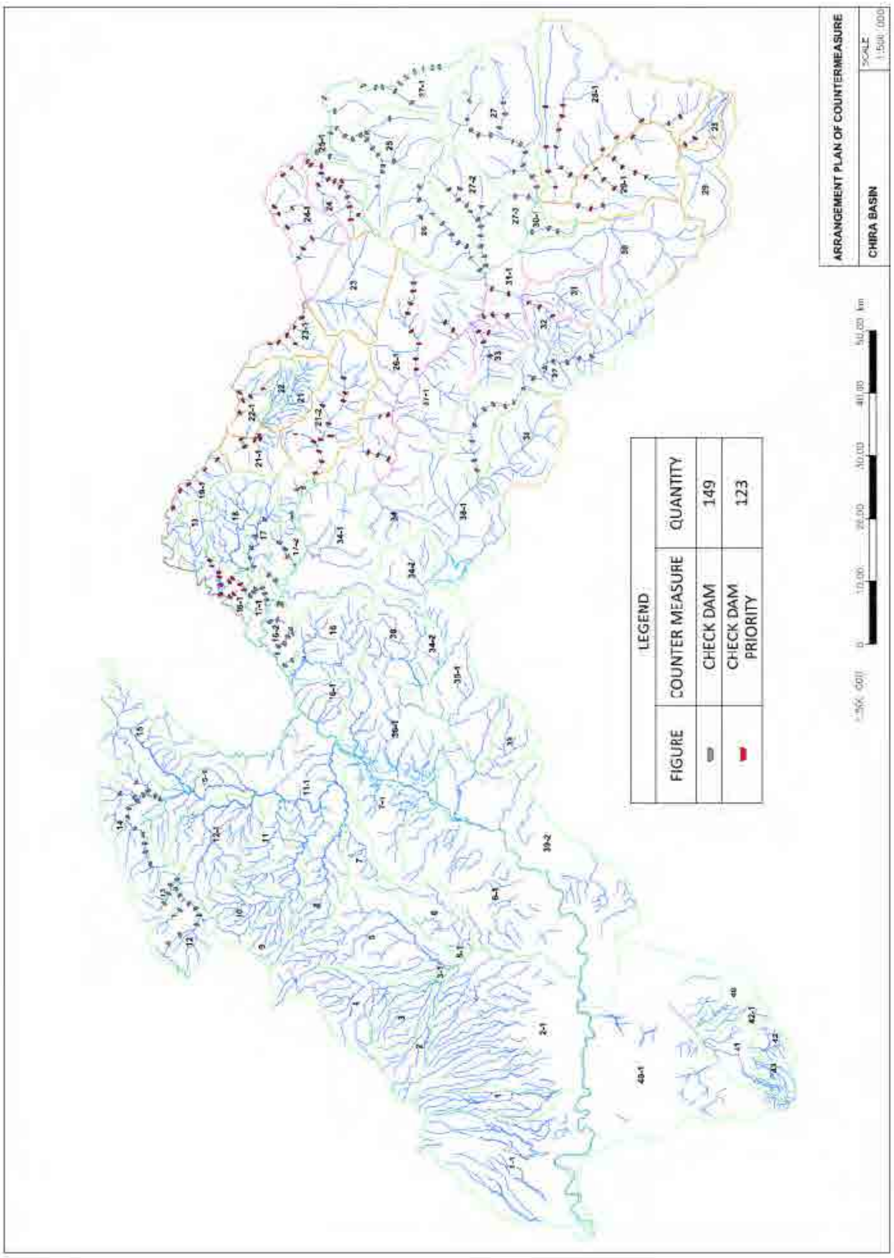


Figure 4.12.3-1 Sediment control works location on Chira River Watershed

5. CONCLUSIONS

The selected alternative for flood control in this Study is structurally safe and the environmental impact is small. However the social evaluation shows the low viability of the Project so that it is difficult to adopt this Project.

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
PRE-FEASIBILITY STUDY REPORT
II-3 PROJECT REPORT (CAÑTE RIVER)

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.

Composition of Final Report

I. Feasibility Study Report

I-1 Program Report

I-2 Project Report (Cañete River)

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

Annex – 6 Sediment Control

Annex – 7 Afforestation and Vegetation Recovery Plan

Annex – 8 Plan and Design of Facilities

Annex – 9 Construction Planning and Cost Estimate

Annex – 10 Socio-economy and Economic Evaluation

Annex – 11 Environmental and Social Considerations/ Gender

Annex – 12 Technical Assistance

Annex – 13 Stakeholders Meetings

Annex – 14 Implementation Program of Japanese Yen Loan Project

Annex－15 Drawings

I-7 Data Book

II. Pre- Feasibility Study Report

II-1 Program Report

II-2 Project Report (Chira River)

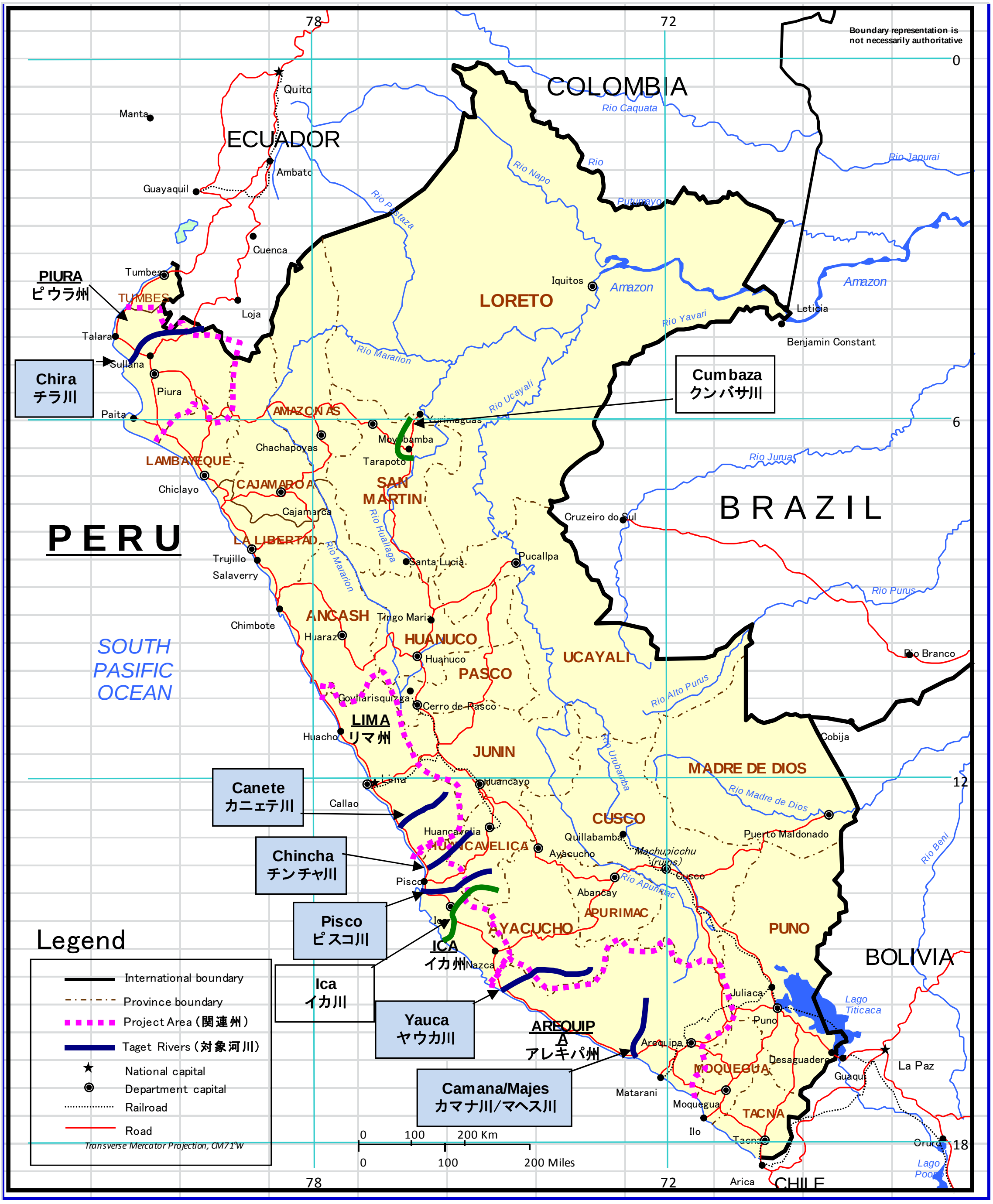
II-3 Project Report (Cañete River) (This Report)

II-4 Project Report (Chincha River)

II-5 Project Report (Pisco River)

II-6 Project Report (Yauca River)

II-7 Project Report (Majes-Camana River)



Location Map

(dark blue line)	Objective Study Basin
(green line)	Excluded Study Basin

Abbreviation

Abbreviation	Official Name or meaning
ANA	Water National Authority (Autoridad Nacional del Agua)
ALA	Water Local Authority (Autoridad Local del Agua)
C/B	Cost-Benefit relation (Cost-Benefit Ratio)
GDP	PBI (Producto Bruto Interno) (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)
DGPM	Dirección General de Programación Multianual del Sector Público (Public Sector Multiannual Program General Direction)
DNEP	Dirección Nacional de Endeudamiento Público (Public Indebtedness National Direction)
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)
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

ON

PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOODS IN THE REPUBLIC OF PERU

FINAL REPORT
PRE-FEASIBILITY STUDY REPORT
II-3 PROJECT REPORT
(CAÑETE RIVER)

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 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) 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

1.5 Non-structural measures

1.5.1 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 4.12 "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 narrowing of the river by the presence of obstacles, using vegetation strips between the river and the elements to be protected.
- Methodology: Create vegetation stripes of a certain width between the river and river structures.
- Execution of works: Plant vegetation on a portion 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, 3.4 km y 3.7 ha respectively.

1.5.2 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 4.12 "Medium and long term plan". 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.

The Watershed Plantanal, was built in Cañete River watershed last year, which retains dragged sediments. This will lead that the amount of sediments that dragged to the lower watershed will be reduced drastically and the impact that will happen to the river on the inferior section will be almost null. Due to which, it is considered not necessary to take a special measure to control sediments.

1.6 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

1.7 Costs

In the Table 1.7-1 the costs of this Project in Cañete watershed is shown. The cost of the watersheds is around 30.5 million soles.

Table 1.7-1 Project cost

(1,000 soles)

Watershed	Structural Cost					Non-structural cost		Technical Assistance Cost	Total
	Construction Cost	Detail Design Cost	Construction Supervision Cost	Environmental Cost	Sub total	Afforestation Cost	Flood Alert System Cost		
Cañete	21,902	1,095	2,190	219	25,406	40	0	219	25,666

1.8 Social Assessment

(1) Benefits

The benefits of flood control are the reduction of losses caused by floods which would be achieved by the implementation of the project and is determined by the difference between the loss amount without project and with project. Specifically, to determine the benefits, first the amount of losses by floods is calculated from different return periods (between 2 and 50 years), assuming that flood control works will last 50 years, and then the average annual reduction loss amount is determined from the reduction of losses from different return periods. In Tables 1.8-1 and 1.8-2 show the average anual amount of reduction loss that would be achieved by implementing this project, expressed in costs at private prices and costs at social prices.

Table 1.8-1 Annual average damage reduction amount (at private prices)

s/1000

流域 Basin	流量規模 Return period	超過確率 Probability	被害額 (Total damage – miles de S/.)			区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
			事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,660	153	1,507	754	0.500	377	377
	5	0.200	6,068	832	5,236	3,372	0.300	1,012	1,388
	10	0.100	73,407	8,413	64,994	35,115	0.100	3,512	4,900
	25	0.040	98,357	11,776	86,581	75,787	0.060	4,547	9,447
	50	0.020	149,018	16,428	132,589	109,585	0.020	2,192	11,639

Table 1.8-2 Annual average damage reduction amount (at social prices)

s/1000

流域 Basin	流量規模 Return period	超過確率 Probability	被害額 (Total damage – miles de S/.)			区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
			事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,582	272	2,311	1,155	0.500	578	578
	5	0.200	10,558	1,024	9,534	5,922	0.300	1,777	2,354
	10	0.100	105,137	9,908	95,229	52,382	0.100	5,238	7,593
	25	0.040	144,972	14,260	130,712	112,971	0.060	6,778	14,371
	50	0.020	213,134	20,117	193,018	161,865	0.020	3,237	17,608

(2) Social assessment results

The objective of the social assessment in this study is to evaluate the efficiency of investments in the structural measures using the method of cost-benefit relation (C/B) from the point of view of national economy. To do this, we determined the economic evaluation indicators (C/B 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.

In Tables 1.8-3 and 1.8-4 the costs at private prices and at social prices resulting from this project assessment are shown. It is noted that the project will have enough economic effect.

Table 1.8-3 Social Assessment (at private prices)

流域名	年平均被害軽減額 Gathered Average Annual Benefit	評価期間被害軽減額(15年) Gathered Average Annual Benefit (in 15 years)	事業費 Project Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) Valor Actual Neto (VAN)	Internal Rate of Return (IRR) Tasa Interna de Retorno (TIR)
Cañete	151,304,096	68,325,931	25,665,970	1,423,638	2.96	45,266,114	36%

Table 1.8-4 Social Assessment (at social prices)

流域名	年平均被害軽減額 Gathered Average Annual Benefit	評価期間被害軽減額(15年) Gathered Average Annual Benefit (in 15 years)	事業費 Project Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) Valor Actual Neto (VAN)	Internal Rate of Return (IRR) Tasa Interna de Retorno (TIR)
Cañete	228,904,527	103,368,747	20,648,077	1,144,605	5.57	84,817,688	62%

Below are the positive effects of the Project that are 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.

- Contribution to increase from stable agricultural production income, relieving flood damage.
- 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.

1.9 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. Usually the central government (in this case, the DGIH) assumes 80%, the irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both 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.

(1) Profitability

We have seen that Cañete river watershed is sufficiently profitable and sustainable. The amount of investment required is estimated at S/ 25.7 million soles (cost at private prices), but the economic impact implementation of the Project in terms of costs at social prices is C/B = 5.57, IRR = 62% approx., and NPV = S/. 84.8 millions, indicating that it is an effective economic project.

(2) Operation and maintenance costs

The annual cost of operation and maintenance required for the project, having as base year 2008 is estimated at 109,511 soles, which corresponds to 0.5% of the construction cost of the project in the Cañete river watershed. On the other hand, the operating expenses average in the last four years of irrigation committees is 2,421,157 soles.

When considering that the annual cost of operation and maintenance represents 4.5% of the annual irrigation budget, the project would be sustainable enough because of the financial capacity of these committees to maintain and operate the constructed works.

Table 1.9-1 Irrigation committee's budget

Rivers	Annual Budget (Unit/ S)				
	2007	2008	2009	2010	Average of four years
Cañete	2.355.539.91	2.389.561.65	2.331339.69	2.608.187.18	2.421.157

1.10 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).

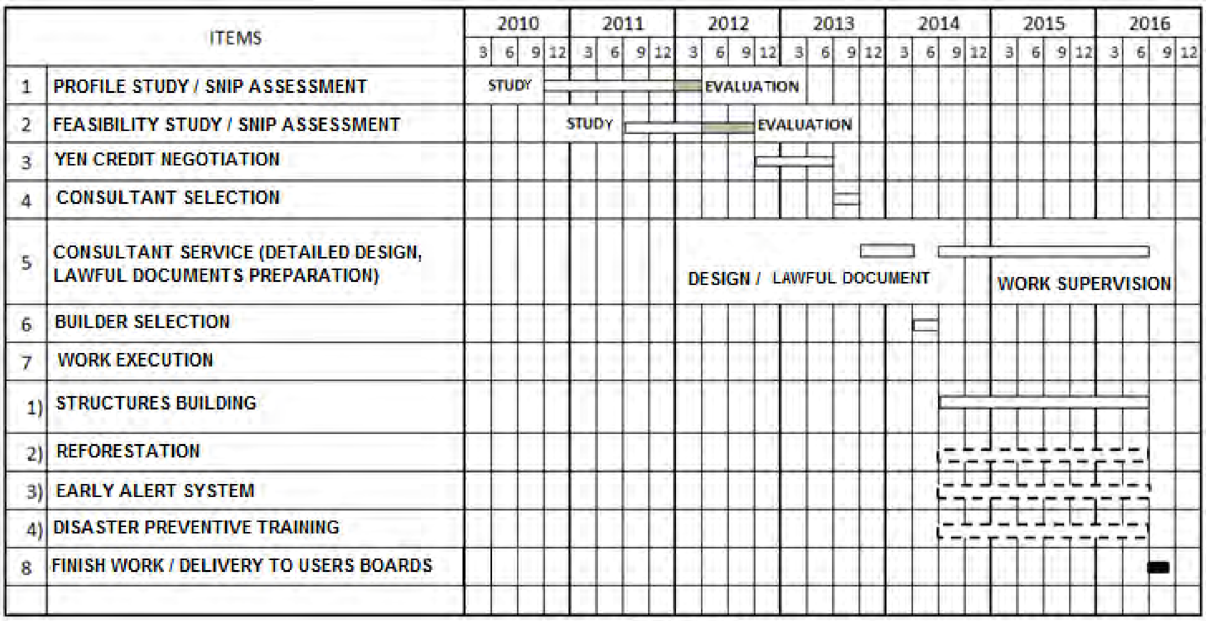
The EAP showed that the environmental impact would be manifested by the implementation of this project in the construction and maintenance stages, mostly, it is not very noticeable, and if it were, it can be prevented or mitigated by appropriately implementing the management plan environmental impact.

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.

1.11 Execution plan

Table 1.11-1 presents the Project execution plan.

Table 1.11-1 Execution plan



1.12 Institutions and management

The institutions and its administration in the investment stage and in the operation and maintenance stage after the investment, shown in the figures 1.12-1 and 1.12-2.

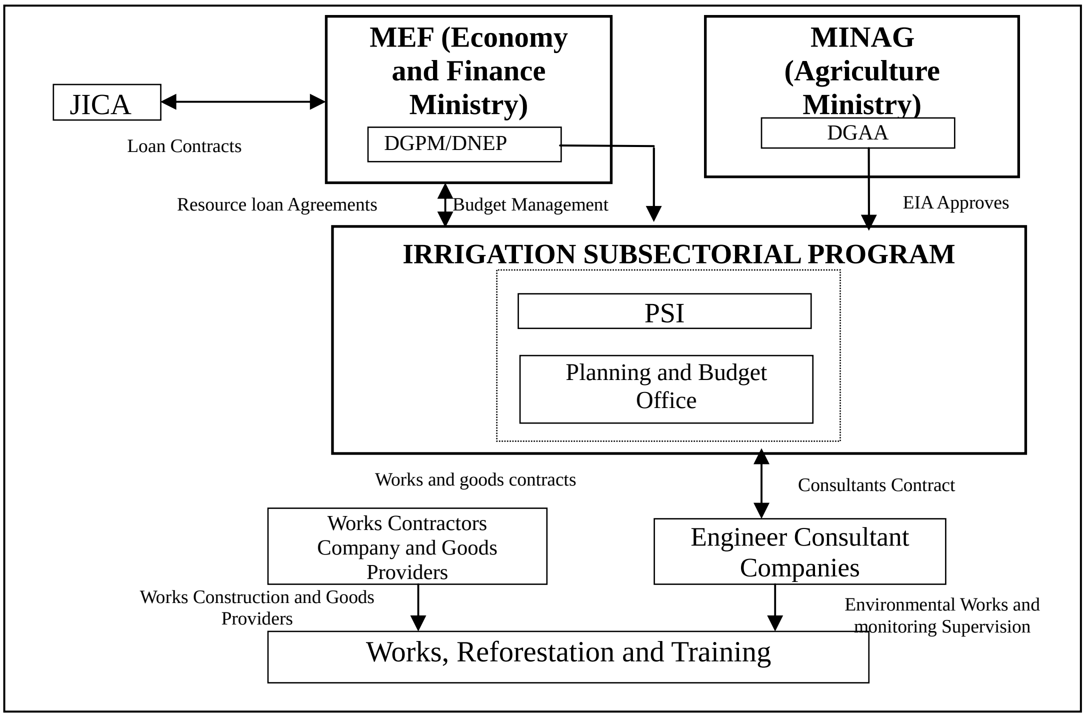


Figure 1.12-1 Institutions related to the project (investment stage)

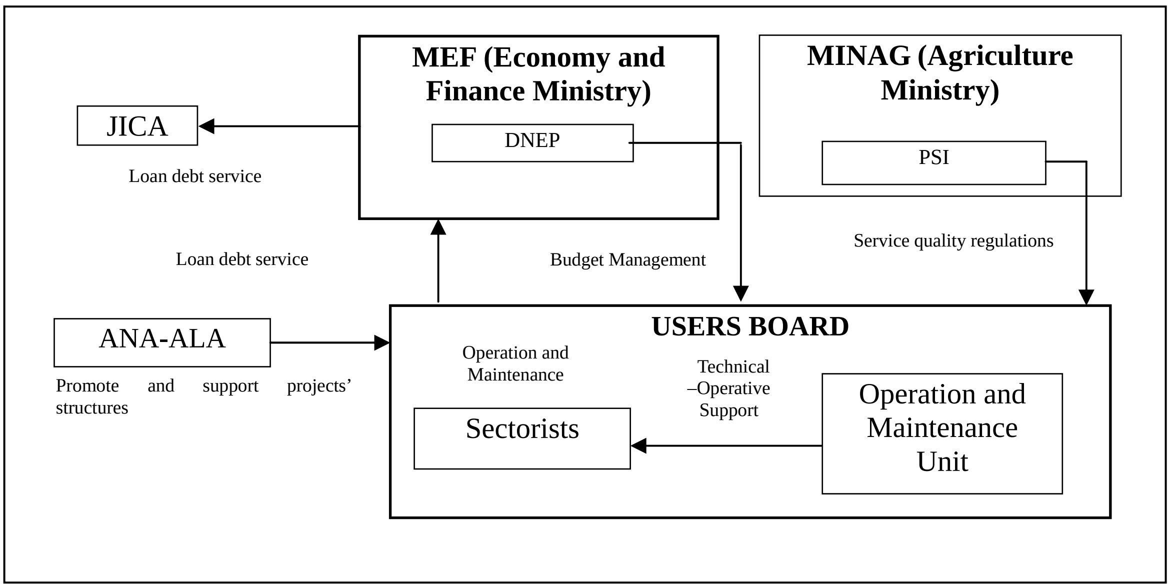


Figure 1.12-2 Institutions related to the project (operation and maintenance stage)

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	Scio-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 areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, bank erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, bank erosion progress and watershed's downstream erosion.	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, road damages prevention, construction of 28 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			
B-1 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)

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	171,269,615	77,341,963	104,475,371	8,236,962	0.81	-17,765,825	6%

Table 1.14-2 Project Cost and Social Assessment of the general flood control plan (social prices costs)

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	253,314,406	114,391,764	83,998,198	6,622,517	1.50	37,925,103	18%

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. 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.

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 its 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

Name: Hydraulic Infrastructure General Direction, Agriculture Ministry
Responsible: Orlando Chirinos Hernan Trujillo
General Director of the Water Infrastructure General Direction
Address: Av. Benavides N° 395 Miraflores, Lima 12 - Peru
Phone: (511) 4455457 / 6148154
Email: ochirinos@minag.gob.pe

(2) Executor Unit

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) Administration Office (OA)

- 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)

- 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)

Public Sector's Multiannual Programming General Direction (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 pre-feasibility 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 the Civil Defense National System. 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 this context, the central government has implemented El Niño phenomenon I and II contingency plans in 1997-1998, throughout the Agriculture and Livestock Ministry (MINAG) in order to rebuild water infrastructures devastated by this phenomenon. Next, the Hydraulic Infrastructure General Direction (DGIH) of the Agriculture Ministry (MINAG) began in 1999 the River Channeling and Collection 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 margin protection. In the multiyear PERPEC plan between 2007-2009 it had been intended to execute a total of 206 margin 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 punctual, without giving a full and integral solution to control floods. So, every time floods occur in different places, damages are still happening.

MINAG developed 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 help 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 draft from AOD of 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 Discussions Minutes (hereinafter “M/D”) that were signed on January 21 and April 16, 2010. This study was implemented on this M/D.

(2) Progress of Study

The Profile Study Report for this Project at Program’s level for nine watersheds of five regions has been 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) 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 going to be 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 an accurate pre-feasibility level and handed DGIH the Program Report of group A and the reports of the five watershed projects by late 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 received through 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 because they belong to a single watershed (Majes-Camana).

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 for the second time the Meeting Minutes (refer to Meetings Minutes Second Amendment about the Initial Report, Lima, July 22nd, 2011)

So, the JICA Study Team began in August the prefeasibility study for the watershed above mentioned, which was completed in late November.

This report corresponds with the pre-feasibility study of the Cañete watershed project, of Group B. The feasibility study wants to be finished by mid-January 2012, and the feasibility study for all selected watersheds around the same dates.

Remember that DGIH processed on July 21st, the SNIP registration of four of the five watersheds (except Yauca), based on projects reports at pre-feasibility level from JICA. DGIH decided to discard Yauca River due to its low impact in economy.

The Project Reports with pre-feasibility level for 4 watersheds (Chira, Cañete , Chincha, Pisco) were submitted to OPI from DGIH, and OPI issued their comments on the reports on September 22, 2011. The revision of the reports is under discussion among OPI, DGIH and JICA Study Team.

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

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.

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

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.

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.

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 rover within the five rivers chosen in this city. 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 mosl and only 10% below 1.000 mosl. The lower watershed, which is the study area, is were the river has a slope approximately of 1/90 with a 200 meters width.

Annual rainfalls of Cañete River vary according the altitude. For example, in areas with more than 4.000mosl, annually 1000mm of rain happen and in areas with less than 500mosl, only 20mm fall, suiting the desert. However, the surface of the water watershed 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 banks. 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 27.9 and 56.5% of the economically active population (EAP).

Table 3.1.2-5 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 3.1.2-7 Poverty index

	Distrito											
	San Vicente		Cerro Azul		Imperial		Nuevo Imperial		San Luis			
	People	%	People	%	People	%	People	%	People	%	Total	%
Regional Populatior	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 3.1.2-9 Type of housing

Variable/Indicator	Distrito									
	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

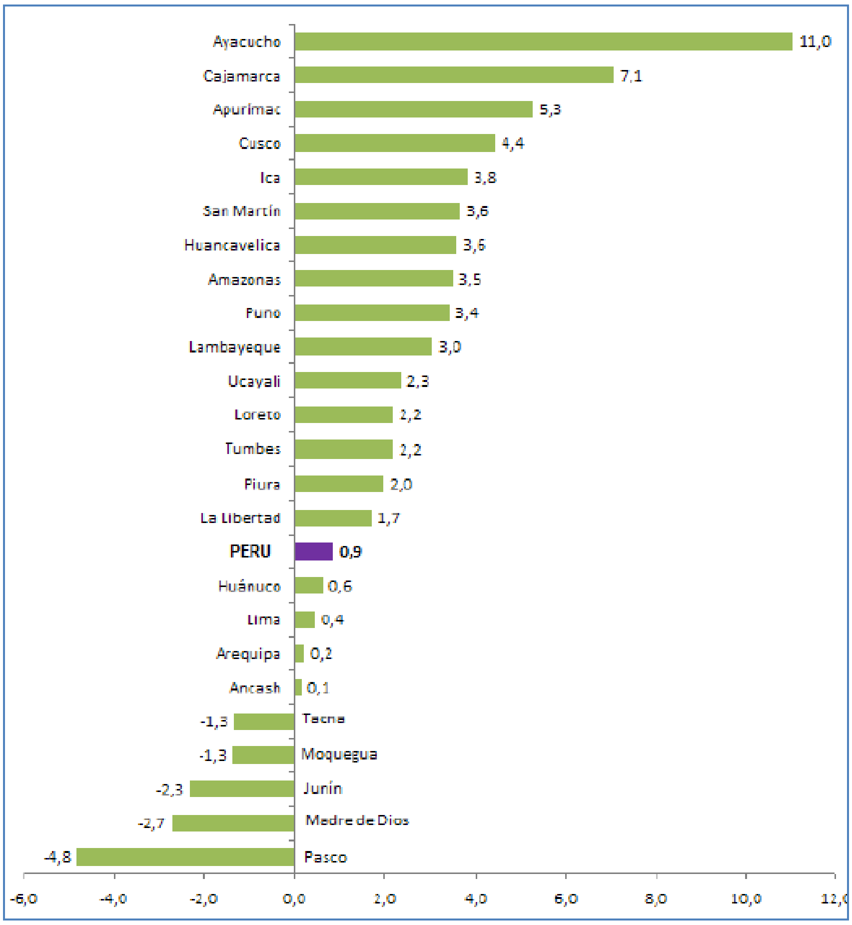
Source: Prepared by JICA Study Team, Statistics National Institute- INEI, 2007 Population and Housing Census.

(6) GDP

Peru's GDP in 2009 was S./392,565,000,000.

The growth rate in the same year was of + 0.9 % compared with the previous year with the poorest level within 11 years.

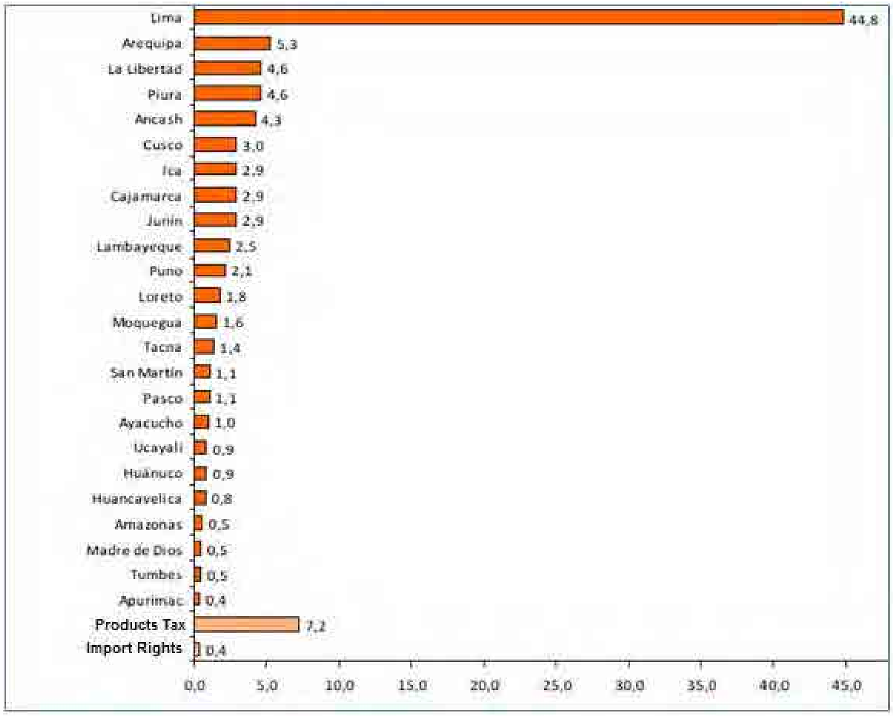
Itemized by regions, Ica registered a growth of 3.8 %, Piura 2.0 %, Lima 0.4 % and Arequipa 0.2 %. Particularly Ica and Piura regions registered Figures that were beyond the national average.



INEI Source – National Accounts National Direction

Figure 3.1.2-1 Growth rate of GDP per region (2009/2008)

The table below shows the contribution of each region to the GDP. Lima Region represents almost half of the total, that is to say 44.8%. Arequipa contributed with 5.3 %, Piura 4.6 % and Ica 2.9 %. Taxes and duties contributed with 7.2 % and 0.4 %, respectively.

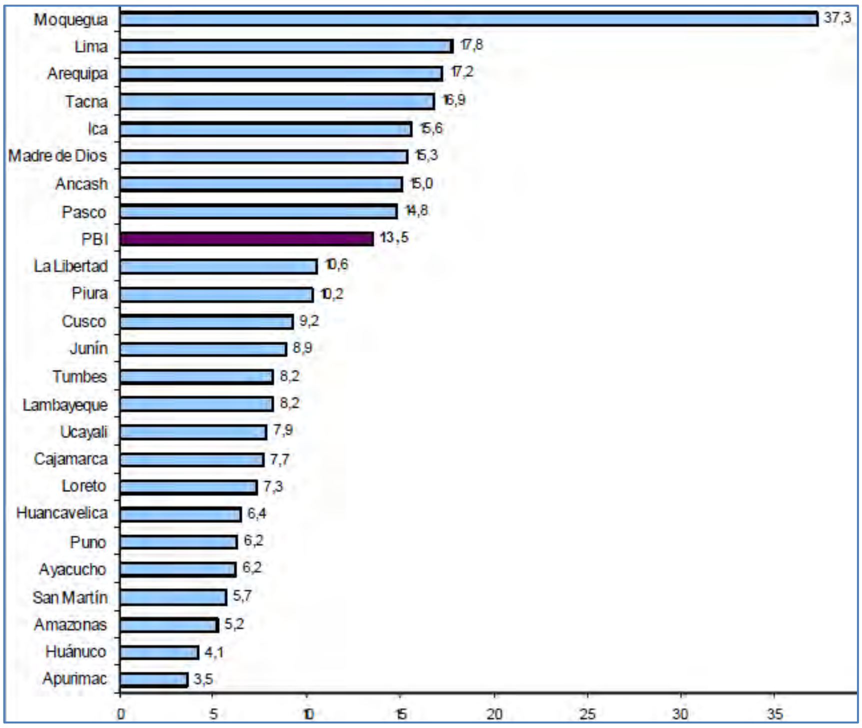


INEI Source – National Accounts National Direction

Figure 3.1.2-2 Region contribution to GDP

The GDP per capita in 2009 was of S/.13,475.

The Table below shows data per region: Lima S/.17,800, Arequipa S/.17,200, Ica S/.15,600 and Piura S/.10,200. The first three regions exceeded the national average, with exception of Piura.



INEI Source – National Accounts National Direction

Figure 3.1.2-3 GDP per capita (2009)

Table 3.1.2-7 shows the variation along the years of the GDP per capita per region, during the last 9 years (2001-2009).

The GDP national average increased in 44% within nine years from 2001 until 2009. The Figures per region are: +83. % for Ica, +54. % for Arequipa, +48. % for Piura y +42. % 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/.)

Departament	2001	2002	2003	2004	2005	2006	2007P/	2008P/	2009E/	Accumulated Growth 2001-2009 (%)
Cusco	2 194	2 086	2 195	2 565	2 768	3 071	3 340	3 554	3 685	67,9
Ica	4 055	4 259	4 343	4 663	5 214	5 582	6 025	7 265	7 457	83,9
La Libertad	3 162	3 316	3 483	3 410	3 697	4 216	4 586	4 874	4 895	54,8
Ucayali	3 063	3 149	3 203	3 411	3 584	3 754	3 846	4 007	4 039	31,9
Moquegua	10 405	11 967	12 670	13 455	13 882	13 794	13 606	14 201	13 865	33,3
Arequipa	5 387	5 766	5 895	6 143	6 488	6 807	7 786	8 379	8 308	54,2
Apurimac	1 216	1 278	1 334	1 400	1 494	1 619	1 653	1 691	1 770	45,5
Piura	2 733	2 780	2 847	3 049	3 192	3 472	3 780	4 007	4 052	48,3
San Martin	2 026	2 059	2 094	2 232	2 393	2 476	2 655	2 870	2 928	44,5
Ayacucho	1 788	1 870	1 942	1 900	2 045	2 207	2 448	2 640	2 896	61,9
Amazonas	1 835	1 910	1 996	2 081	2 212	2 349	2 510	2 684	2 761	50,5
Madre de Dios	4 441	4 708	4 550	4 846	5 171	5 215	5 617	5 878	5 564	25,3
Cajamarca	2 493	2 731	2 947	2 968	3 165	3 113	2 864	3 094	3 295	32,2
Ancash	4 037	4 703	4 772	4 876	4 999	5 089	5 408	5 852	5 827	44,3
Tumbes	2 744	2 802	2 873	3 018	3 385	3 212	3 427	3 594	3 611	31,6
Lima	6 451	6 579	6 700	6 925	7 284	7 817	8 520	9 314	9 220	42,9
Puno	2 105	2 236	2 234	2 270	2 365	2 460	2 617	2 731	2 800	33,0
Lambayeque	2 941	3 046	3 132	2 959	3 164	3 300	3 615	3 882	3 963	34,8
Junin	3 245	3 311	3 350	3 527	3 505	3 856	4 072	4 379	4 248	30,9
Loreto	2 827	2 917	2 936	2 995	3 079	3 192	3 287	3 402	3 429	21,3
Huánuco	1 678	1 694	1 833	1 866	1 890	1 915	1 942	2 050	2 044	21,8
Pasco	5 137	5 552	5 481	5 634	5 644	6 062	6 711	6 729	6 349	23,6
Tacna	6 004	6 124	6 382	6 643	6 782	6 941	7 256	7 458	7 253	20,8
Huancavelica	2 700	2 632	2 683	2 697	2 864	3 014	2 903	2 959	3 039	12,5
GDP	4 601	4 765	4 890	5 067	5 345	5 689	6 121	6 643	6 625	44,0

INEI Source – National Accounts National Direction

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 5,43 hectares.

Table 3.1.3-1 Basic data of the irrigation commissions

<table>
<tr><th rowspan="2">Irrigation Sectors</th><th rowspan="2">Irrigation Commissions</th><th colspan="2">Areas under irrigation</th><th rowspan="2">Nº of Beneficiaries (People)</th><th rowspan="2">River</th></tr>
<tr><th>ha</th><th>%</th></tr>
<tr><td>Roma Rinconada. La Huerta</td><td rowspan="9">Canal Nuevo Imperial</td><td rowspan="9">7.883</td><td rowspan="9">35</td><td rowspan="9">2.202</td><td rowspan="10">Cañete</td></tr>
<tr><td>Lateral A</td></tr>
<tr><td>Cantera Almenares</td></tr>
<tr><td>Lateral B</td></tr>
<tr><td>Lateral T</td></tr>
<tr><td>Túnel Grande</td></tr>
<tr><td>Quebrada Ihuanca</td></tr>
<tr><td>Cantagallo-U Campesina</td></tr>
<tr><td>Caltopa Caltopilla</td></tr>
<tr><td>Casa Pintada Sn Isidro</td><td>Canal Viejo Imperial</td><td>3.715</td><td>17</td><td>1.080</td></tr>
</table>

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/.219,95,80. 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

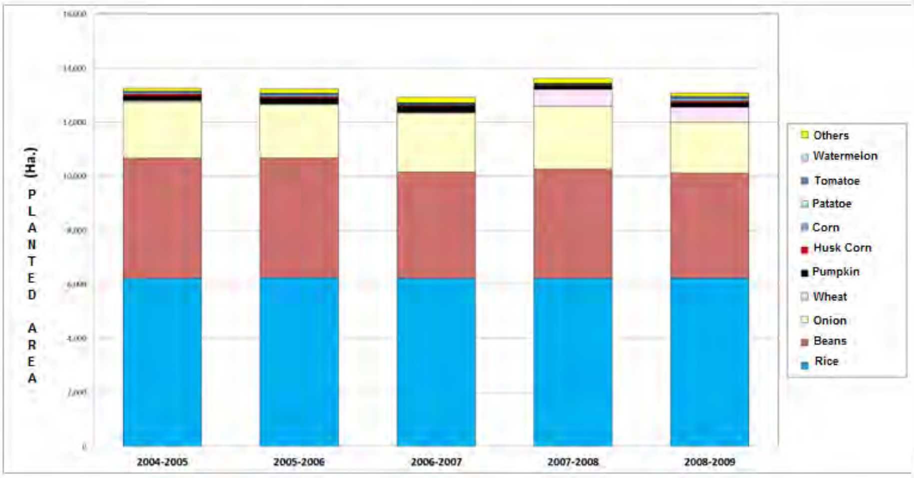


Figure 3.1.3-1 Planted Surface

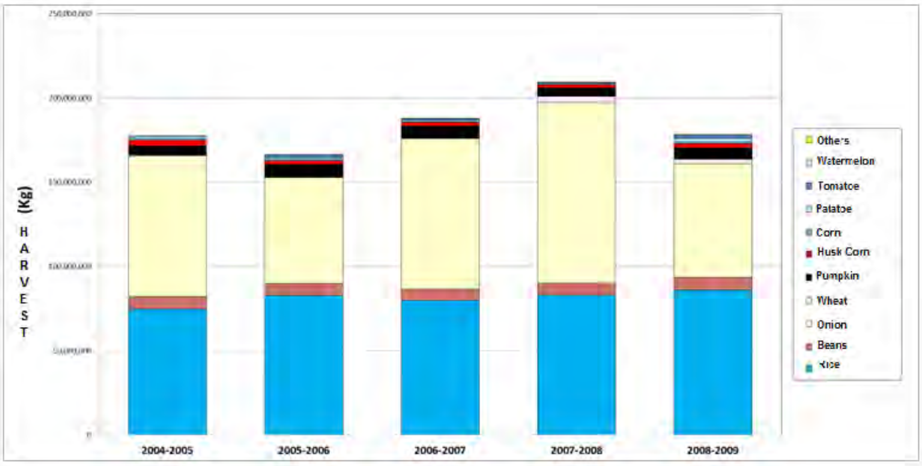


Figure 3.1.3-2 Harvest

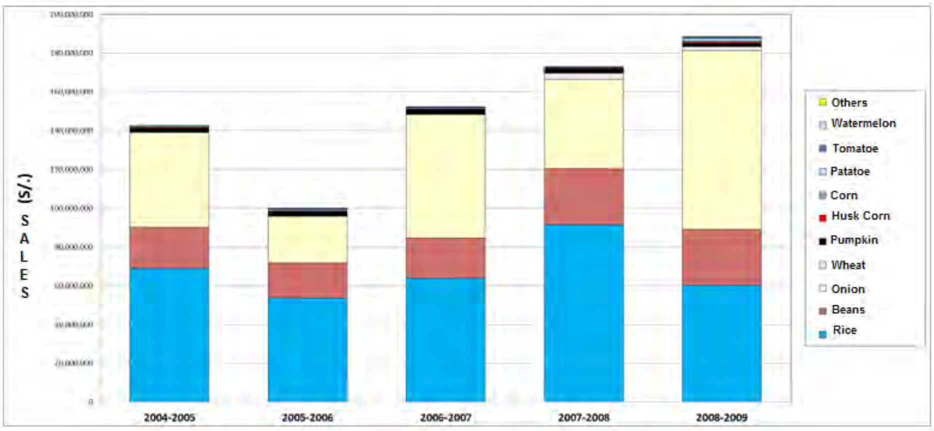


Figure 3.1.3-3 Sales

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 822.9km of roads, 265.km of them (32.%) are national roads, 59.6km (7.%) regional roads, and 496.4km (60.%) 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 Maria 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) 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.

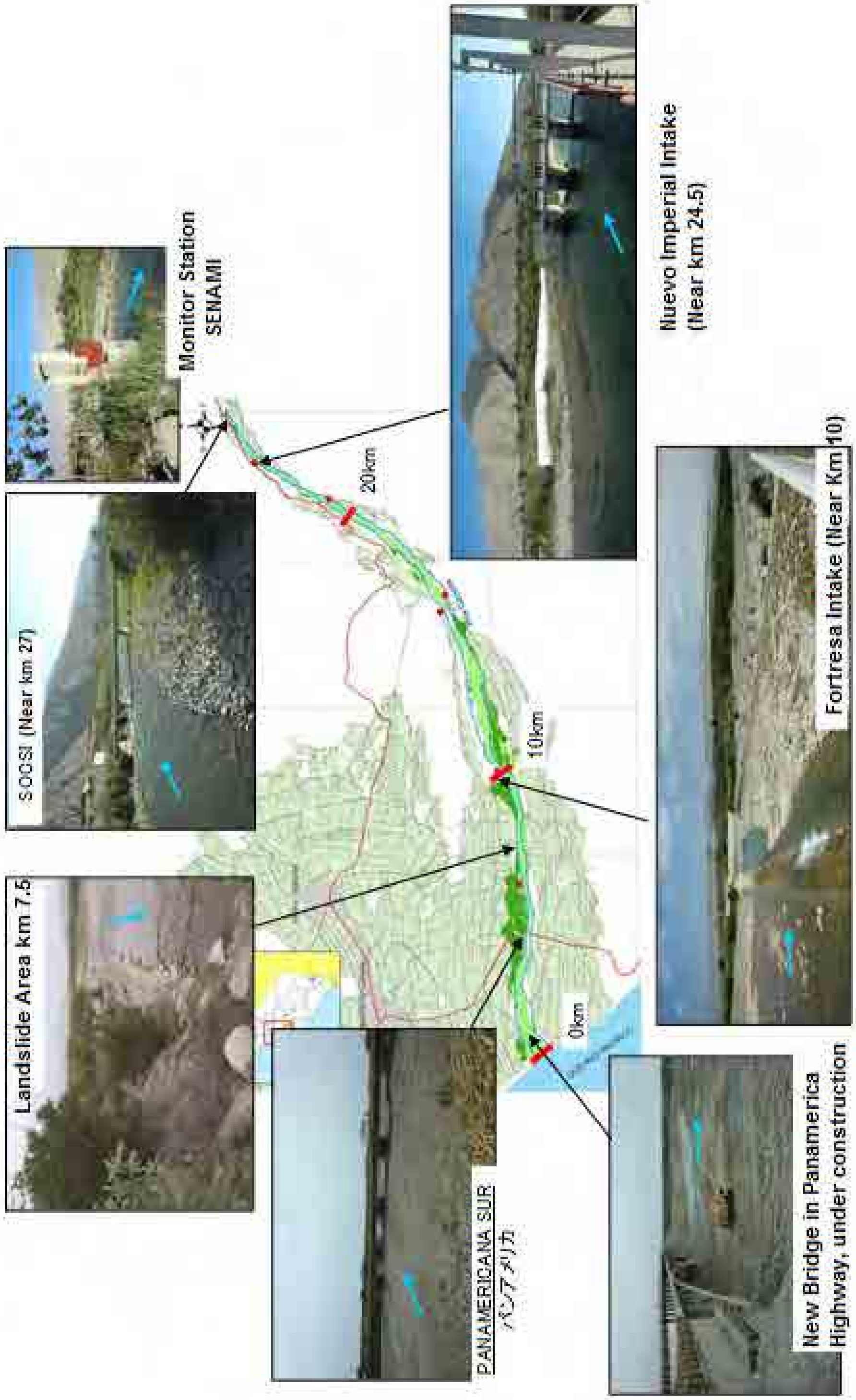


Figure 3.1.6-1 Visit to the Study Site (Cañete River)

(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.)

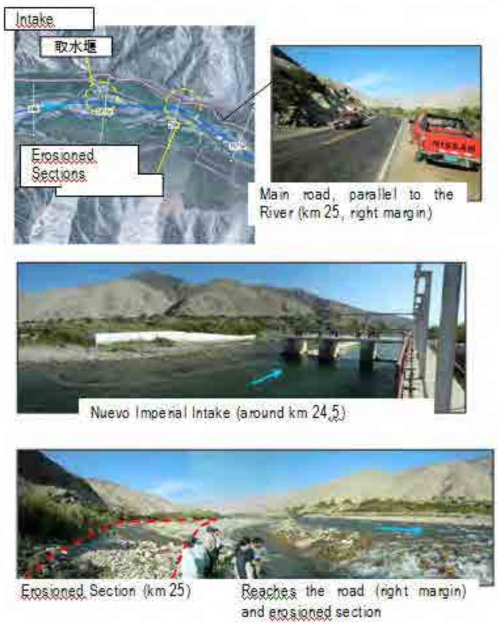


Figure 3.1.6-2 Local conditions related with Challenge 1 (Cañete River)

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 (approx 200 mt) has been protected with a dike, 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 discharge 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 watershed extends from the coast to the Andean mountains; usually, they feature different vegetal coverage according to the altitude. From coast up to the 2,500msnm (Cu, Dc) have scarce vegetation. Some meters above in altitude, there are only scarce bushes disseminated in the area due to the rains. Although, in zones close to the rivers, high trees are mainly develop, even in arid zones.

Table 3.1.7-1 List of representative vegetable forming in the Cañete watershed

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 3.7.2-1). 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 four watersheds, Cañete, Chincha, Pisco and Yauca 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 of

(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

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

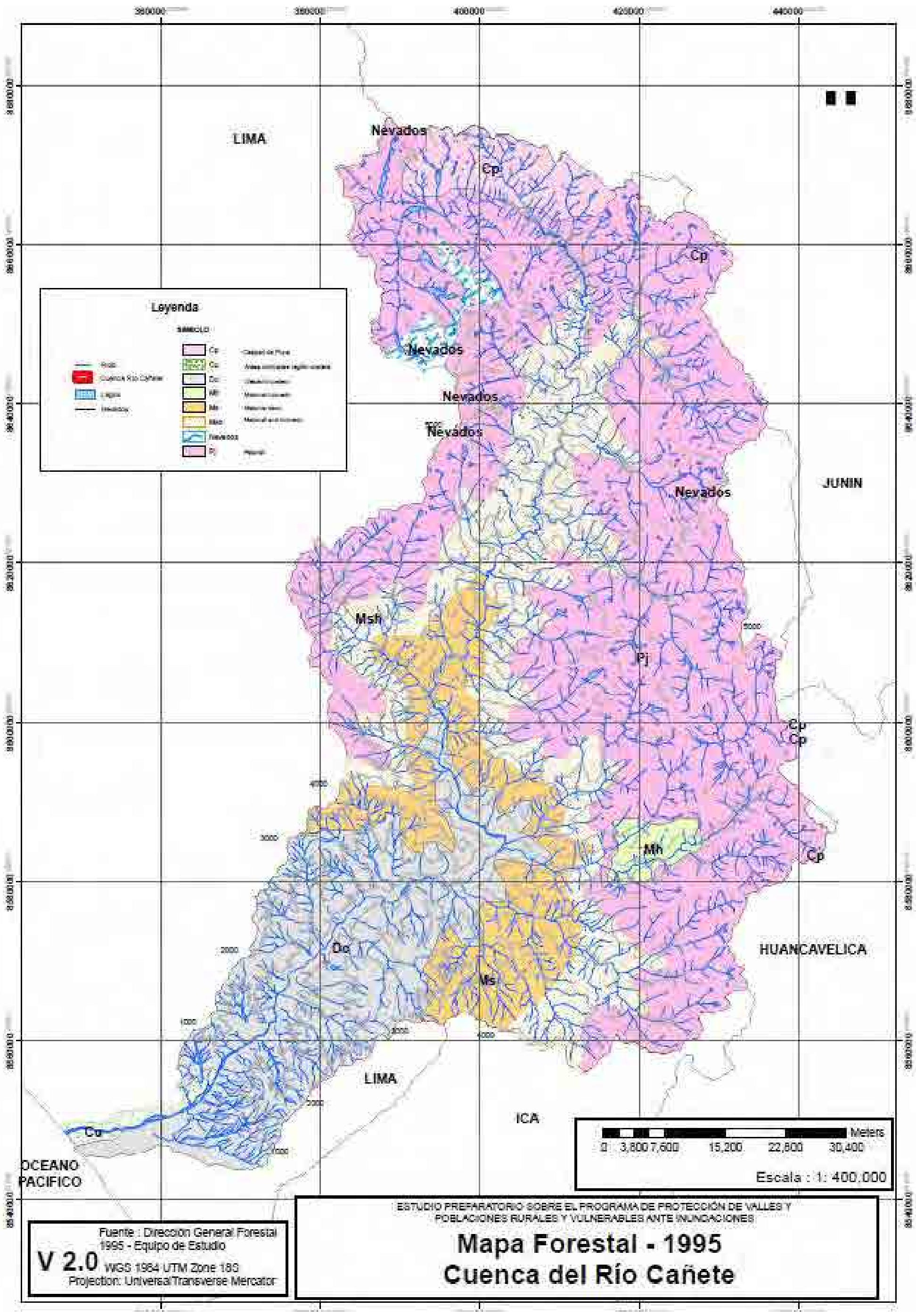


Figure 3.1.7-1 Forestry map of Cañete River Watershed

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 (msnm)	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

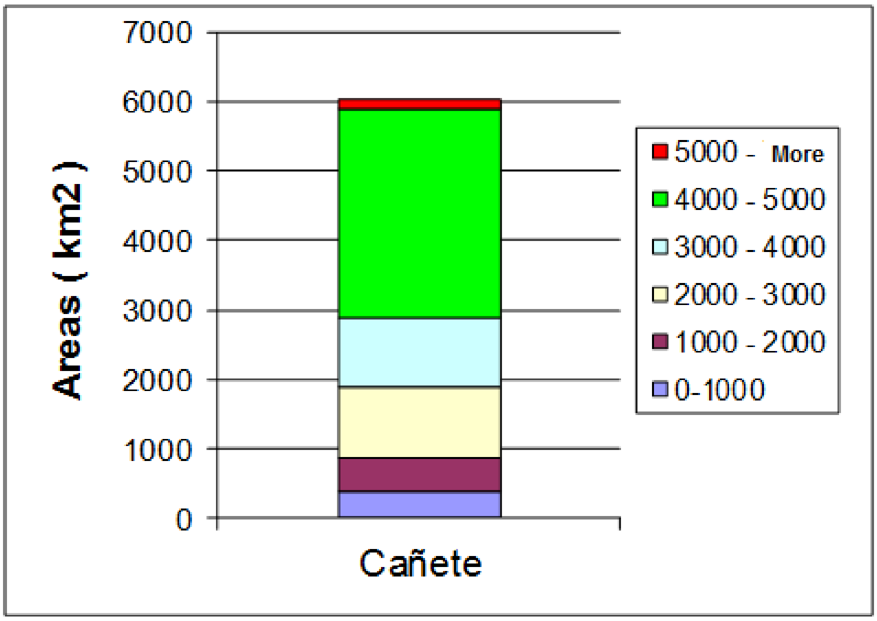


Figure 3.1.8-1 Surface according to altitude

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%

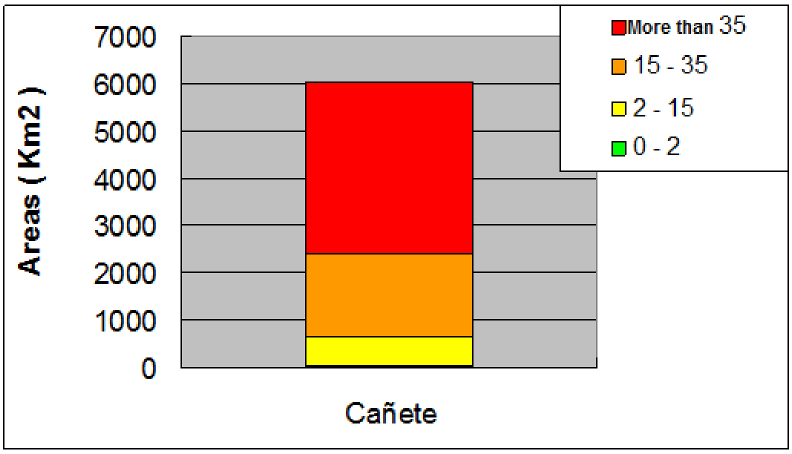


Figure 3.1.8-2 Slopes and surface

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

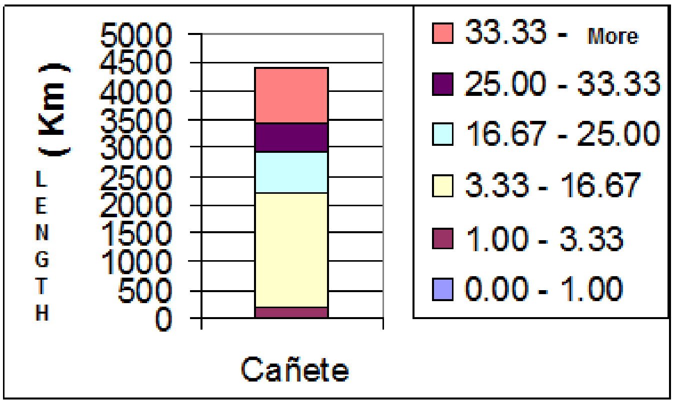


Figure 3.1.8-3 River-bed Slope and total length of streams

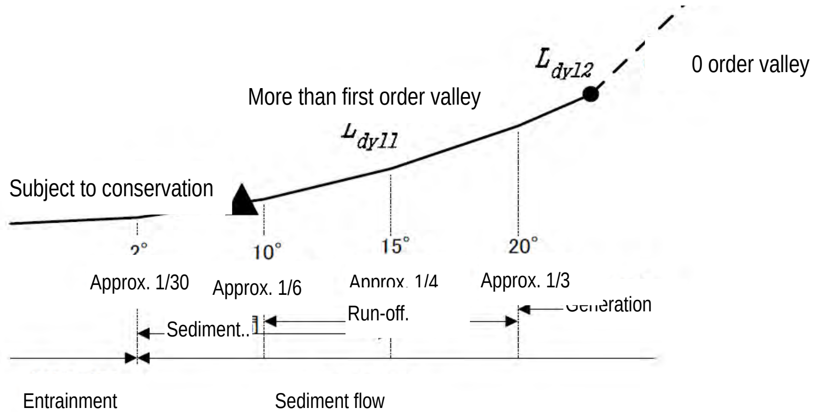


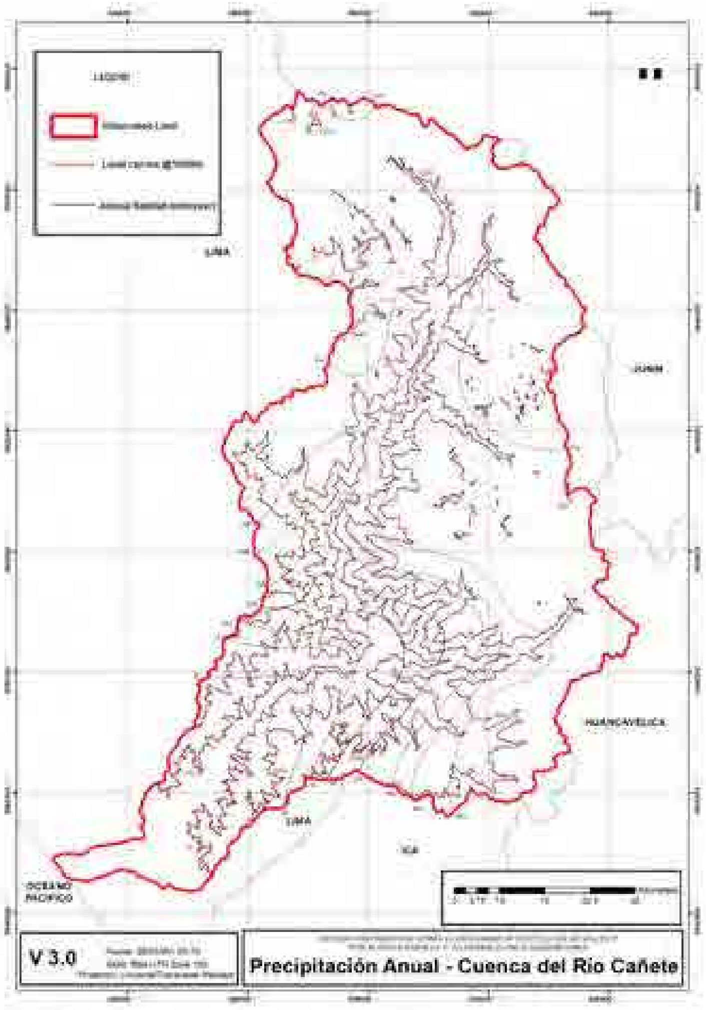
Figure 3.1.8-4 River-bed slope and sediment movement pattern

3) Rainfall

On the Pacific coast there is an arid arez 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 750 and 100 m.a.s.l.

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.

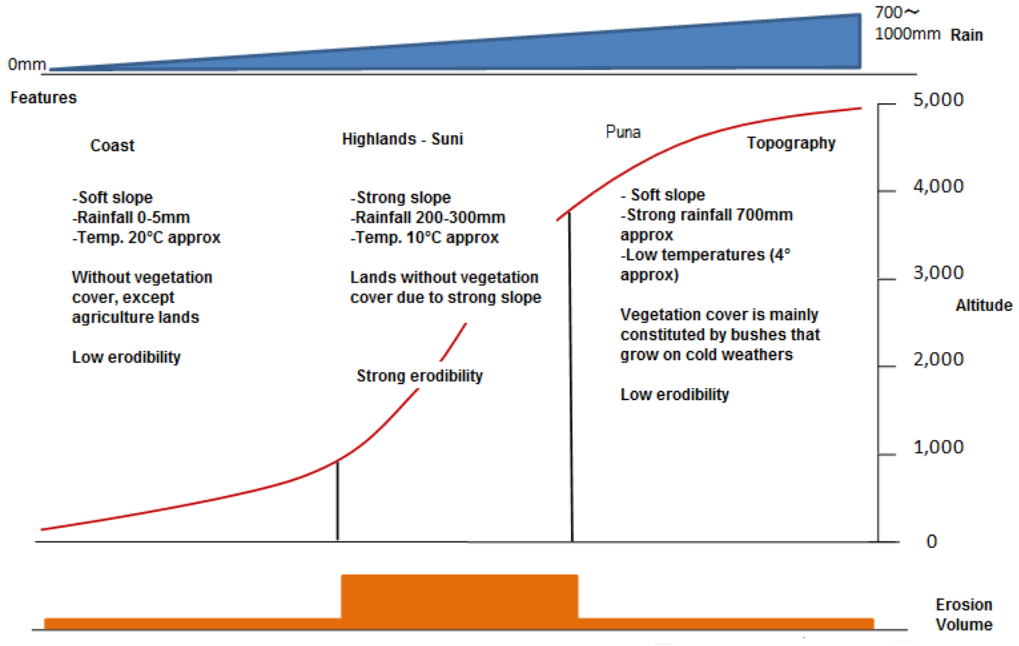


Figure 3.1.8-6 Relation between the erosion volume and the different causes

(5) 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%

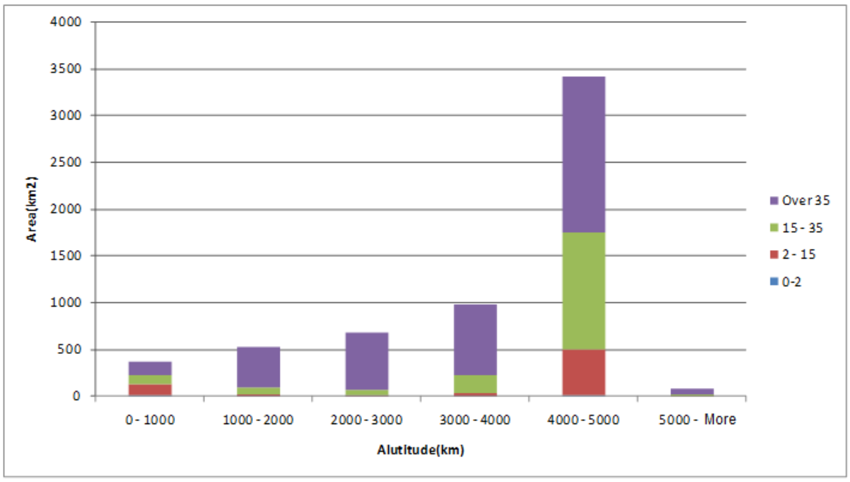


Figure 3.1.8-7 Slopes according to altitudes of Cañete River

(6) 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

Figure 3.1.8-10 Cactus Invasion

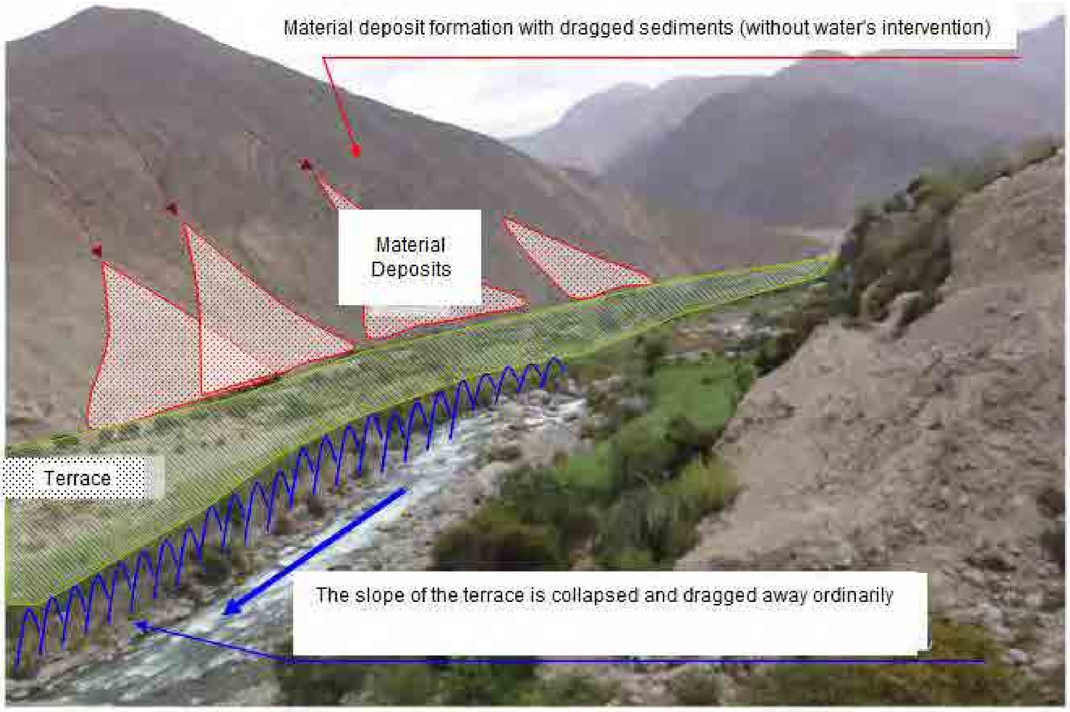


Figure 3.1.8-11 Movement of the sediment in the stream

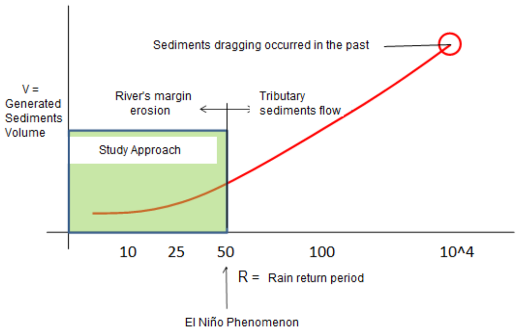
2） Sediments movement (in the stream)

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)

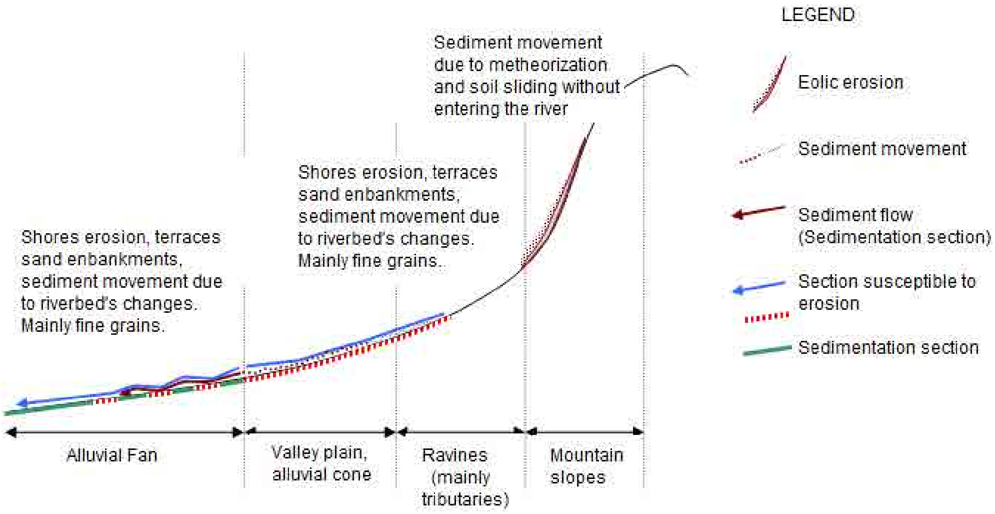


Figure 3.1.8-12 Production and entrainment of sediments in an ordinary year

(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

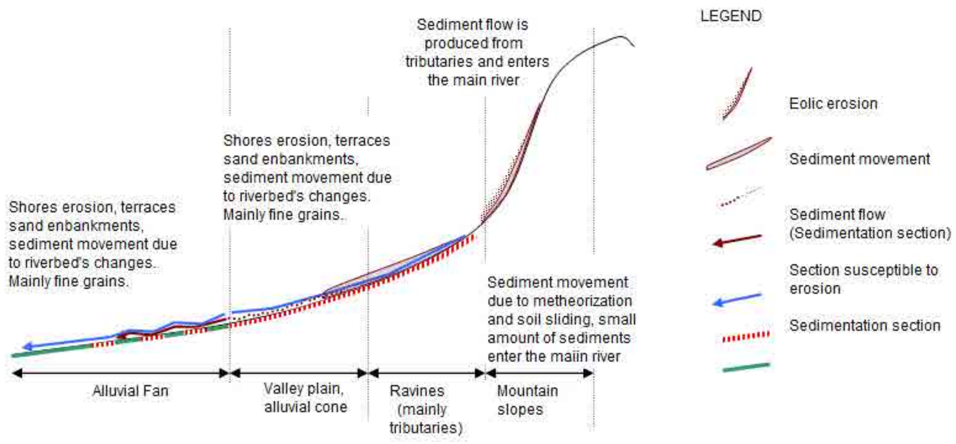


Figure 3.1.8-13 Production and entrainment of sediments during the torrential rainfall of magnitude similar to that of El Niño (1:50 year return period)

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

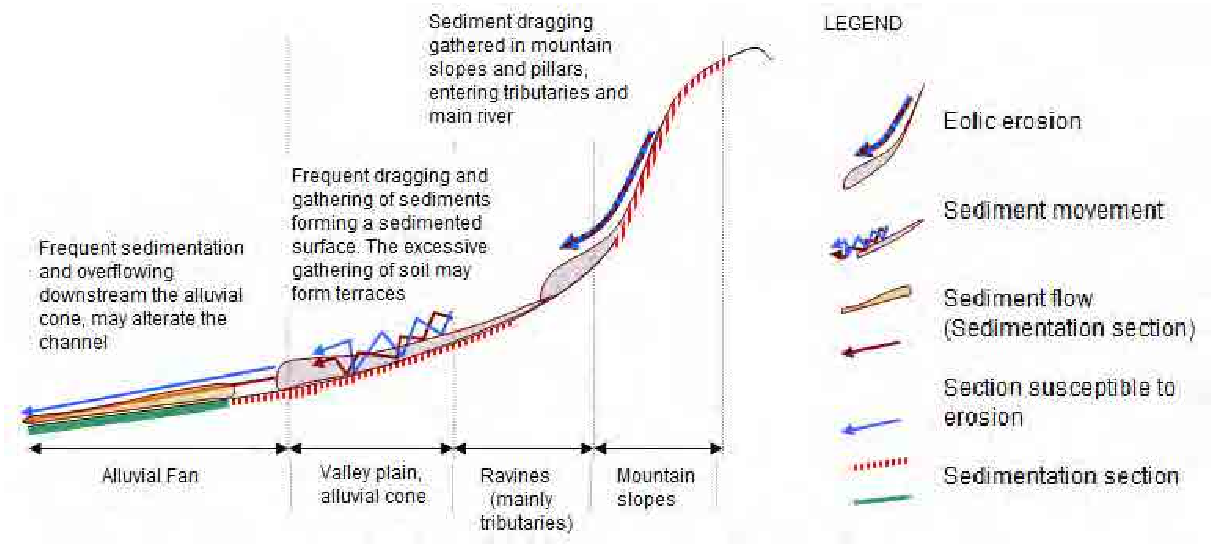


Figure 3.1.8-21 Production of sediments in large overflowing (geologic scale)

3.1.2 Run off analysis

(1) Rainfall data

1) Current rainfall monitoring system

The current rainfall data collection system used for the discharge analysis was reviewed; besides, the necessary rainfall data was collected and processed for such analysis. Rainfall data was obtained from SENAMHI and ELECT.PERU.

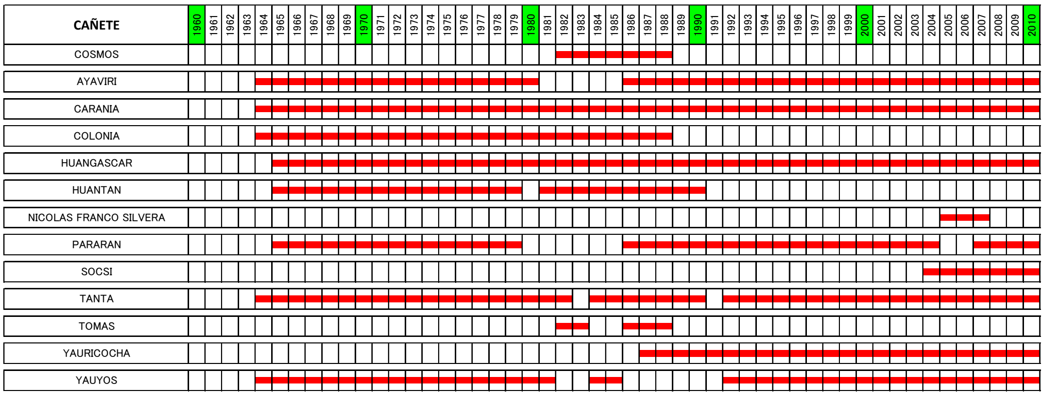
Tables 3.1.9-1~2 and Figure 3.1.9-1 indicate the rainfall monitoring points and the data collected according to the period in Cañete River watershed.

In Cañete river watershed rainfall monitoring is performed in 13 stations (including those currently non-operative), for a maximum period of 47 years since 1964 until 2010.

Table 3.1.9-1 List of rainfall monitoring stations (Cañete river watershed)

CODE	STATION	DEPARTMENT	LENGTH	LATITUDE
636	YAUYOS	LIMA	75° 54'38.2	12° 29'31.4
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 3.1.9-2 Period of rainfall data collection (Cañete river watershed)



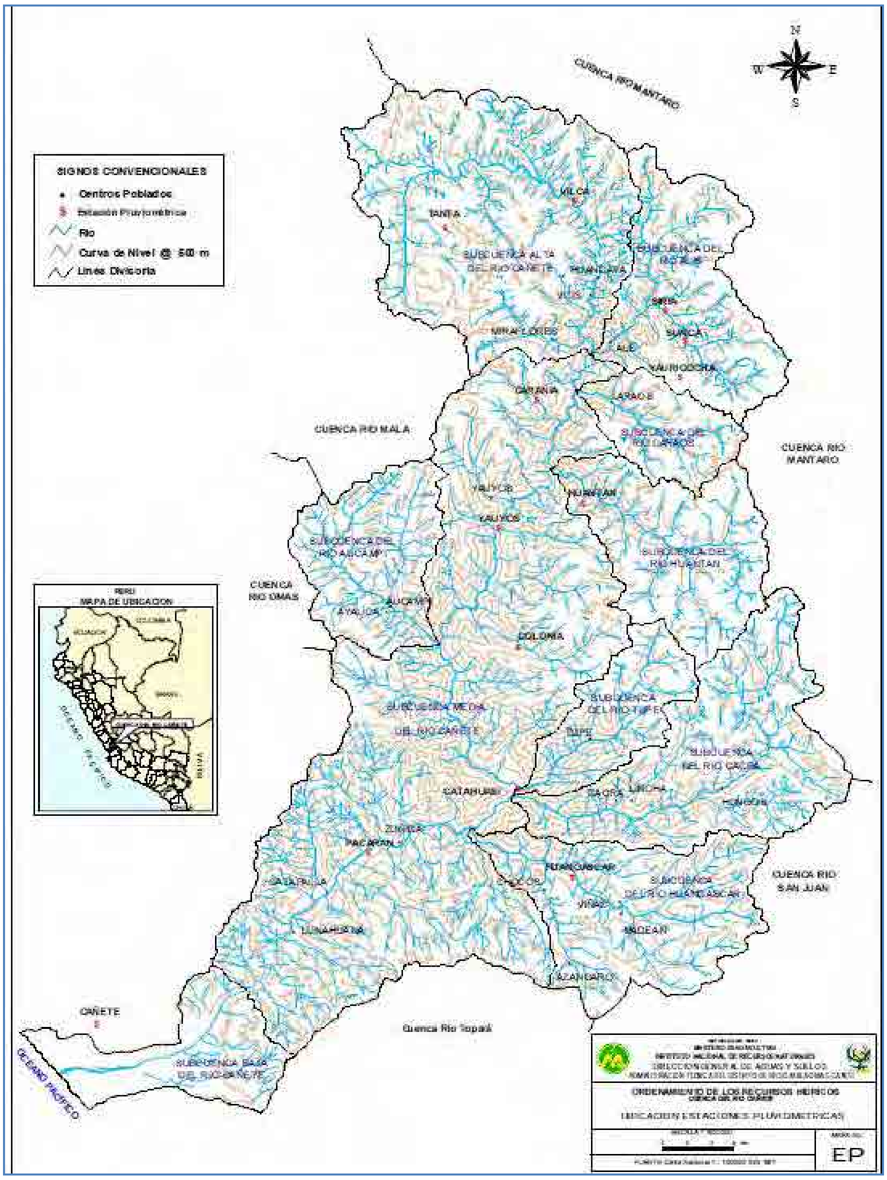


Figure 3.1.9-1 Monitoring stations location map
(Cañete River watershed)

2) Isohyet map

Annual rain isohyets maps are described next (average of 10 years) elaborated by SENAMHI using data recovered in the period 1965-1974.

Figure 3.1.9-2 shows a map of the isohyet of Cañete River watershed.

In the Cañete River Watershed is observed that the considerable variation of the annual rainfall depending on the zones, with a minimum of 25mm and a maximum of 750 mm approximately. The rainfall is lower on the lower watershed and it increases as the altitudes get near the upper watershed, increasing the altitudes.

The annual rainfall in the low watershed, subject to the control of floods, is reduced ranging from

25 to 50 mm.

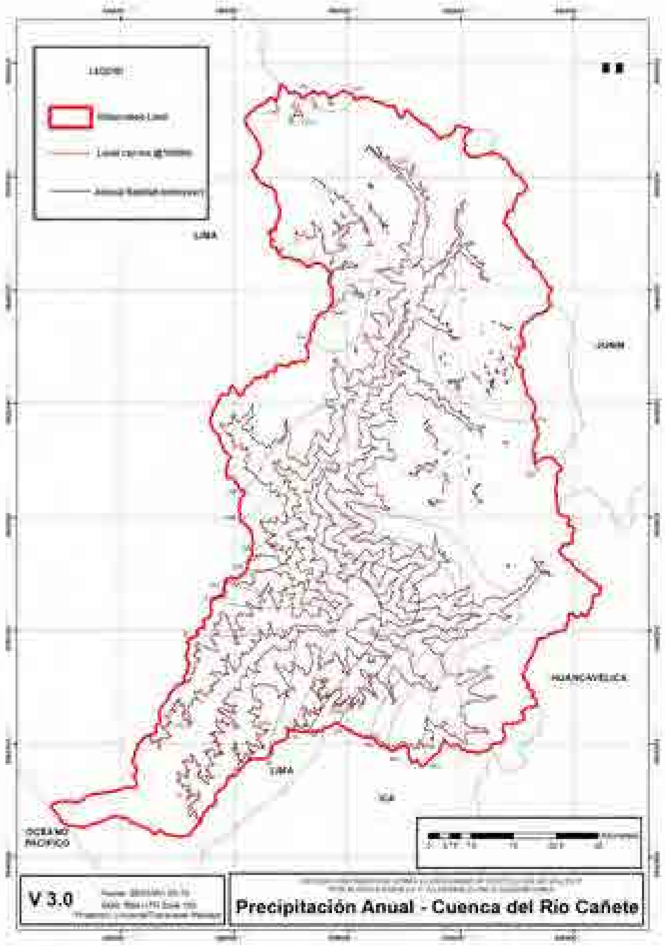


Figure 3.1.9-2 Isohyet Map (Cañete River watershed)

(2) Rainfall analysis

1) Methodology

The statistic hydrologic calculation was made using the rainfall data collected from several stations, to determine the rainfall with 24 hour return period in every station.

Several models of distribution of return periods were tested and the most adequate one was adopted. Thus, the precipitation with 24 hours return period was determined with this model.

The statistic hydrologic models were.

- Normal distribution (Normal)
- Log-Normal distribution
- Log-Normal distribution of 2-parameters
- Log-Normal distribution of 2 or 3 parameters
- Log Pearson Type III distribution (the log Pearson III)

- Gumbel distribution (Gumbel)
- General distribution of extreme value

2) Results of the rainfall analysis of return period– t

The rainfall of several stations are shown below and the reference point of each watershed, according to return periods.

Table 3.1.9-3 shows the monitoring points and the rainfall with 24 hour return period in the reference point (Socsi Station). Figure 3.1.9-3 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-3 Rainfall with 24 hour return period
(Cañete river watershed)

STATION NAME	RETURN PERIOD [YEARS]						
	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

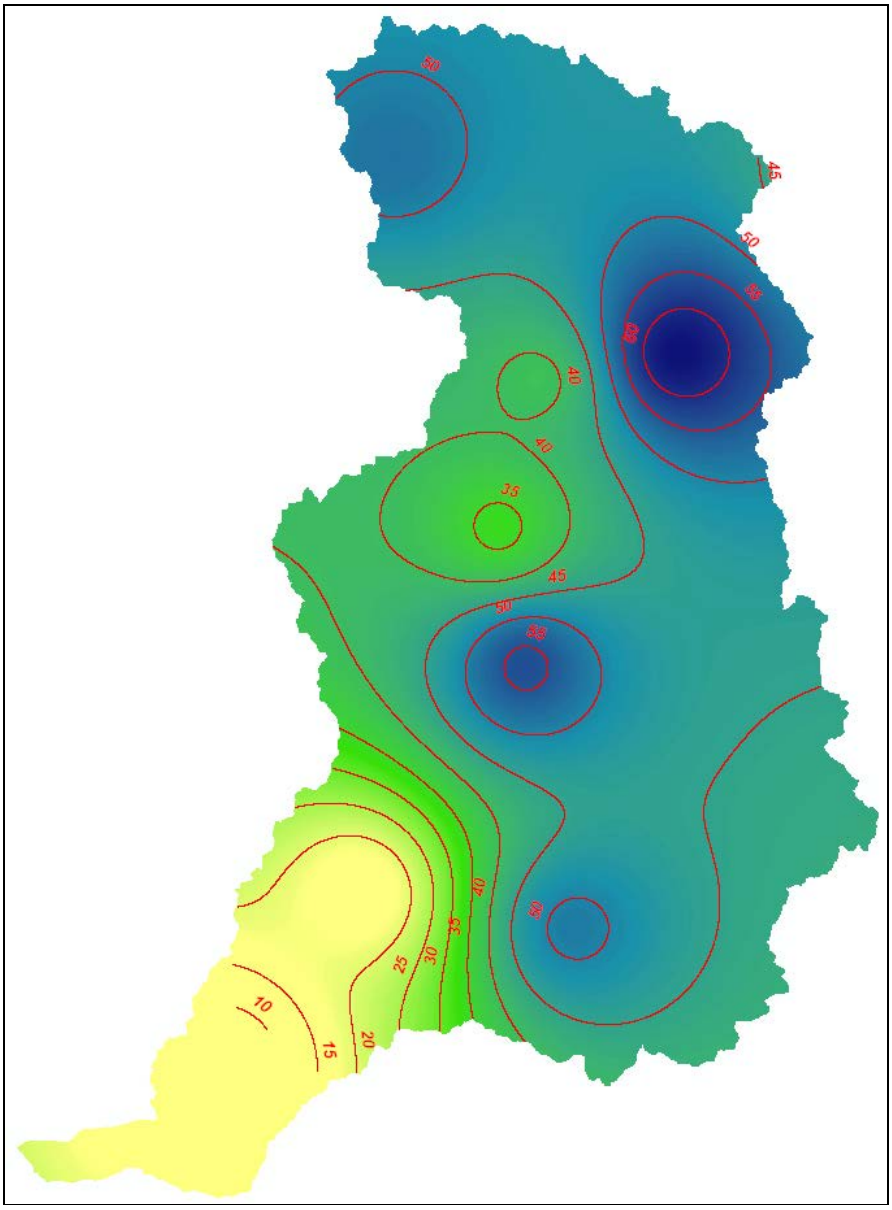


Figure 3.1.9-3 Map of isohyets of a 50 years period rainfall (Cañete river watershed)

(3) Discharge flow analysis

1) Flow monitoring

The current flow data collection system used in the discharge analysis was reviewed, and the necessary flow monitoring data were collected and processed for such analysis. The flow data have been obtained mainly from the Water National Authority (ANA in Spanish)

2) Analysis of discharge flow

The statistic hydrological calculation was made using the data of the maximum annual discharge collected and processed in the reference points, to determine the flow with different probabilities. Table 3.1.9-4 shows the probable flow with return periods between 2 and 100 years.

Table 3.1.9-4 Probable flow in control points

(m^3/s)

Rivers	Return periods					
	2 years	5 years	10 years	25 years	60 years	100 years
Río Cañete Socsi	313	454	547	665	753	840

3) Analysis of flooding flow with t-years return periods

(a) Methodology

The probable flooding flow was analysed using the HEC-HMS model, with which the hyetograph or return periods was prepared, and the peak flow was calculated.

For the rainfall used in the analysis, the hyetograph of several periods prepared in the rainfall analysis was used.

(b) Analysis results

Table 3.1.9-5 shows the flow of floodings with return periods between 2 and 100 years of the Cañete river watershed.

Likewise, Figure 3.1.9-4 shows the hydrographical map of probable flood in the Cañete river watershed.

It can be noticed that the numbers in Tables 3.1.9-4 and 3.1.9-5 are similar. So, for the following flood analysis the figures of Table 3.1.9-5 were decided to be used because they match the hydrograph.

Table 3.1.9-6 Flood flow according to the return periods
(Peak flow: Reference point)

(m^3/s)

	Return period					
Rivers	2 years	5 years	10 years	25 years	50 years	100 years
Río Cañete Socsi	331	408	822	1.496	2.175	2.751

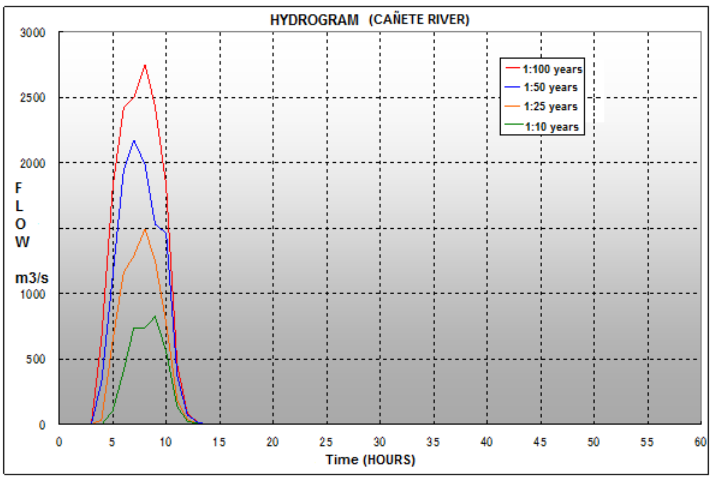


Figure 3.1.9-4 Hydrograph of Cañete river

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 river 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 methods

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

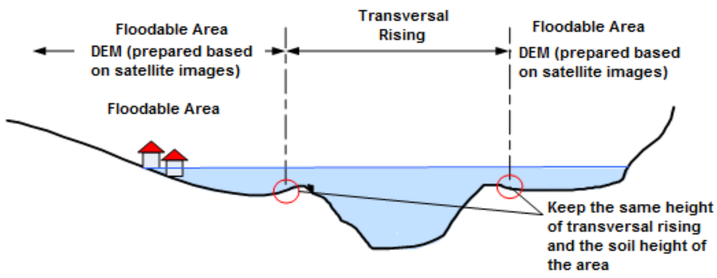
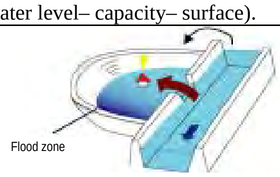
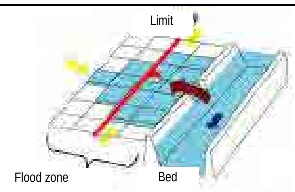


Figure 3.1.10-1 Idea of unidimensional model

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) Inundation analysis method

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

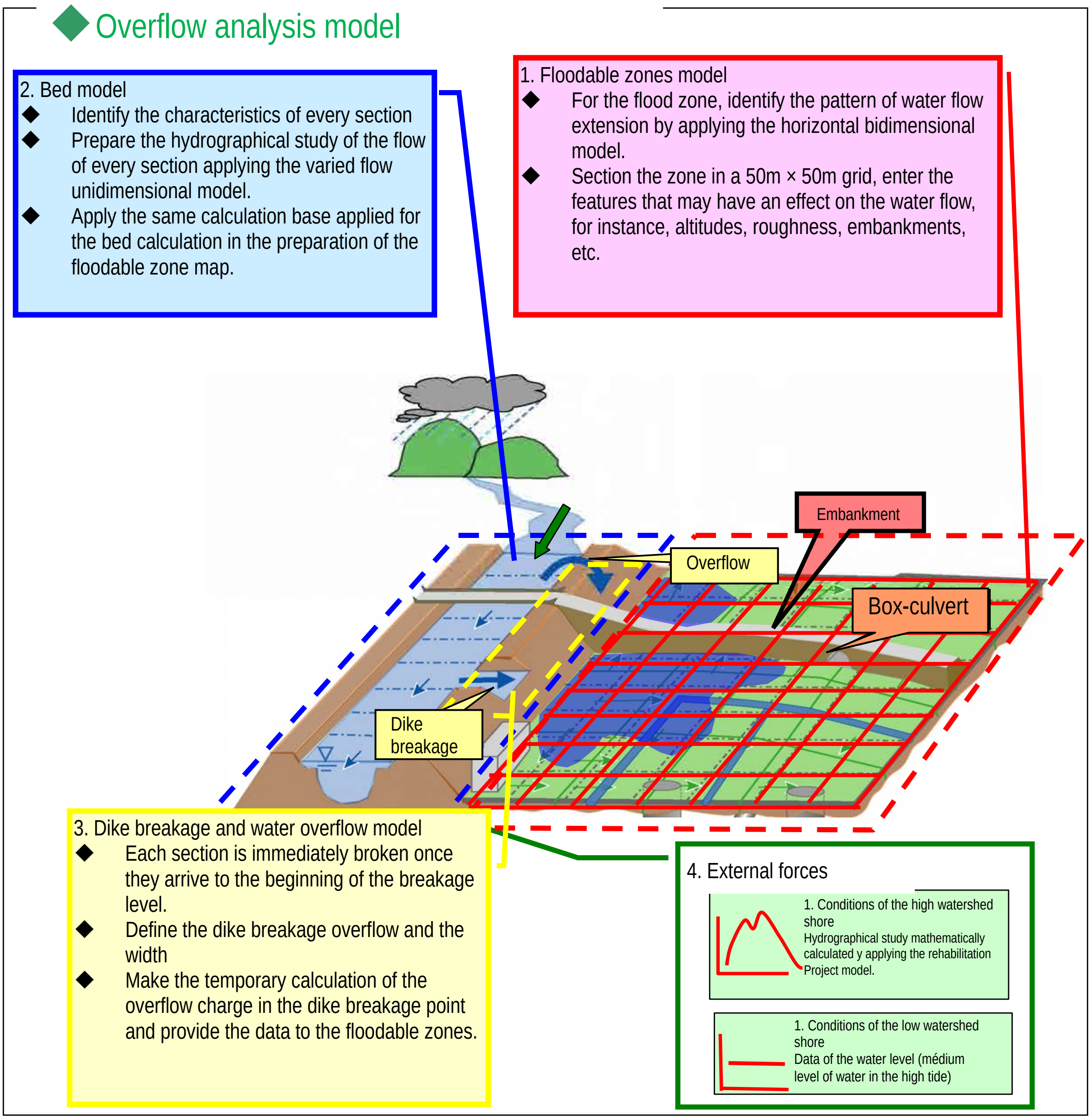


Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge capacity analysis

The current hydraulic capacity of the beds 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, which allow evaluating in what points of the Cañete river watershed flood may happen and what magnitude of flood flow may they have.

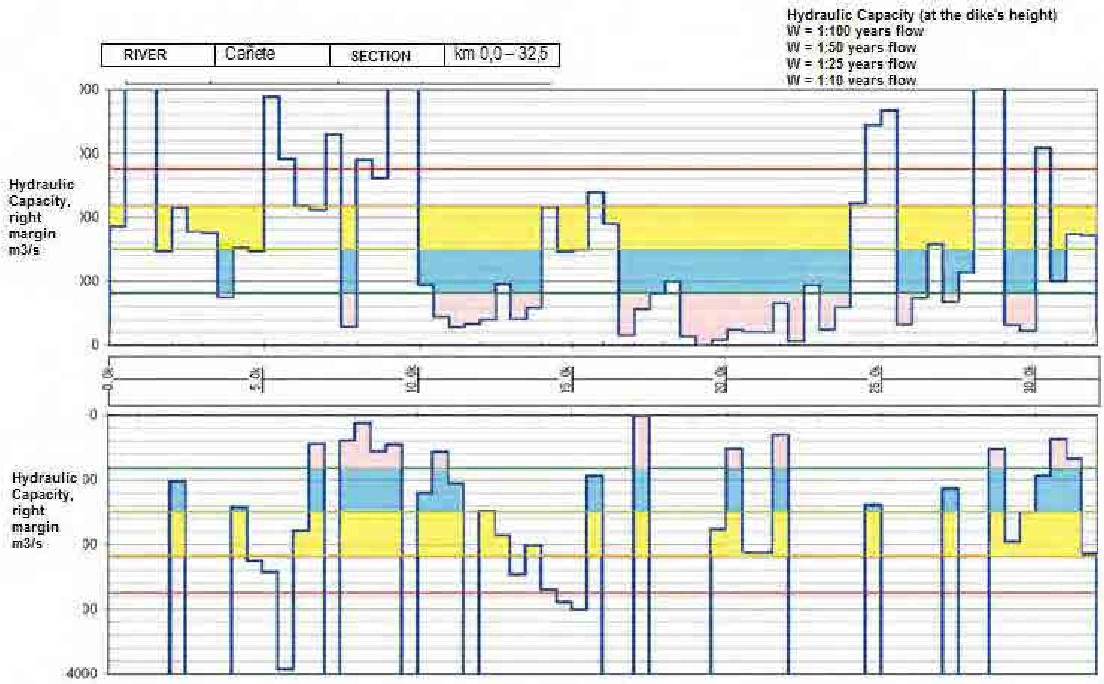


Figure 3.1.10-3(1) Current hydraulic capacity of Cañete River

(4) Inundation area

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

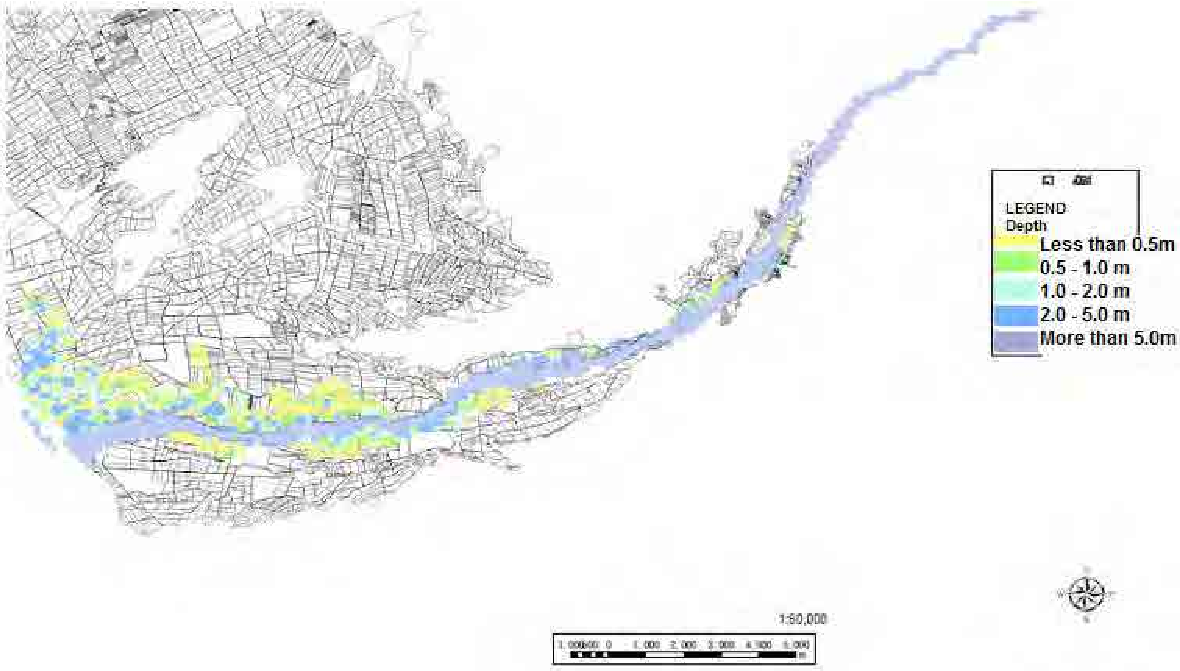


Figure 3.1.10-4(1) Inundation area of Cañete river (50 year period floods)

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.

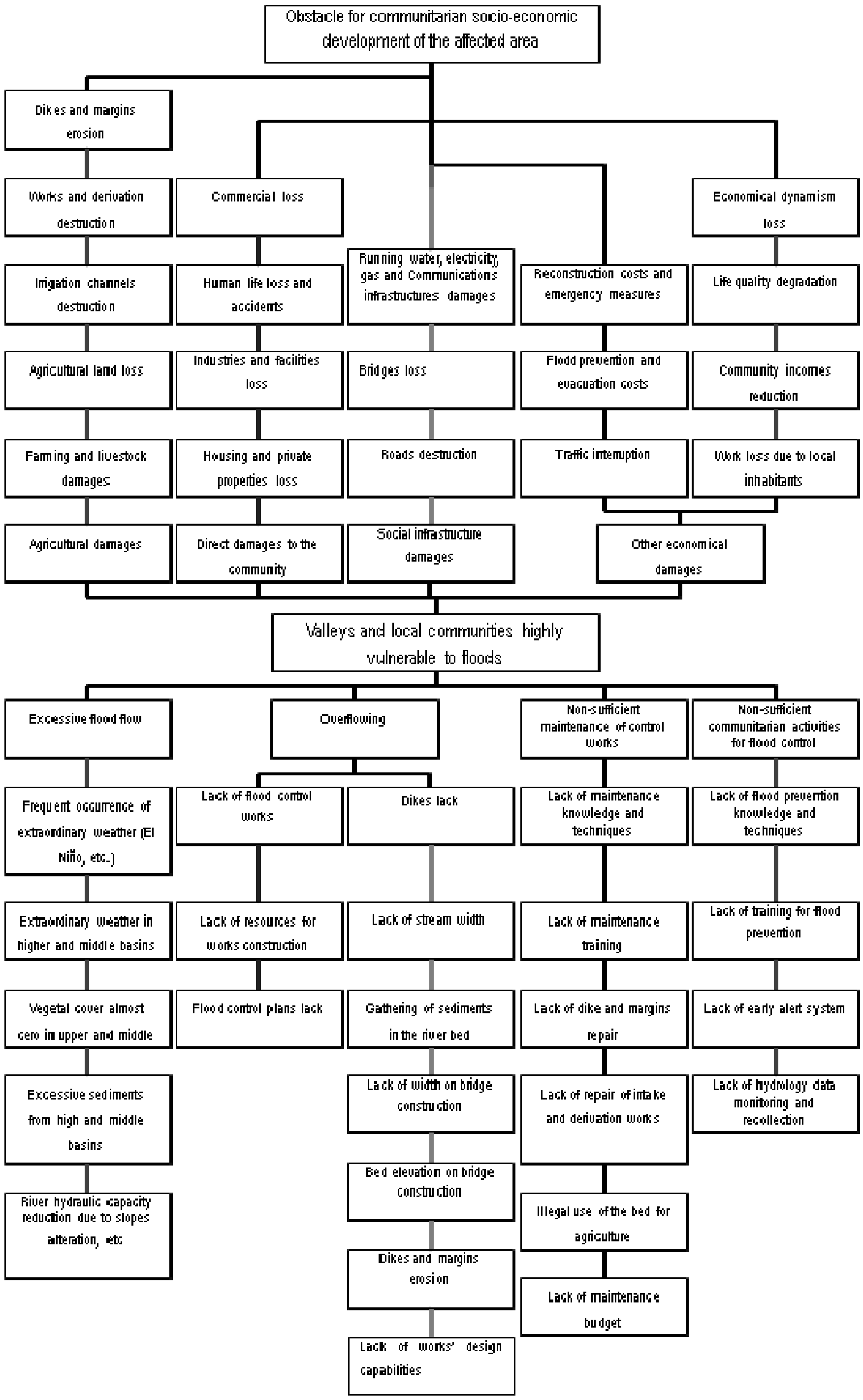


Figure 3.2.4-1 Causes and effects diagram

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.

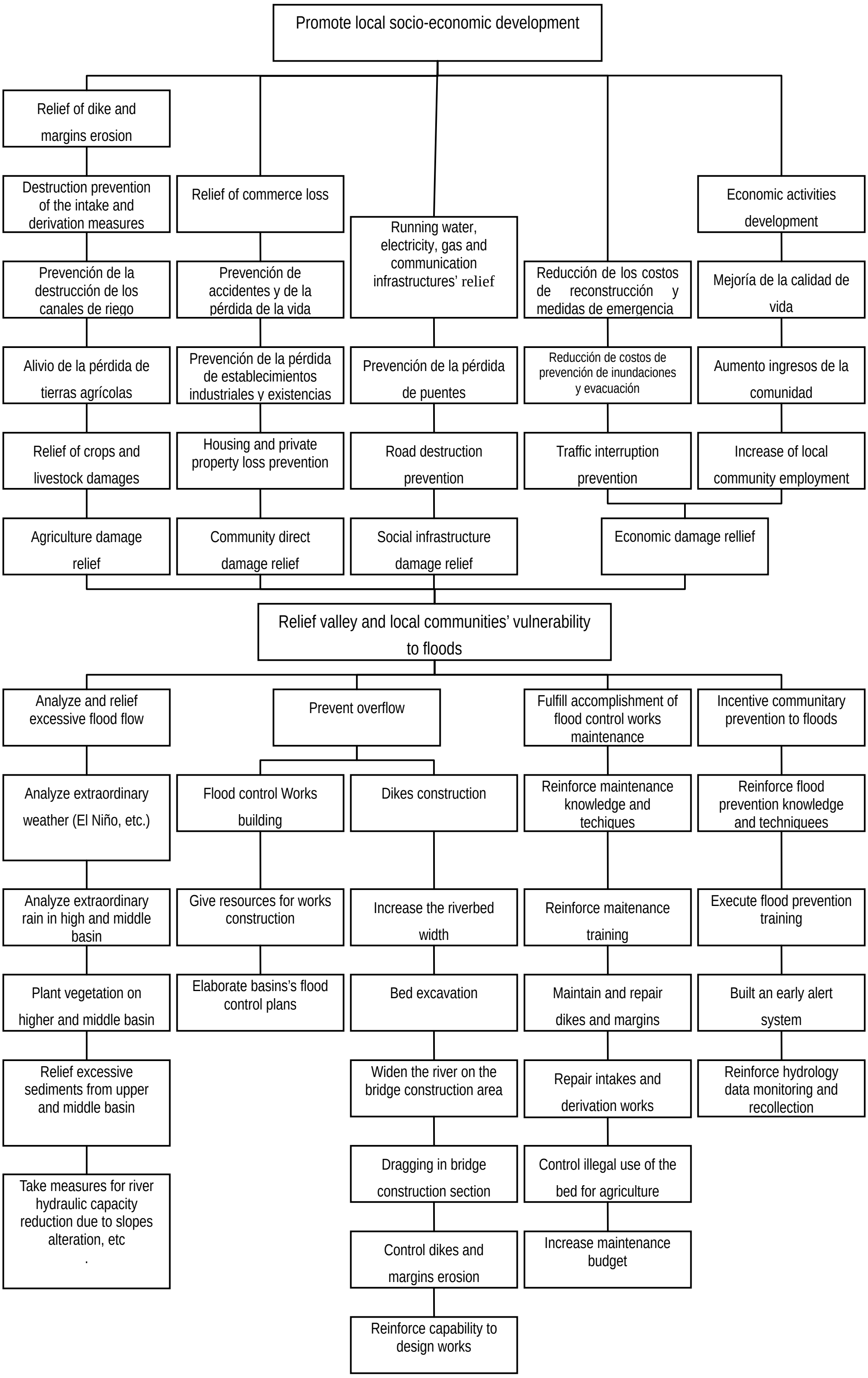


Figure 3.3.3-1 Measures - objectives – impacts diagram

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 4.12 “Medium and Long Term Plan” and 4.12.1 “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) 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 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

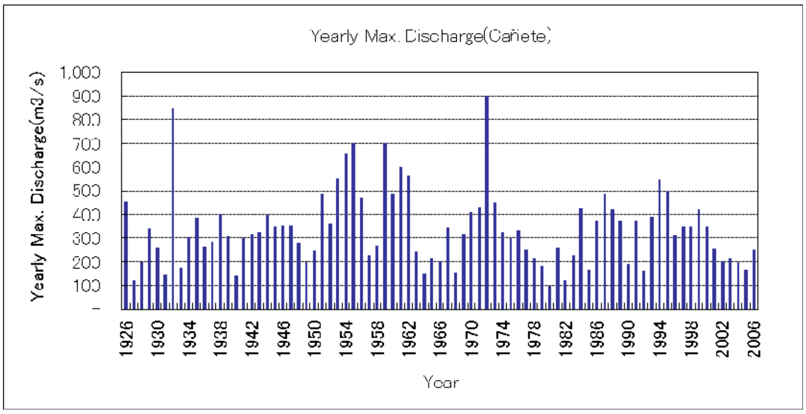


Figure- 4.3.1-1 Yearly Max. Discharge (Cañete)

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.

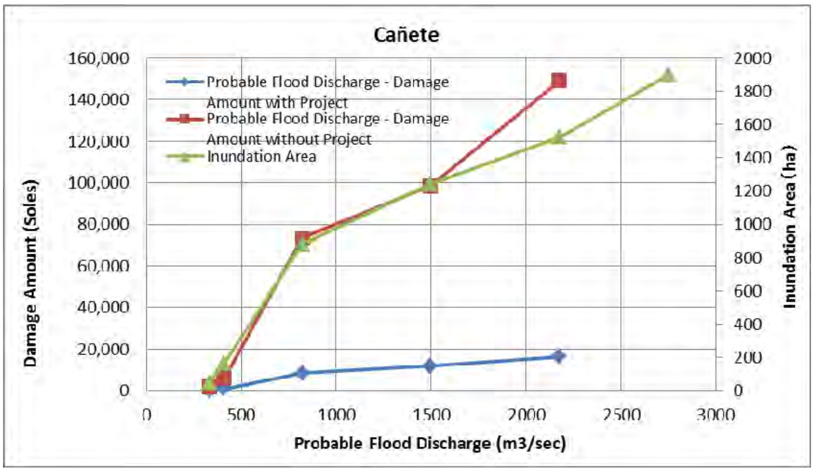
① The more increase probable flood discharge, the more increase inundation area (green line in the figure).

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.



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.

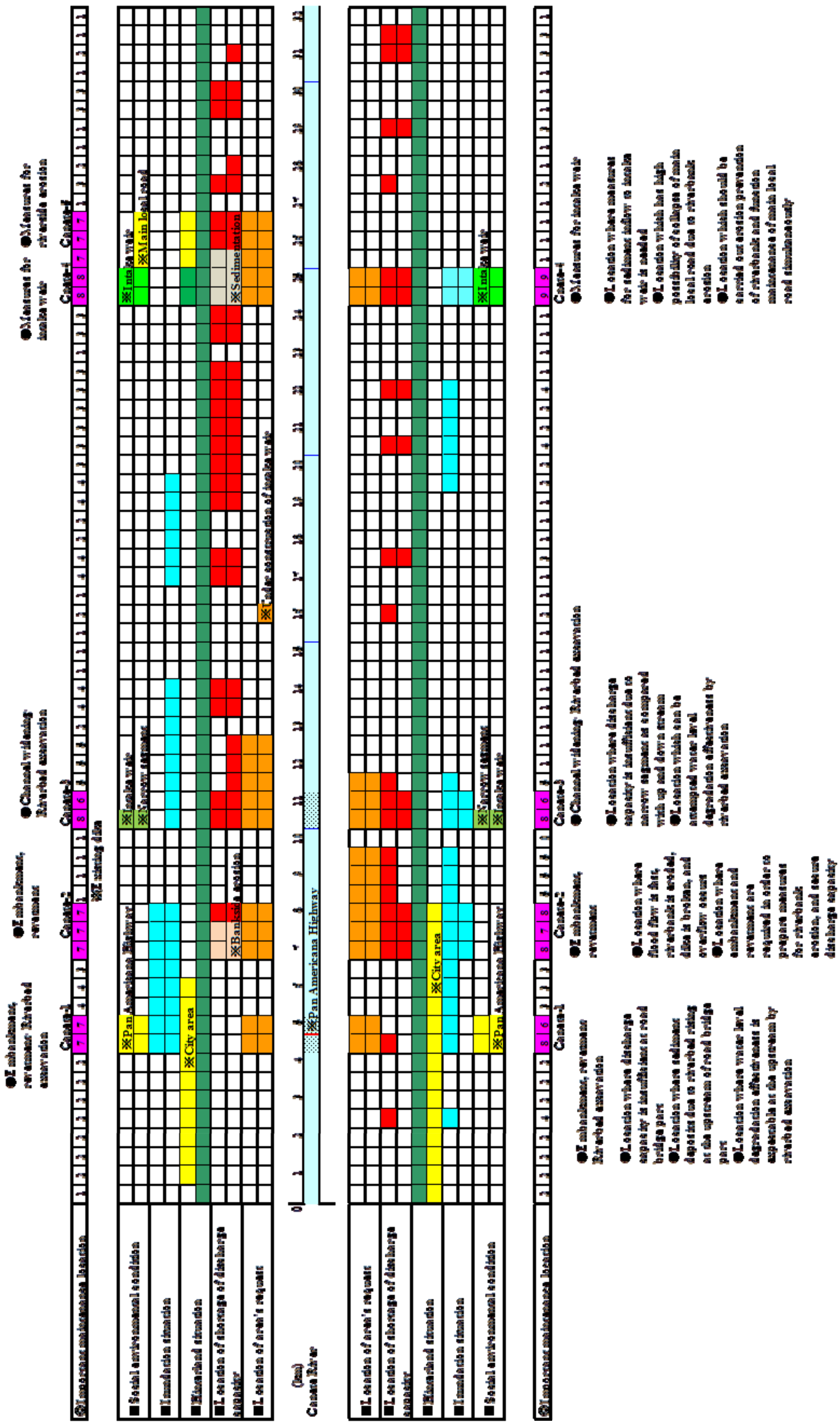


Figure 4.3.1-3 Selection results of prioritized flood protection works in Cañete river

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.

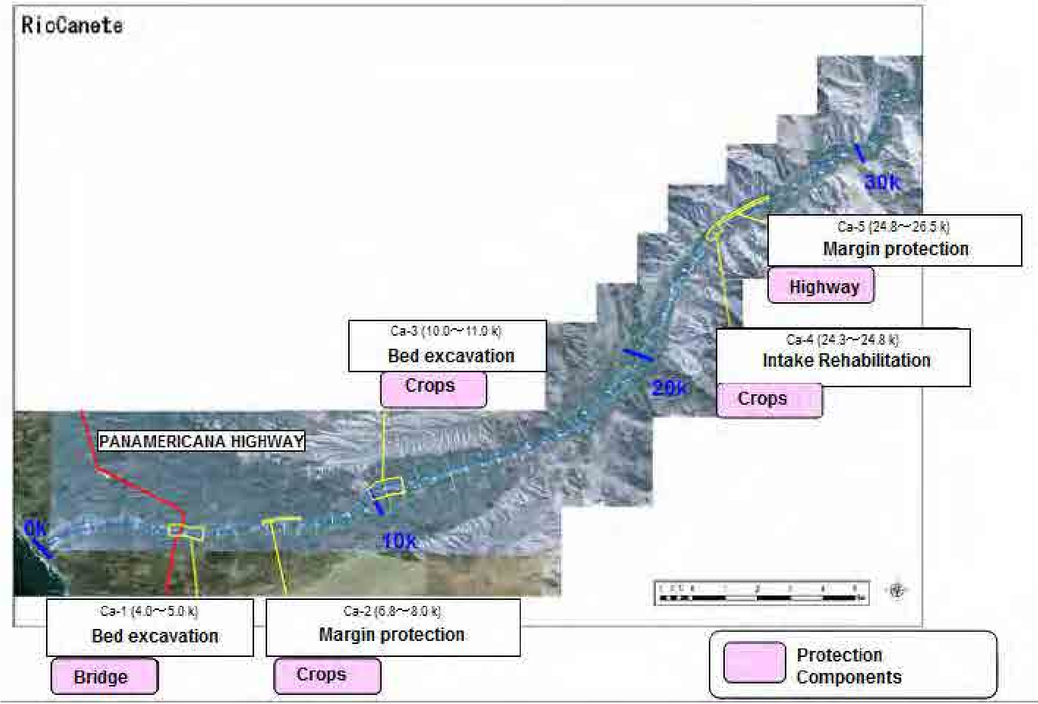


Figure 4.3.1-4 Priority Works on flood control in the Cañete River

Table 4.3.1-5 Summary of priority works

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Cañete	1	4.3km	Narrow Section	Road bridge	Riverbed excavation	Ex.width ; 100m Ex. depth ; 1.0m L ; 1,000m	4.0km～5.0km(total)
	2	6.8k～8.0k	Inundation	Crop land	Revetment	H ; 2.0m slope ; 1:3 L ; 1,200m	6.5km～8.1km(right bank)
	3	10.25k	Narrow Section		Riverbed excavation	Ex.width ; 100m Ex. depth ; 1.0m L ; 1,000m	10.0km～11.0km(total)
	4	24.5k	Intake		Diversion weir	Weir width ; 150m H ; 3.0m T ; 2.0m	24.25km～24.75km(total)
	5	25.0k, 26.25k	Erosion	Road	Revetment	H ; 2.0m Slope ; 1:3 L ; 750m	24.75km～26.5km(right bank)

(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: $\tan\theta=\tan\varphi/n$ (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 ($\tan\theta=0.385$).

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

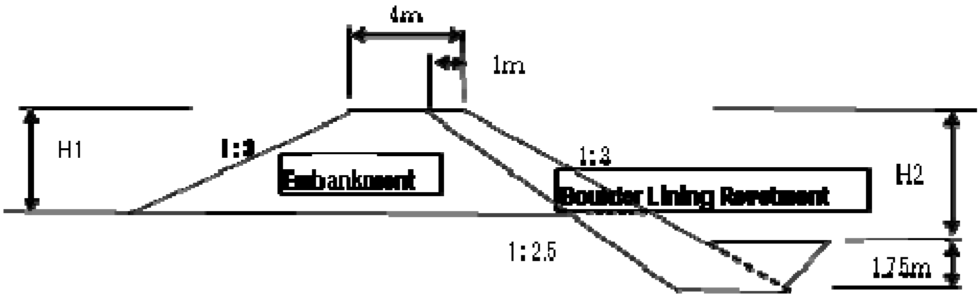


Figure 4.3.1-5 Standard dike section

4.3.2 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 4.12 "Medium and long term Plan", 4.12.2 "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 fluvial structures

This proposal consists in planting trees along fluvial structures such as protection works of banks, dikes, etc.

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 fluvial structures and the river.

c) Work execution: Plant vegetation at a side of the fluvial structures (dikes, etc.)

d) Maintenance post reforestation: The maintenance will be assumed by irrigator commissions by own initiative.

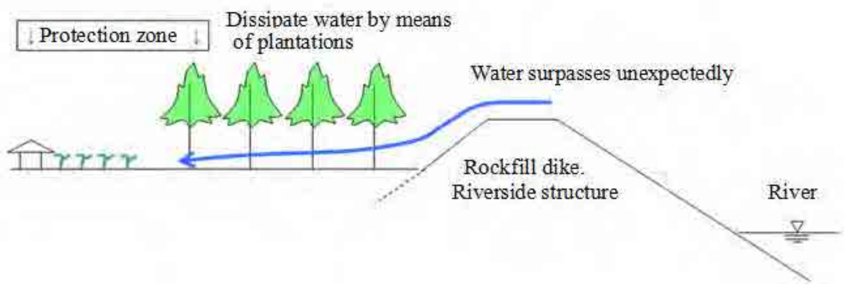
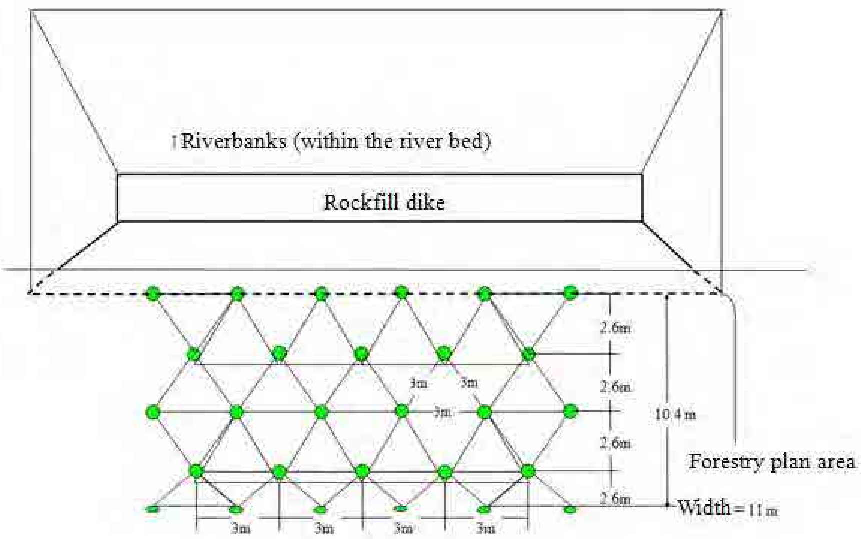


Figure 4.3.2.1-1 Conceptual Diagram Forestry in the Riverside structures (A Type)
(Source: JICA Study Team)

(3) Reforestation Plan Measure

1) Structure (forestry location)

In Peru the most common location for forestry is with equilateral triangles. This project also uses this model by planting trees with 3-meter intervals. If this method is used, it is expected that trees will act to stop and cushion even 1-meter diameter rocks, for what rows will be quadrupled, thus increasing their effectiveness. However, the main goal is to avoid overflow surpass the limit; in case floods strike directly with plants sowed, good results might be expected.



(Source: JICA Study Team)

Figure 4.3.2.1-3 Location of the forestry design plan in the riverside structure

2) Species to be forested

Species to be planted along the river were selected applying the following criteria and submitted to an overall assessment.

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 land 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 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-4.3.2.1-2 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 4.3.2.1-2 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) Volume of the Reforestation Plan

The forestry plan has been selected as it is mentioned in the location and type of species plan, in the dikes and rockfill, sedimentation wells along the riverside. The width of the forest is 11 meters; and within sand reservoir, tree will be planted excepting on the normal water route.

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

Table 4.3.2.1-3 Construction estimating for the forestry and vegetation cover recovery plan (Along the river)

N°	Location (bank)		Length (m)	Width (m)	Area (ha)	Quantity (unit)	Distribution according to the specie (unit)		
							Willow	Casuarina	Total
Ca-1	General			0,0	0	―	―	―	―
Ca-2	Derecho	1.600	11	1,8	5.328	2.664	1.598	1.066	5.328
Ca-3	General			0,0	0	―	―	―	―
Ca-4	General			0,0	0	―	―	―	―
Ca-5	Derecho	1.750	11	1,9	5.624	2.812	1.687	1.125	5.624
Total		3.350		3,7	10.952	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 4.5.1.3(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 4.3.2.1-4, 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 4.3.2.1-4 Unitary cost of plants

Watersheds	Species	Unitary cost (unitary price + transportation) (in Soles/plant)
Cañete	Eucalipto	1,4
	Huarango	1,6
	Casuarina	1,9

ii) Labor cost

Reforestation work performance ratio was determined in 40 trees/person-day according to the information gathered through interviews to AGRORURAL and to irrigator commissions. As to riverside reforestation, the labor unitary cost will be 33.6 Soles/man-day. In the high Watershed 16.8 Soles/man-day, corresponding to half of the first one.

iii) Reforestation execution cost

Work costs for the forestry and vegetation cover recovery plan in the riverside structures are detailed in Table 4.3.2.1-5.

Table 4.3.2.1-5 Forestry work cost

Watershed	Code	Cost		
		Plants	Labor	Total
Cañete	Ca-1			
	Ca-2	8.312	4.476	12.788
	Ca-3			
	Ca-4			
	Ca-5	6.074	4.724	10,798
Total		14.386	9.200	23.586

(Source: JICA Study Team)

6) **Implementation process plan**

The Process Plan of forestry works in riverbanks is part of the coastal structure, thus the same will be considered for the Construction Plan of the Coastal Structure. Forestry 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 forestry, it is most convenient is to take advantage of water rise, but according to the Construction Process Plan of the coastal structure there are no major forestry issues in seasons where water level is low, if the execution schedule of water structures require so. The gravity irrigation system can only 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	Bank erosion and river bed change	Bank erosion and river bed change Sediment flow from ravines
Measures	Erosion control → Bank protection Control of riverbed variation → compaction of ground, bands (compaction of ground in the alluvial cone, bands)	Erosion control → bank protection Riverbed variation control →compaction of ground, bands (compaction of ground in the alluvial cone, bands) Sediment flow → protection of slopes, sediment control dams

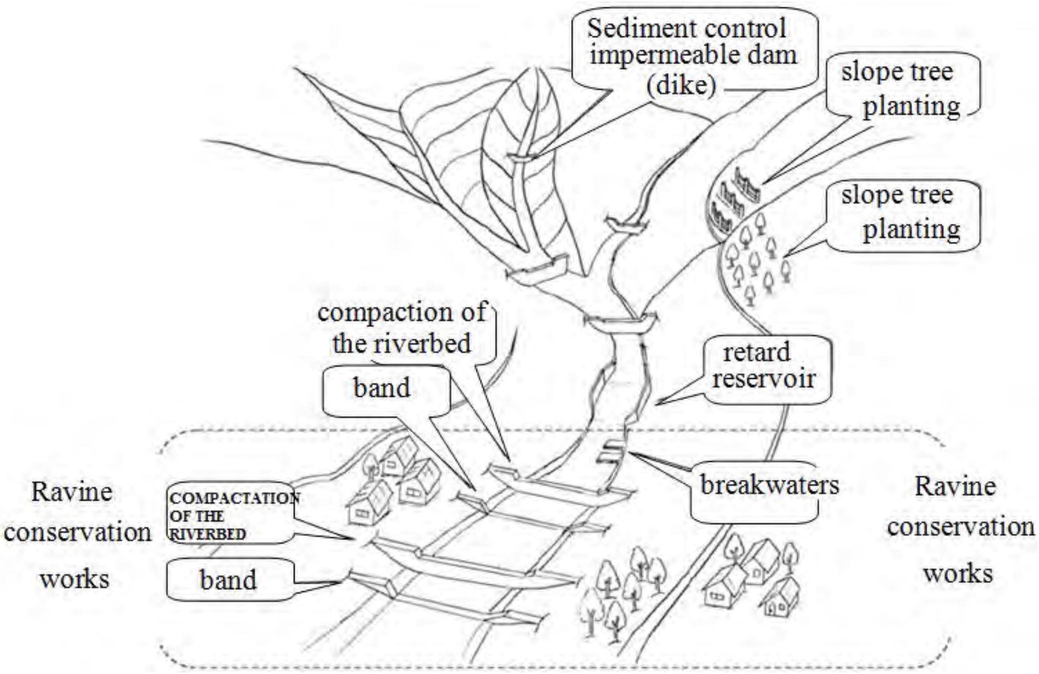


Figure 4.3.2.2-1 Sediment control works

1) Sediment control plan in the upper Watershed

The next section 4.12 “Medium and long term Plan” 4.12.3 “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.

Below are the analysis results on the riverbed variation in the Cañete River with the Poechos dam.

Total volume of dragged sediment (in thousands of m^3)	3.000
Annual average of dragged sediment (in thousands of m^3)	60
Total volume of riverbed variation (in thousands of m^3)	673
Annual average of variation of riverbed height (m)	0.2

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.

(1) 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".

(2) 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.

(3) 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.

(4) Activities

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

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

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 144,050 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

Item	Activities	Unit	Unit price(soles)	No.of basin	Amount(soles)
1.0	**Knowledge on river bank protection action in consideration of agriculture and natural environment**				
1.1	Workshop on operation and maintenance of facilites	event	9,300	1	9,300
1.2	Workshop on river bank plantation management	event	9,300	1	9,300
	Prevention and mitigation for erosion	event	9,300	1	9,300
	Natural resources management	event	9,300	1	9,300
2.0	**Preparation of community disaster management plan for flood control**				
2.1	Workshop on risk management plan	event	8,370	1	8,370
2.2	Details of 2.1	event			
	Community activity planning in consideration of ecological zoning	event	12,200	1	12,200
	Risk management	event	12,200	1	12,200
	Resource management	event	12,200	1	12,200
	Preparation of community disaster management plan	event	12,200	1	12,200
2.3	Preliminary flood forecasting and warning	event			
	Risk management and early warning system	event	9,300	1	9,300
	Joint activity with local government, users' association, etc.	event	5,580	1	5,580
3.0	**Hillside management for river sedimentation prevention**				
3.1	Field works for hillside conservation technique	event	7,500	1	7,500
	Forest seedling productions	event	7,900	1	7,900
	Forest planatation setting up	event	7,900	1	7,900
	Forest resource management and conservation		7,900	1	7,900
3.2	Difusion of posters and leaflet		3,600	1	3,600
	Total				**144,050**

(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 costs include the following:

① Work direct costs = total number of works by type × unit price
② Common provisional works = ① x 10%
③ Construction cost -1 = ① + ②
④ Miscellaneous = ③ x 15%
⑤ Benefits = ③ x 10%
⑥ Construction cost -2 = ③+④+⑤
⑦ Tax = ⑥ x 18% (IGV)
⑧ Construction cost = ⑥+⑦
⑨ Environmental measures cost = ⑧ x 1%
⑩ Detailed design cost = ⑧ x 5%
⑪ Works supervision cost = ⑧ x 10%
⑫ Project Cost = ⑧+⑨+⑩+⑪

(2) Work direct costs

On table 4.4.1-1 a summary table of direct costs for structural measures is presented for the Cañete River Watershed.

(3) Project Costs

The project cost is estimated in 25.7 million of soles as shown in Table 4.4.1-2. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance. The annual operation and maintenance cost of completed works is approximately 0.5% of the project's cost.

Table 4.4.1-1 Summary Table of the work's direct cost (at private prices)

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Direct Cost 直接工事費計 (1)
Rio Cañete	1	4.0K～5.0K	Flow desilting	河床掘削	2,250,000
	2	6.5K～8.1K	Dike building + coastal defense	築堤・護岸工	2,786,000
	3	10.0K～11.0K	Flow desilting	築堤・護岸工・河床掘削	2,656,000
	4	24.25K～24.75K	intake channel wall + desilting	導流壁・河床掘削・築堤・護岸工	2,822,000
	5	24.75K～26.5K	Coastal defense	築堤・護岸工	2,985,000
				SUB TOTAL	13,499,000

Table 4.4.1-2 Project Cost (at private prices)

Watershed 流域名	PRIVATE PRICES COSTS															
	COMPONENT A														COMPONENT B	TOTAL COST OF THE PROGRAM 全体事業費
	STRUCTURAL MEASURES												NON STRUCTURAL MEASURES 非構造物対策		TECHNICAL ASSISTANCE 能力開発	
	DirectCost(直接工事費)			INDIRECT COST (間接工事費)								HYDRAULIC INFRASTRUCTURE Total Cost 構造物・事業費	REFORESTATION Total Cost 植林/植生回復事業費	EARLY ALERT SYSTEM Total Cost 洪水予警報事業費	TRAINING Total Cost 防災教育事業費	
	Direct Cost 直接工事費計	Temporary works cost 共通仮設費	Works Cost 工事費	Operative Expenses 諸経費	Utility 利益	Total Cost of Infrastructure 構造物工事費	TAX 税金	Total work cost 建設費	Environmental Impact 環境影響	Technical FIle 詳細設計	Supervision 施工管理費					
	(1)	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)	(13)	(14)	(15)	(16) = (12)+(13)+(14)+(15)
CAÑETE	13.499.000	1.349.900	14.848.900	2.227.335	1.484.890	18.561.125	3.341.003	21.902.128	219.021	1.095.106	2.190.213	25.406.468	40.397	0	219.105	25.665.970

4.4.1 Cost Estimate (at social prices)

(1) Work direct costs

In Table 4.4.2-3 a summary table of direct costs for structural measures is presented for the Cañete River watershed. The works' direct cost at private prices was turned into social prices applying the conversion factor.

(2) Project Costs

The project cost is estimated in 20.6 million of soles as shown in Table 4.4.2-4. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance, before converting from private prices.

Table 4.4.2-3 Summary Table of the work's direct cost (at social prices)

Watershed 流域名	Critical Points クリティカル・ポイント		Measures	対策	Private Prices 民間価格 (PP)	Correction Factor 係数 (fs)	Social Price 社会価格 (PS) =
Rio Cañete	1	4.0K～5.0K	Flow desilting	河床掘削	2.250.000	0,804	1.809.000
	2	6.5K～8.1K	Dike building+coastal defense	築堤・護岸工	2.786.000	0,804	2.239.944
	3	10.0K～11.0K	Flow desilting	築堤・護岸工・河床掘削	2.656.000	0,804	2.135.424
	4	24.25K～24.75K	Intake channel wall + desilting	導流壁・河床掘削・築堤・護岸	2.822.000	0,804	2.268.888
	5	24.75K～26.5K	Coastal Defense	築堤・護岸工	2.985.000	0,804	2.399.940
				SUB TOTAL	13.499.000		10.853.196

Table 4.4.2-4 Project cost (at social prices)

Watershed 流域名	SOCIAL PRICES COSTS															
	COMPONENT A														COMPONENT B	TOTAL COST OF THE PROGRAM 全体事業費
	STRUCTURAL MEASURES												NON STRUCTURAL MEASURES 非構造物対策		TECHNICAL ASSISTANCE 能力開発	
	DIRECT COST(直接工事費)			INDIRECT COST (間接工事費)								HYDRAULIC INFRASTRUCTURE Total Cost 構造物・事業費	REFORESTATION Total Cost 植林/植生回復事業費	EARLY ALERT SYSTEM Total Cost 洪水予警報事業費	TRAINING Total Cost 防災教育事業費	
	Direct Cost 直接工事費計	Temporal works cost 共通仮設費	Works Cost 工事費	Operative Expenses 諸経費	Utility 利益	Infrastructure total cost 構造物工事費	TAX 税金	Work's Total Cost 建設費	Environmental Impact 環境影響	Technical File 詳細設計	Supervision 施工管理費					
	(1)	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)	(13)	(14)	(15)	(16) = (12)+(13)+(14)+(15)
CAÑETE	10.853.196	1.085.320	11.938.516	1.790.777	1.193.852	14.923.145	2.686.166	17.609.311	176.093	880.466	1.760.931	20.426.800	31.517	0	189.759	20.648.077

4.5 Social Assessment

4.5.1 Private prices

(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

- Determine 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)
- After, 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 (Cañete 1 to 5).
- Determine the difference between ① and ②. Add the benefits of other works different than dikes (intakes, roads and dams 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 flood 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.

a. Dams damage

The loss amount due to dam damage is calculated by adding the direct loss (dam'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)

b. 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-trafficability (usually in Peru it takes five days to complete the rehabilitation of a temporary road)

2) Loss estimated amount according to disasters in different return periods

In table 4.5.1-2 the amounts of loss with and without Project are shown. These are estimated for disasters of different return periods in the Cañete River.

Table 4.5.1-2 Loss Estimated Value (at private prices)

(s./1,000)

Case	t	Cañete
Without Project	2	1,660
	5	6,068
	10	73,407
	25	98,357
	50	149,018
	Total	328,510
With Project	2	153
	5	832
	10	8,413
	25	11,776
	50	16,428
	Total	37,602

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

The annual average loss amount that is expected to be reduced by the Project by the total annual average loss amount occurred as flow multiplying the amount of loss reduction occurred as flow for the corresponding flood probabilities.

Considering that floods happen probabilistically, the annual benefit is determined as the annual average amount of loss reduction. Next find the procedures of calculation.

Table 4.5.1-3 Loss reduction annual average 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			$d_1+d_2+d_3+d_4+d_5+d_6+d_7$			

In Table 4.5.1-4 Results of loss amount calculus are presented (annual average), which are expected to be reduced when implementing the Project in the Cañete River Watershed.

Table 4.5.1-4 Annual average of damage reduction (private prices)

s/1000

流域 Watershed	流量規模 Retunr Period	超過確率 Probability	被害額 (Total damage – thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①－② Mitigated damages ③=①－②	区間平均被害額 ④ Damage Avergare	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
CAÑETE	1	1,000	0	0	0			0	0
	2	0,500	1.660	153	1.507	754	0,500	377	377
	5	0,200	6.068	832	5.236	3.372	0,300	1.012	1.388
	10	0,100	73.407	8.413	64.994	35.115	0,100	3.512	4.900
	25	0,040	98.357	11.776	86.581	75.787	0,060	4.547	9.447
	50	0,020	149.018	16.428	132.589	109.585	0,020	2.192	11.639

(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 4.5.1-5 Analysis assessment indicators of cost-benefit relation

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

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. In this Study the following SCF values were used:

Dams 0.804

Gabions 0.863

Intakes 0.863

TAX (Peruvians use IGV) is not taken into account in the conversion of market prices to socioeconomic prices.

iii) Other preliminary conditions

Price level: 2010

Social discount rate: 10%

Annual maintenance cost: 0.5% of construction cost

3) Cost-benefit relation analysis (C/B)

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 4.5.1-6 results of calculations C/B, NPV and IRR to private prices is shown.

Table 4.5.1-6 Social Assessment (C/B, NPV, IRR) (at private prices)

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Cañete	151.304.096	68.325.931	25.665.970	1.423.638	2,96	45.266.114	36%

4.5.2 Costs at social prices

(1) Benefits

1) Estimated loss amount according to different return periods

In table 4.5.2-1 the amounts of loss with and without Project are shown. These are estimated for disaster of different return periods in the Cañete River Watershed.

Table 4.5.2-1 Estimated loss amount (at social prices)

千ソーレス

Case ケース	t 確率年	Cañete
Without Project 事業を実施しない場合	2	2,582
	5	10,558
	10	105,137
	25	144,972
	50	213,134
	Total	476,384
With Project 事業を実施した場合	2	272
	5	1,024
	10	9,908
	25	14,260
	50	20,117
	Total	45,580

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

In table 4.5.2-2 results of loss amount calculation (annual average) that are expected to reduce to implement the Project in the Cañete River are shown.

Table 4.5.2-2 Annual average of damage reduction (at social prices)

s/1000

流域 Watershed	流量規模 Retunr Period	超過確率 Probability	被害額 (Total damage - thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①−② Mitigated damages ③=①−②	区間平均被害額 ④ Damage Avergare	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,582	272	2,311	1,155	0.500	578	578
	5	0.200	10,558	1,024	9,534	5,922	0.300	1,777	2,354
	10	0.100	105,137	9,908	95,229	52,382	0.100	5,238	7,593
	25	0.040	144,972	14,260	130,712	112,971	0.060	6,778	14,371
	50	0.020	213,134	20,117	193,018	161,865	0.020	3,237	17,608

(2) Social Assessment

In table 4.5.2-3 results of the calculation C/B, NPV and IRR at social prices are shown.

Table 4.5.2-3 Social Assessment (C/B, NPV, IRR) (at social prices)

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Cañete	228,904,527	103,368,747	20,648,077	1,144,605	5.57	84,817,688	62%

4.5.3 Social assessment conclusions

The social assessment shows that the Project in Cañete River watershed has a high economic impact on private and social prices. Also, the following economical non-quantifiable positive impacts are shown:

- 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

	Watershed	Variables	Base Case	Case 1 Cost increase 5%	Case 2 Cost increase 10%	Case 3 Benefit reduction 5%	Case 4 Benefit redcution 10%	Case 5 Discount rate increase 5%	Case 6 Discount rate increase 10%
Private prices	CAÑETE	IRR (%)	36%	35%	33%	35%	33%	36%	36%
		B/C	2,96	2,82	2,69	2,81	2,67	2,28	3,99
		NPV(s)	45.266.114	44.113.123	42.960.132	41.849.817	38.433.521	27.605.013	74.293.435
Social prices	CAÑETE	IRR (%)	62%	60%	57%	60%	57%	62%	62%
		B/C	5,57	5,31	5,07	5,29	5,01	4,29	7,50
		NPV(s)	84.817.688	83.890.135	82.962.582	79.649.251	74.480.814	57.014.823	130.016.170

(3) Assessment of the sensitivity analysis

As to the sensitivity analysis of the Project, the socio economic conditions change do not affect the project viability within the scope of examination at both private price and social price.

4.7 Sustainability Analysis

This project will be co-managed 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. Usually the central government (in this case, the DGIH) takes the 80%, irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both parties. 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.

Table 4.7-1 presents the data of the budget for irrigation committees of Cañete River Watershed in recent years.

Table 4.7-1 Project Budget of the irrigation commissions

Rivers	Annual Budget				(In soles)
	2006	2007	2008	2009	2010
Cañete River	2.355.539,91	2.389.561,65	2.331339,69	2.608.187,18	2.421.157

(1) Profitability

The project in Cañete river Watershed is sufficiently profitable and highly sustainable. The investment amount in this watershed is estimated in 25.7 million soles at private prices. However, the C/B relation is 5.57, the internal return rate is = 62% approx. and the NPV is estimated in 84.8 million soles. These figures show that the project's economic efficiency is very high.

(2) Cost of operation and maintenance

The annual cost of operation and maintenance required for the project, having as a base year 2008 is estimated at 109,511 soles, corresponding to 0.5% of the project construction cost. On the other hand, the average operating expenses for the last 4 years of the irrigation commissions was 2,421,157 soles.

When considering that the annual operation and maintenance cost represents 4.5% of the annual expense of irrigation commissions, the project would be sustainable enough according to the financial capacity of these committees to maintain and operate the constructed works.

4.8 Environmental Impact

4.8.1 Procedure of Environmental Impact Assessment

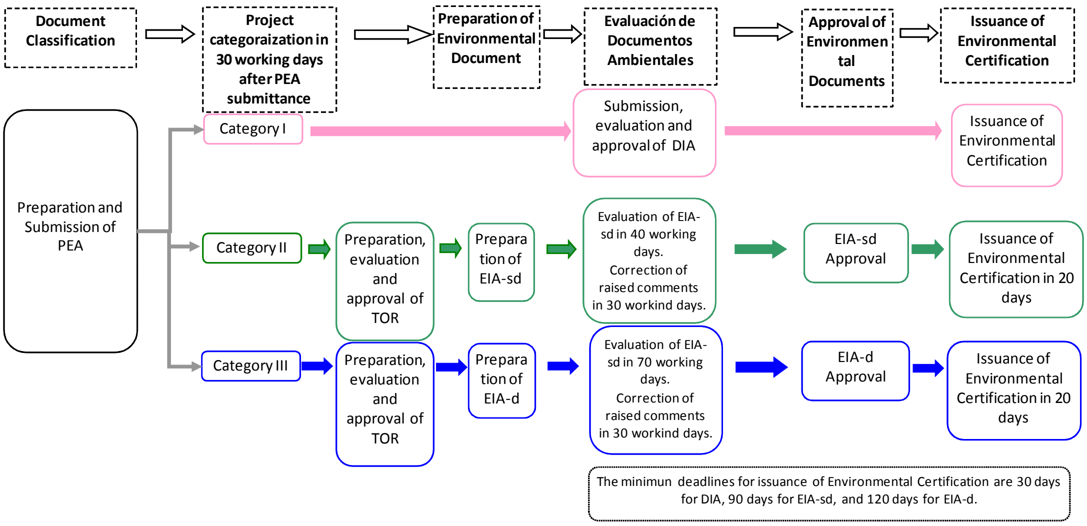
Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The following table shows the environmental management instruments that are required for each category. The Project holder 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 4.8.1-1 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 4.8.1-1 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 4.8.1-2 describes "working sites" to be considered in the Environmental Impact section for Cañete river.

Table 4.8.1-2 Works Description

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Cañete	1	4.3km	Narrow Section	Road bridge	Riverbed excavation	Ex.width ; 100m Ex. depth ; 1.0m L ; 1,000m	4.0km～5.0km(total)
	2	6.8k～8.0k	Inundation	Crop land	Revetment	H ; 2.0m slope ; 1:3 L ; 1,200m	6.5km～8.1km(right bank)
	3	10.25k	Narrow Section		Riverbed excavation	Ex.width ; 100m Ex. depth ; 1.0m L ; 1,000m	10.0km～11.0km(total)
	4	24.5k	Intake		Diversion weir	Weir width ; 150m H ; 3.0m T ; 2.0m	24.25km～24.75km(total)
	5	25.0k, 26.25k	Erosion	Road	Revetment	H ; 2.0m Slope ; 1:3 L ; 750m	24.75km～26.5km(right bank)

Source: JICA Study Team

4.8.2 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 4.8.2-1 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 4.8.2-2 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

4.8.3 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 4.8.3-1 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						
Environment	**Component**	**Environmental Factors**	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**
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 4.8.2 Methodology. The following tables show the environmental and social assessment results for each basin, during the construction and operation stages.

Table 4.8.3-2 Environmental Impact Assessment Matrix – Cañete River

Medio	Componente	Acciones del proyecto	The Cañete River Basin															
			Construction Stage											Operation Stage				
			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.

4.8.4 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 4.8.4-1 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

4.8.5 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:

<u>Water Quality and Biological Parameters:</u>

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 4.8.5-1 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 4.8.5-2 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

Noise Quality

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 4.8.5-3, the terms are described.

Table 4.8.5-3 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 4.8.5-4 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	^oC			
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.

4.8.6 Cost for the environmental impact management

The direct costs of previously mentioned measures to mitigate environmental impacts in the Cañete River Watershed is shown in the Table 4.8.6-1. In any case, it is necessary to determine in detail these measures' budget for the watershed in the detailed design stage.

Table 4.8.6-1 Direct costs of measures to manage environmental impact

Actions	Unit	Qty	Unitary price (S/.)	Subtotal (S/.)	Total (s/.)
Sign for vehicles entrance	Month	6	S/. 1.400,0	S/. 8.400,0	S/. 8.400,0
Industrial weaste transportation	Month	6	S/. 4.200,0	S/. 25.200,0	S/. 25.200,0
Project sites landscape protection measures	Month	6	S/. 2.800,0	S/. 16.800,0	S/. 16.800,0
Operation and maintenance of construction equipment	Month	6	S/. 1.960,0	S/. 11.760,0	S/. 11.760,0
Measures for staff noise protection	Month	6	S/. 1.120,0	S/. 6.720,0	S/. 6.720,0
Functioning expenses to implement environmental impact mitigation measures	Month	6	S/. 4.480,0	S/. 26.880,0	S/. 26.880,0
Soil and air contaminant prevention capacity development	Month	6	S/. 2.520,0	S/. 15.120,0	S/. 15.120,0
Bed and aquatic fauna monitoring					S/. 11.239,2
Diversity indicators monitoring	times	3	S/. 672,0	S/. 2.016,0	
Water flow monitoring	times	3	S/. 588,0	S/. 1.764,0	
Tº, pH, OD monitoring	times	3	S/. 571,2	S/. 1.713,6	
DBO monitoring	times	3	S/. 638,4	S/. 1.915,2	
Total solids dissolve monitoring (SDT)	times	3	S/. 638,4	S/. 1.915,2	
Total suspended solids monitoring (SST)	times	3	S/. 638,4	S/. 1.915,2	
Air and noise quality monitoring					S/. 37.500,0
Gas emissions monitoring	times	3	S/. 4.500,0	S/. 13.500,0	
Dust monitoring	times	3	S/. 5.000,0	S/. 15.000,0	
Noise monitoring	times	3	S/. 3.000,0	S/. 9.000,0	
Total					S/. 159.619,2

4.8.7 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.

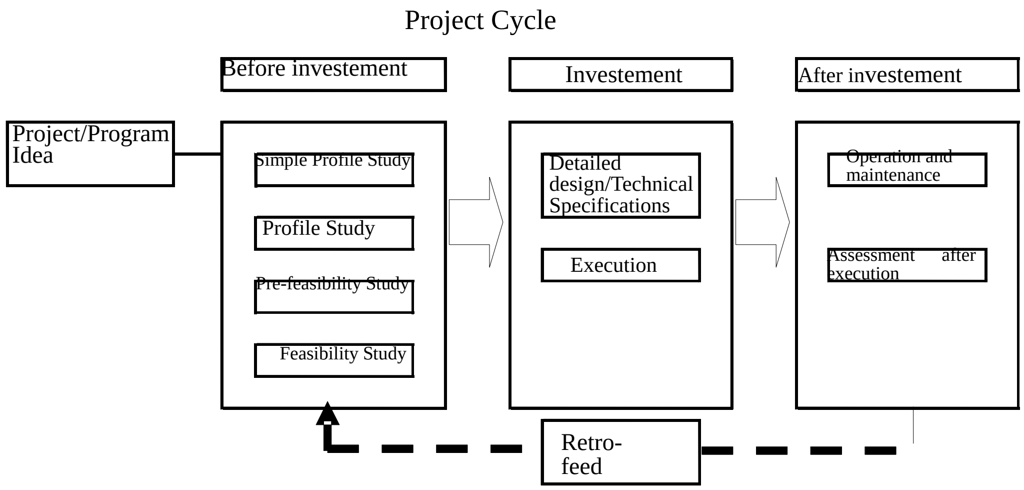
4.9 Execution Plan

The Project's Execution Plan will review the preliminary schedule, which includes the following components. For pre-investment stage: ① full execution of pre-feasibility 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.

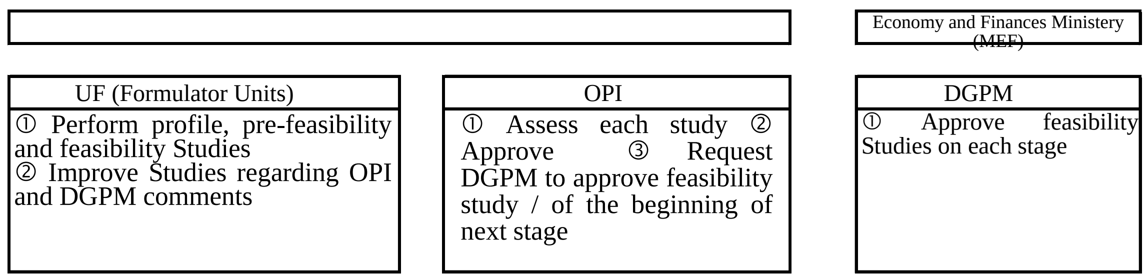


(Source: DGPM HP)

Figure 4.9-1 SNIP Cycle Project

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 quite different in each stage, in SNIP procedures, the project's training unit (UF) conducts studies of each stage, the Planning and Investment Office (OPI) assesses and approves the UF's presented studies and requests Public Sector Multi-Annual Programming General Direction (hereinafter referred DGPM) to approve feasibility studies and initiation of following studies. Finally DPGM evaluates, determines and approves the public investment's justification.



(See Regulation No.001-2009-EF/68.01.)

Figure 4.9-2 Related Institutions to SNIP

Due to the comments of examining authorities (OPI and DGPM) to FU, 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.

(2) Yen loan contract

Once the feasibility studies reports are submitted and examined in SNIP, discussions on the loan in yen will begin. It is estimated to be a period of 6 months for procedures.

(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 development of detailed design and technical specifications, the contractors' selection and the work's supervision. Table 4.9-1 presents the Project's overall schedule.

1) Consultant selection: 3 months, builder selection: 3 months

2) Develop detailed design and technical specifications of the work's period

① River and re-forestation works along these works

Detailed design and technical specifications elaboration: 6 months

Working Period: 2 years

② Capacity Building

It will be executed on the same work period of river facilities.

Detailed design and technical specifications elaboration: 6 months

Working Period: 2 years

Table 4.9-1 Implementation Plan

	ITEMS	2010	2011	2012	2013	2014	2015	2016
1	PROFILE STUDY / SNIP ASSESSMENT	STUDY		EVALUATION				
2	FEASIBILITY STUDY / SNIP ASSESSMENT		STUDY	EVALUATION				
3	YEN CREDIT NEGOTIATION							
4	CONSULTANT SELECTION							
5	CONSULTANT SERVICE (DETAILED DESIGN, LAWFUL DOCUMENTS PREPARATION)			DESIGN / LAWFUL DOCUMENT			WORK SUPERVISION	
6	BUILDER SELECTION							
7	WORK EXECUTION							
1)	STRUCTURES BUILDING							
2)	REFORESTATION							
3)	EARLY ALERT SYSTEM							
4)	DISASTER PREVENTIVE TRAINING							
8	FINISH WORK / DELIVERY TO USERS BOARDS							

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:

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 DGIH project management is dedicated to calculate project costs, detail design and supervision of the works execution. The study direction conducts studies for projects and planning formation

＊ The Planning and Investment Office (IPO) 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 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 (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 DGPM 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 DNEP from the Economy and Finance Ministry and **OGA-MINAG**

＊The Public Debt National Direction (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, the investment stage (Project execution) corresponds to PSI from MINAG. The PSI is currently performing JBIC projects, etc. and in case of beginning a new project, it forms the correspondent Project Management Unit (UGP), who is responsible of choosing the consulting firm, hire construction services, works supervision, etc. The following figure describes the structure of the different entities involved in the Project's execution stage.

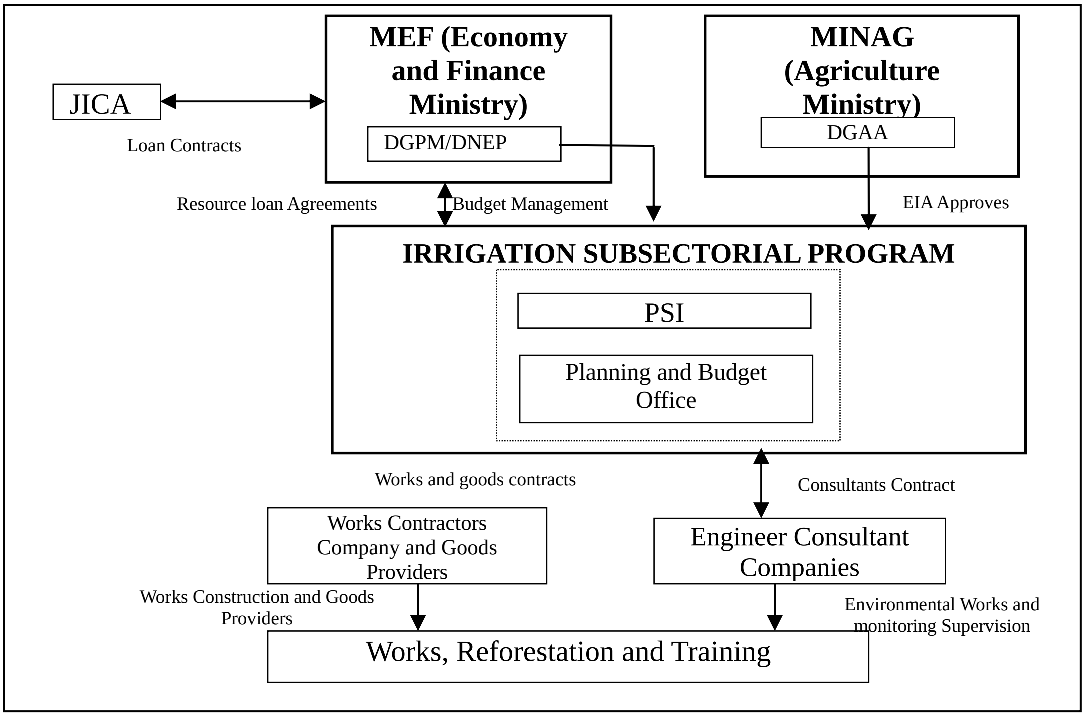


Figure 4.10-1 Related institutions to the Project's execution (investment stage)

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. Likewise, they should pay the construction costs in credits mode. Next, the relationship of different organizations involved in post-project implementation stage is detailed.

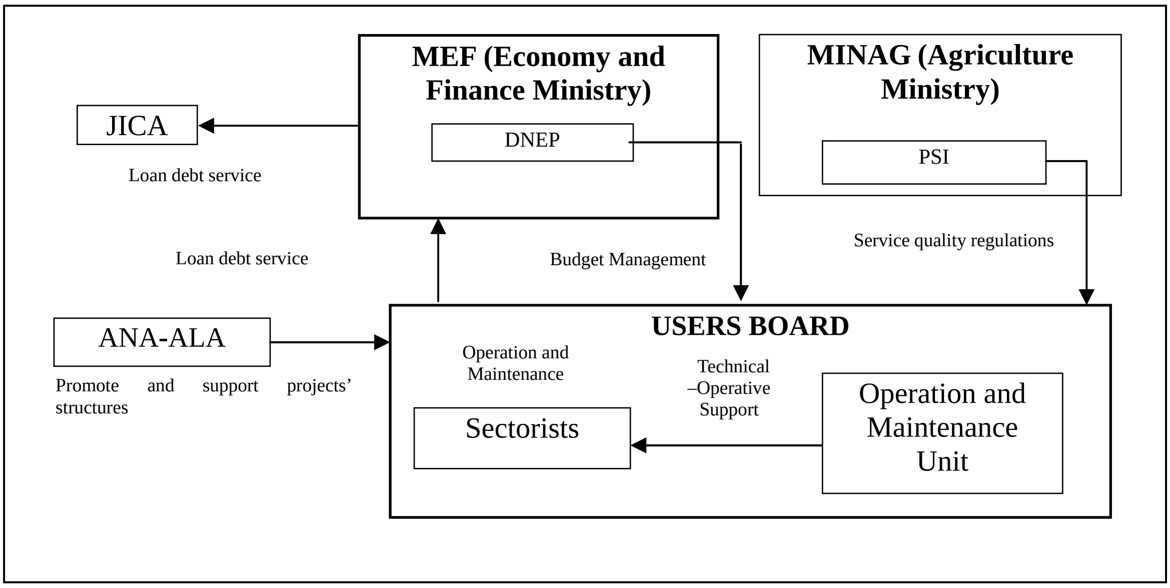


Figure 4.10-2 Institutions related to the Project (operation and maintenance stage)

(2) 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 conformed 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:

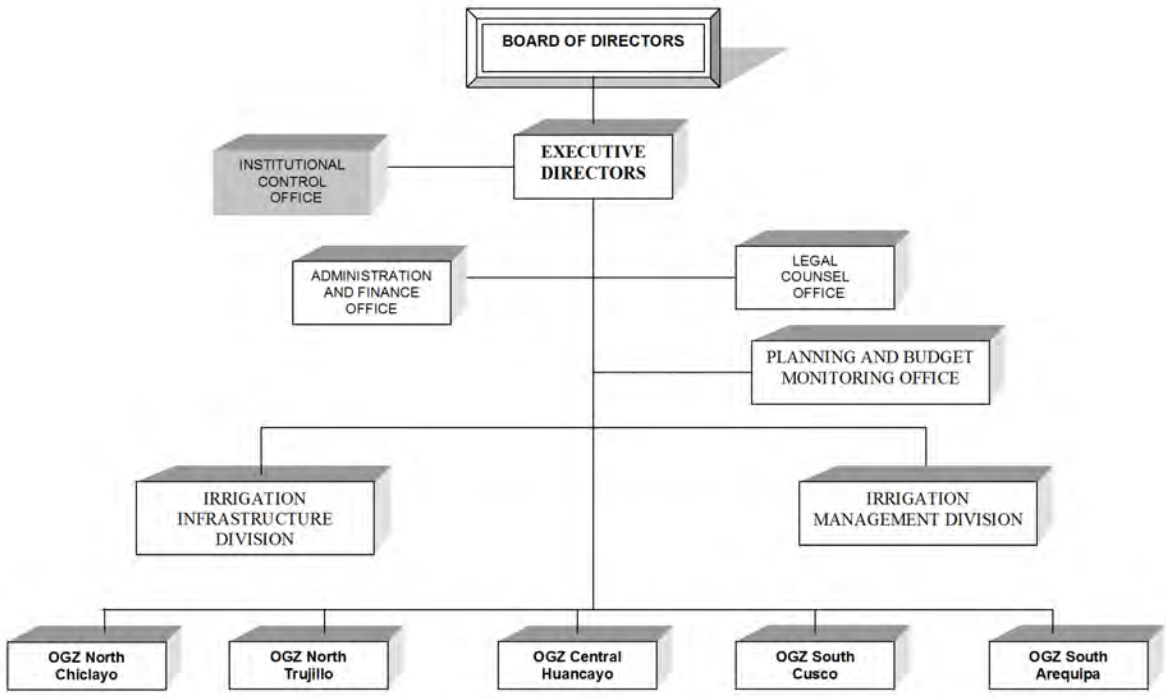


Figure 4.10-3 Organization of PSI

4.11 Logical framework of the eventually selected option

In Table 4.11-1 the logical framework of the definite selected option is shown.

Table 4.11-1 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	Scio-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 areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, bank erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, bank erosion progress and watershed's downstream erosion.	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, road damages prevention, construction of 28 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			
B-1 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

4.12 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.

4.12.1 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, and the dike's standard section will be determined as already mentioned in section 4.3.1, 5), 1). 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 4.12.1-1 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.

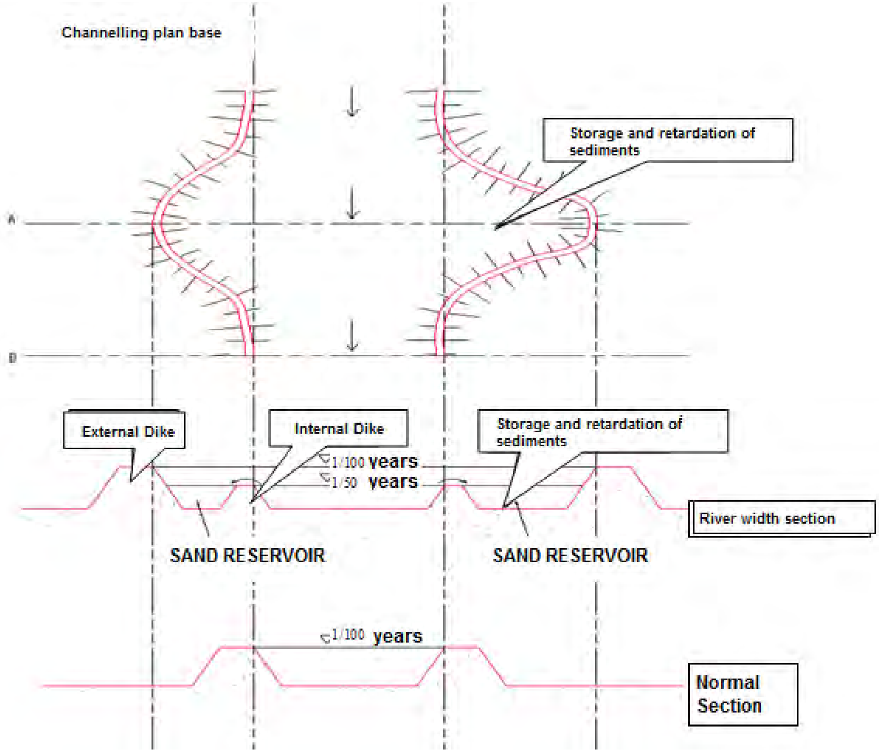


Figure 4.12.1-1 Definition of dike alignment

5) Plan and section of river

The plan and longitudinal section of river are as shown in the Figure 4.12.1-2 and -4.12.1-3.

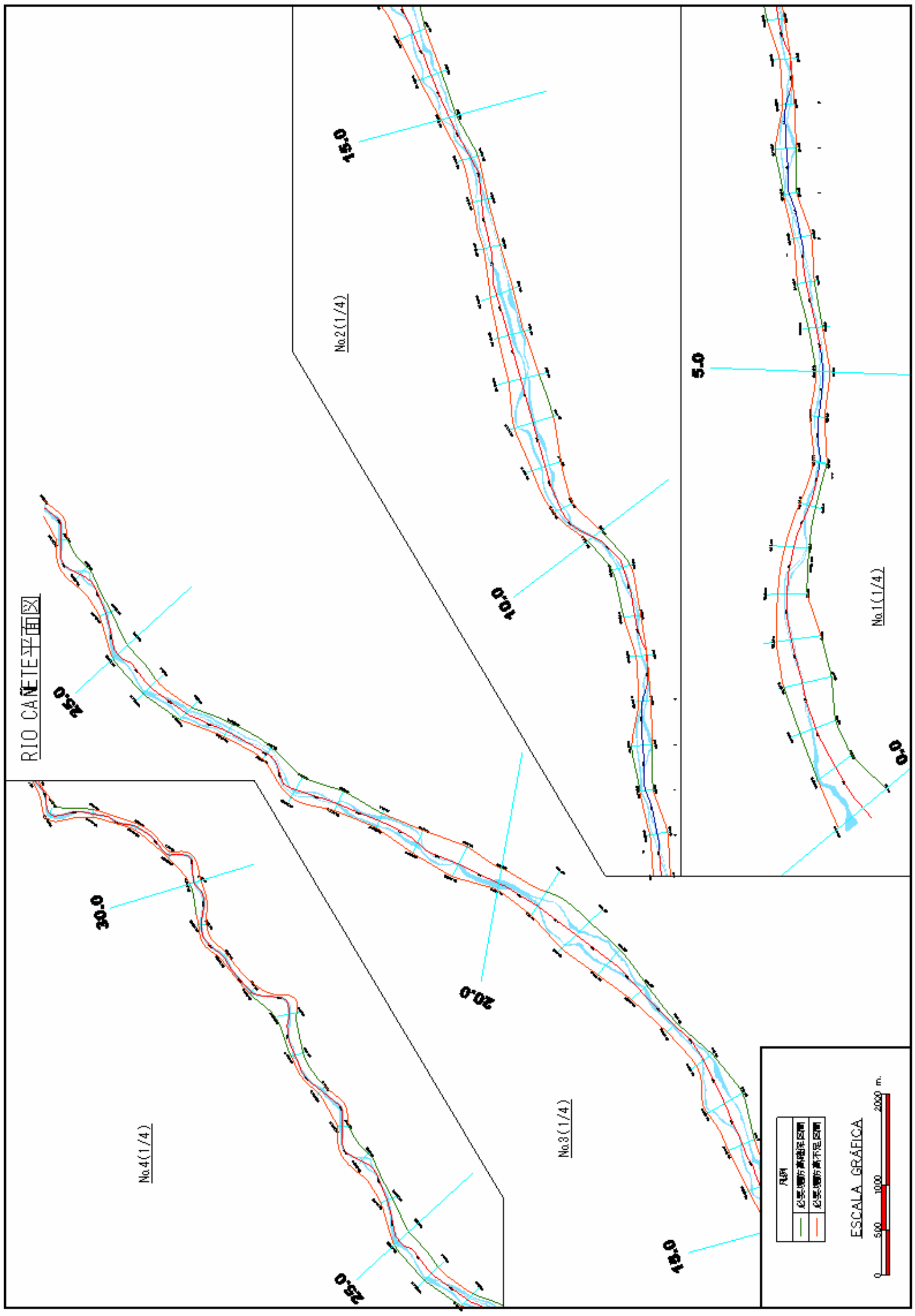


Figure 4.12.1-2 Plan of Cañete River

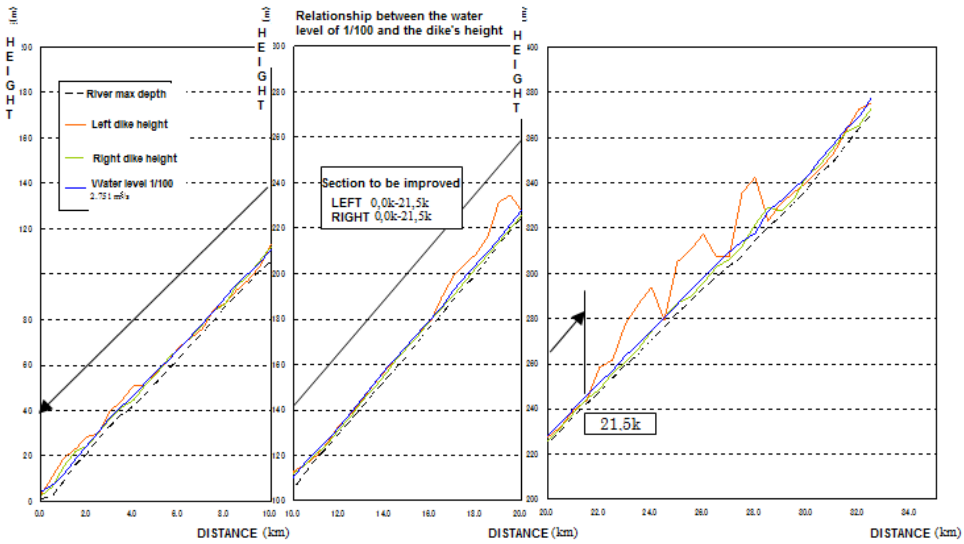


Figure 4.12.1-3 Cañete River Longitudinal Profile

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 4.12.1-1 and Figure 4.12.1-4 show the dike's construction plan on the Cañete River.

Table 4.12.1-1 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

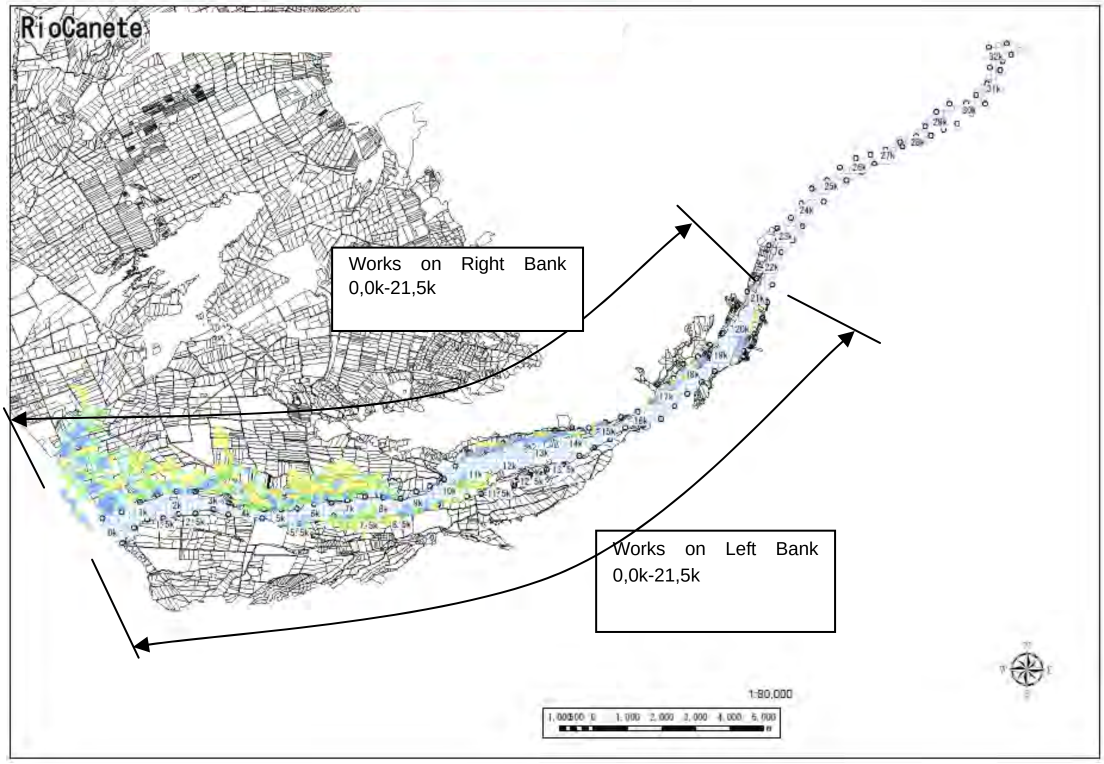


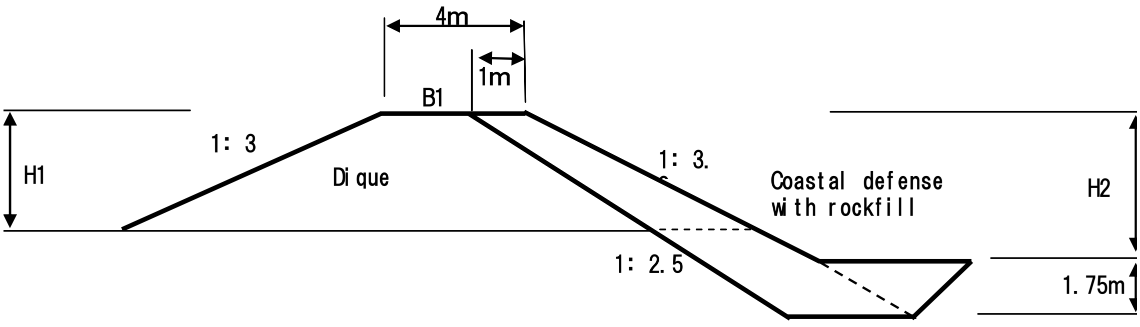
Figure 4.12.1-4 Cañete River dike construction works approach

7) Project Cost

In Tables 4.12.1-2 and 4.12.1-3 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 4.12.1-4.

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)	(km)	(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 4.12.1-3 Projects' Cost (at private prices)

Basin	DIRECT COST			INDIRECT COST								Total Cost
	Direct Cost	Temporary Works cost	WORKS COST	OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	
	(1)	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)
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 4.12.1-4 Projects' Cost (at social prices)

Basin	DIRECT COST			INDIRECT COST								Total Cost
	Direct cost	Temporary Works cost	WORKS COST	OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	(12) = (8)+(9)+(10)+(11)
	(1)	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)
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

2) Operation and Maintenance Plan

The operation and maintenance cost was calculated identifying the trend of the sedimentation and erosion bed 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 gathering 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) Bed variation analysis

Figure 4.12.1-5 shows the results of the Bed variation analysis of the Cañete River for the next fifty years. From this figure a projection of the bed's sedimentation and erosion trend and its respective volume can be made.

2) Sections that need maintenance

In table 4.12.1-5 possible sections that require a process of long-term maintenance in the Cañete River watershed is shown.

3) Operation and maintenance cost

Next the direct work cost at private prices for maintenance (bed excavation) required for each watershed in the next 50 years is shown.

Direct Work Cost

At private prices: 422,000 m^3 x 10 soles = 4,220,000 soles

Tables 4.12.1-6 and 4.12.1-7 show a 50 year Project cost at private and social prices.

Table 4.12.1-5 Sections which bed must be excavated in a programmed way

River	Excavation extension		Maintenance method
Cañete	Section 1	Section: km 3,0km-7,0km Volume：135.000m^3	There are sections were the water overflow. It is considered necessary to perform periodic excavation in this section because the bed will elevate gradually in time.
	Section 2	Section: km100,0-km 101,0 EarthVolume: 460.000 m^3	This section can be elevated due to to the lack of capacity to scour nough dragged sediments. It is considered necessary to perform periodic excavation in this sections because its bed will gradually increase in time.

* Sediments volume that will gather in a 50 year period

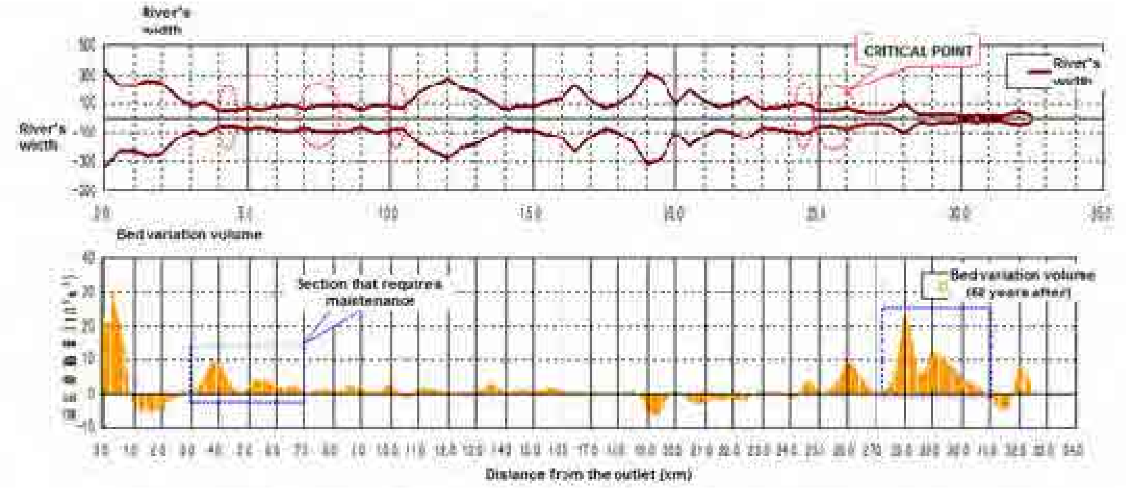


Figure 4.12.1-5 Section that requires maintenance (Cañete River)

Table 4.12.1-6 Excavation Works cost for a 50 year bed (at private prices)

流域名	DIRECT COST Costo Directo	Costo de Obras Temporales	WORKS COST	INDIRECT COST OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	構造物・事業費 (12) = (8)+(9)+(10)+(11)
	-1	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	0
Cañete	4,220	422	4,642	696	464	5,803	1,044	6,847	68	342	685	7,942

Table 4.12.1-7 Excavation Works cost for a 50 year bed (at social prices)

流域名	DIRECT COST Costo Directo	Costo de Obras Temporales	WORKS COST	INDIRECT COST OPERATIVE EXPENSES	UTILITY	INFRASTRUCTURE TOTAL COST	TAX	WORKS TOTAL COST	ENVIRONMENTAL IMPACT	TECHNICAL FILE	SUPERVISION	構造物・事業費 (12) = (8)+(9)+(10)+(11)
	-1	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	0
Cañete	4.220	422	4.642	696	464	5.803	1.044	5.505	55	275	550	6.386

(3) Social Assessment

1) Private prices cost

i) Damage amount

Table 4.12.1-8 shows the damage amount calculated analyzing the overflow caused by floods in the Cañete River with return periods between 2 and 50 years.

Table 4.12.1-8 Amount of damage for floods of different return periods (at private prices)

	Damages in thousand S/. 被害額(千ソーレス)
Return Period (t)	Cañete
2	1,660
5	6,068
10	73,407
25	98,357
50	149,018

ii) Damage reduction annual average

Table 4.12.1-9 shows the damage reduction annual average of each watershed calculated with the data of Table 4.12.1-8.

iii) Project's Cost and the operation and maintenance cost

Table 4.12.1-3 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 4.12.1-6.

iv) Economic evaluation

In Table 4.12.1-10 the results of economic assessment are shown.

Table 4.12.1-9 Damage Reduction Annual Average

s/1000

民間価格:流域全体 (Pivate Prices for ALL watersheds)									
流域 Watershed	流量規模 Returnr Period	超過確率 Probability	被害額 (Total damages - thousand S/.)			区間平均被害額 ④ Damages Average	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of damages flow	年平均被害額の累計=年平均被害軽減期待額 Annual medial damages
			事業を実施しない場合① Without Project ①	事業を実施した場合② With Project ②	軽減額 ③=①−② Mitigated damages ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	1,660	0	1,660	830	0.500	415	415
	5	0.200	6,068	0	6,068	3,864	0.300	1,159	1,574
	10	0.100	73,407	0	73,407	39,737	0.100	3,974	5,548
	25	0.040	98,357	0	98,357	85,882	0.060	5,153	10,701
	50	0.020	149,018	0	149,018	123,687	0.020	2,474	13,175

Table 4.12.1-13 Economic assessment results (private prices costs)

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	171,269,615	77,341,963	104,475,371	8,236,962	0.81	-17,765,825	6%

2) Social prices cost

i) Damage amount

Table 4.12.1-11 shows the damage amount calculated analyzing the overflow caused by floods in the Majes-Camana River with return periods between 2 and 50 years in each watershed.

Table 4.12.1-11 Amount of damage for floods of different return periods (at social prices)

	Damages in thousand S/. 被害額(千ソーレス)
確率年(t)	Cañete
2	2,582
5	10,558
10	105,137
25	144,972
50	213,134
Total	476,384

ii) Damage reduction annual average

Table 4.12.1-12 shows the damage reduction annual average of each watershed calculated with the data of Table 4.12.1-11.

iii) Project's Cost and the operation and maintenance cost

Table 4.12.1-4 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 4.12.1-7.

iv) Economic evaluation

In Table 4.12.1-13 the results of economic assessment are shown.

Table 4.12.1-12 Damage Reduction Annual Average

s/1000

民間価格:流域全体 (Pivate Prices for ALL watersheds)									
流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damages - thousand S/.)			区間平均被害額 ④ Damages Average	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of damages flow	年平均被害額の累計=年平均被害軽減期待額 Annual medial damages
			事業を実施しない場合① Without Project ①	事業を実施した場合② With Project ②	軽減額 ③=①−② Mitigated damages ③=①−②				
CAÑETE	1	1.000	0	0	0			0	0
	2	0.500	2,582	0	2,582	1,291	0.500	646	646
	5	0.200	10,558	0	10,558	6,570	0.300	1,971	2,617
	10	0.100	105,137	0	105,137	57,848	0.100	5,785	8,401
	25	0.040	144,972	0	144,972	125,055	0.060	7,503	15,905
	50	0.020	213,134	0	213,134	179,053	0.020	3,581	19,486

Table 4.12.1-10 Economic assessment results (social prices costs)

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Cañete	253,314,406	114,391,764	83,998,198	6,622,517	1.50	37,925,103	18%

(4) 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.

4.12.2 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.

4.12.3 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 4.12.3-1 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. The results are shown in Table 4.12.3-1.

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 4.12.3-1 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/.)		
Camana-Majes	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

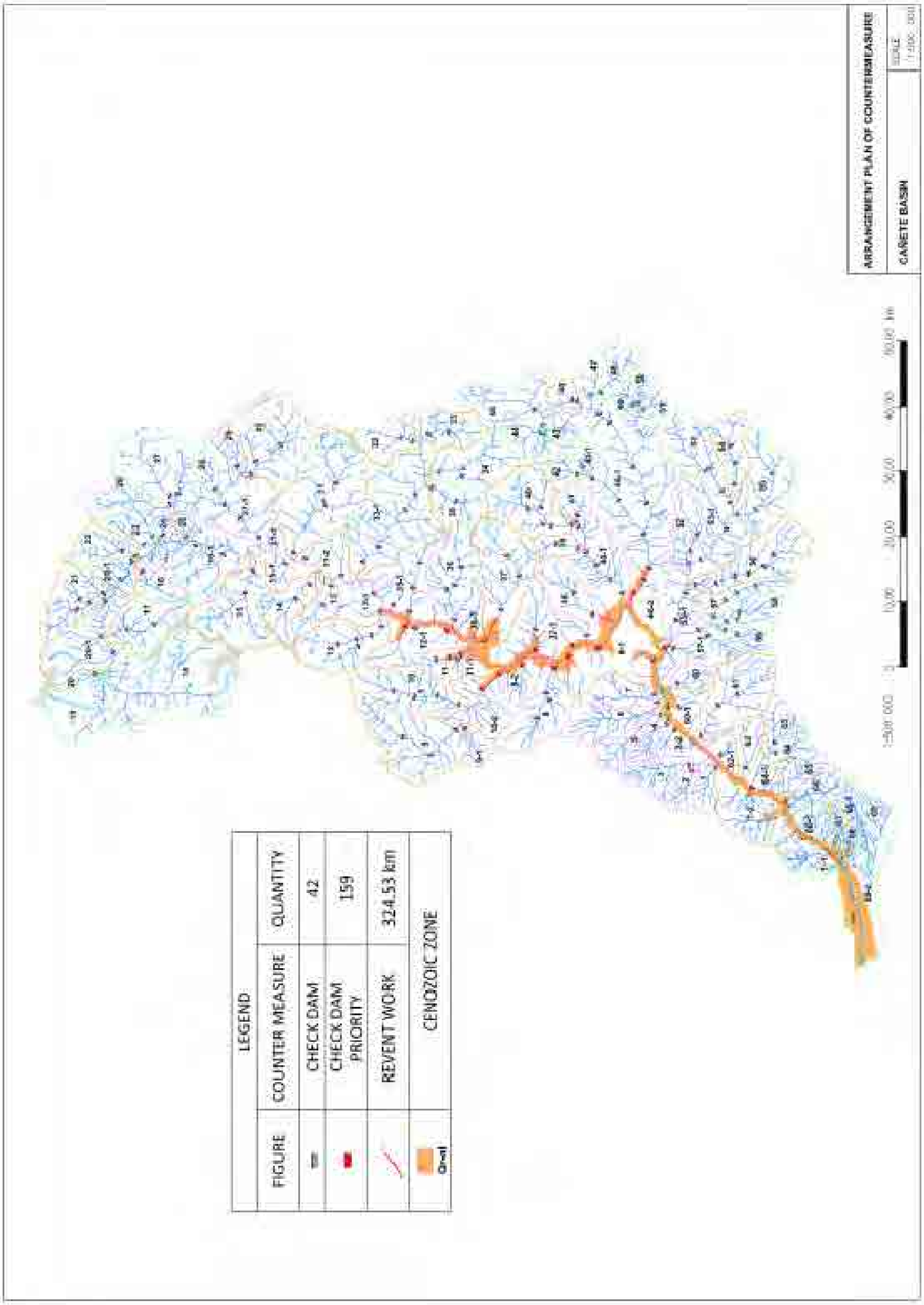


Figure 4.12.3-1 Sediment control works location Cañete River Watershed

5. CONCLUSIONS

The selected alternative for flood control in this Study is structurally safe. Also, the social assessment showed a sufficiently high economic value. Its environmental impact is reduced.

The implementation of this Project will contribute to relief the high vulnerability of valleys and local community to floods, and will also contribute with the local economic development. Therefore, we conclude to implement it as quickly as possible.

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
PRE-FEASIBILITY STUDY REPORT
II-4 PROJECT REPORT
(CHINCHA RIVER)

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
NIPPON KOEI LATIN AMERICA –
CARIBBEAN Co., LTD.

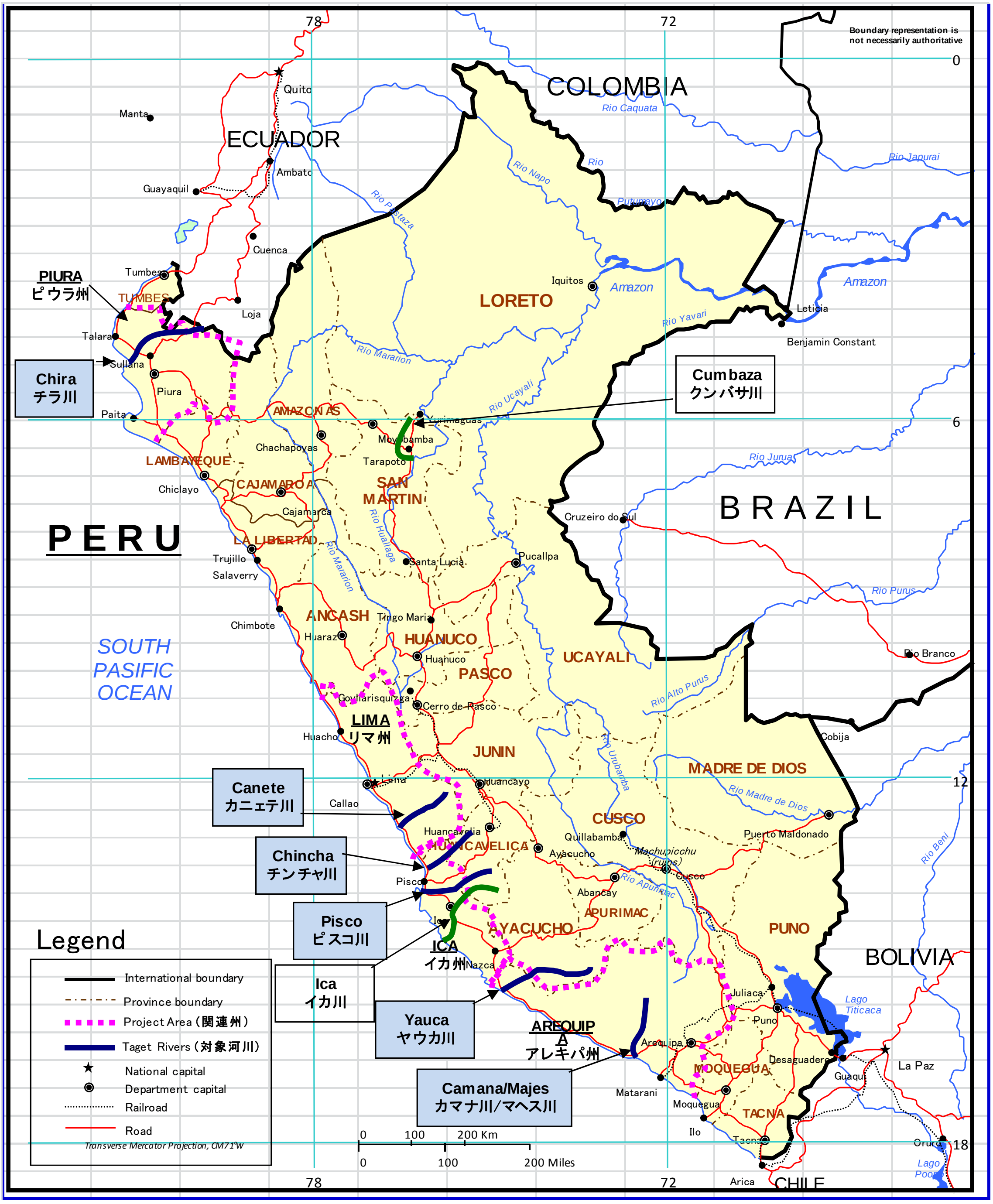
Composition of Final Report

I. Feasibility Study Report

- I-1 Program Report
- I-2 Project Report (Cañete River)
- 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
  - Annex – 6 Sediment Control
  - Annex – 7 Afforestation and Vegetation Recovery Plan
  - Annex – 8 Plan and Design of Facilities
  - Annex – 9 Construction Planning and Cost Estimate
  - Annex – 10 Socio-economy and Economic Evaluation
  - Annex – 11 Environmental and Social Considerations/ Gender
  - Annex – 12 Technical Assistance
  - Annex – 13 Stakeholders Meetings
  - Annex – 14 Implementation Program of Japanese Yen Loan Project
  - Annex－15 Drawings
- I-7 Data Book

II. Pre- Feasibility Study Report

- II-1 Program Report
- II-2 Project Report (Chira River)
- II-3 Project Report (Cañete River)
- **II-4 Project Report (Chincha River) (This Report)**
- II-5 Project Report (Pisco River)
- II-6 Project Report (Yauca River)
- II-7 Project Report (Majes-Camana River)



Location Map

(dark blue line)	Objective Study Basin
(green line)	Excluded Study Basin

Abbreviation

Abbreviation	Official Name or meaning
ANA	Water National Authority (Autoridad Nacional del Agua)
ALA	Water Local Authority (Autoridad Local del Agua)
C/B	Cost-Benefit relation (Cost-Benefit Ratio)
GDP	PBI (Producto Bruto Interno) (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)
DGPM	Dirección General de Programación Multianual del Sector Público (Public Sector Multiannual Program General Direction)
DNEP	Dirección Nacional de Endeudamiento Público (Public Indebtedness National Direction)
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)
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

ON

PROJECT OF THE PROTECTION OF FLOOD PLAIN AND VULNERABLE RURAL POPULATION AGAINST FLOODS IN THE REPUBLIC OF PERU

FINAL REPORT
PRE-FEASIBILITY STUDY REPORT
II-4 PROJECT REPORT
(CHINCHA RIVER)

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 Chincha River, Ica 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 Chincha 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 height (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
Chincha							
Chico	144.81	145.29	144.00	0.80	114.8	0.4	0.45
Matagente	133.72	133.12	132.21	0.80	133.01	0.29	0.36

1.4 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 4.12 “medium and long term plan” This plan proposes the construction of dikes for flood control throughout the watershed. However, the case of Chincha River requires a large project investing at a 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 basin will be constructed progressively over a medium and long term period. Here is where this study focused on the most urgent works, priority for flood control.

(1) Design flood flow
The Methodological Guide for Protection Projects and/or Flood Control in Agricultural or Urban Areas prepared by the Public sector multi annual programming general direction (DGPM) 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 was determined in the set value for floods with a return period of 50 years in the mentioned Guide.

(2) Selection of prioritized flood control 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

1.5 Non-structural measures

1.5.1 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 4.12 “Reforestation Plan and vegetation recovery”, 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 narrowing of the river by the presence of obstacles, using vegetation strips between the river and the elements to be protected.
- Methodology: Create vegetation stripes of a certain width between the river and river structures.
- Execution of works: Plant vegetation on a portion 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, 4.6 km and 10.1ha respectively.

1.5.2 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 4.12 “Medium and long term plan”. 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.

There are different types of sediment control applicable on alluvial fans, for example, sediment retardant reservoir, bed compact, bands, breakwater and ravines protection works, combining some of them. These works do not only are useful to control sediments, but also for fluvial structures. In case of Chincha Watershed, a diversion weir want to be built (Chico-3) in the section where the river divides into two (Chico and Matagente). This flood control work is rated as priority and it includes a channels and a longitudinal dike. Apart from controlling floods, it also controls sediments. This structure is characterized to be economic and it has a high investment return, compared to other sediment control works that are covering the whole watershed. It is considered that its investment return is much higher, even though the maintenance cost is taken into account (stones elimination, etc.).

1.6 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 Chincha 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 Chincha 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

1.7 Costs

In the Table 1.7-1 the costs of this Project in Chincha watershed is shown. The cost of the watersheds is around 44.0 million soles.

Table 1.7-1 Project Cost

(1,000 soles)

Watershed	Structural Cost: Construction Cost	Structural Cost: Detail Design Cost	Structural Cost: Construction Supervision Cost	Structural Cost: Environmental Cost	Structural Cost: Sub total	Non-structural cost: Afforestation Cost	Non-structural cost: Flood Alert System Cost	Technical Assistance Cost	Total
Chincha	37,601	1,880	3,760	376	43,617	129	0	219	43,965

1.8 Social Assessment

(1) Benefits

The benefits of flood control are the reduction of losses caused by floods which would be achieved by the implementation of the project and is determined by the difference between the loss amount without project and with project. Specifically, to determine the benefits, first the amount of losses by floods is calculated from different return periods (between 2 and 50 years), assuming that flood control works will last 50 years, and then the average annual reduction loss amount is determined from the reduction of losses from different return periods. In Tables 1.8-1 and 1.8-2 show the average annual amount of reduction loss that would be achieved by implementing this project, expressed in costs at private prices and costs at social prices.

Table 1.8-1 Annual average damage reduction amount (at private prices)

s/1000

Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total Damages - thousand S/.) 事業を実施しない場合① With Project ①	事業を実施した場合② With Project ②	軽減額 ③=①－② Mitigated damages ③=①－②	区間平均被害額 ④ Damages Average	区間確率 ⑤ Probability Incremental value	年平均被害額 ④×⑤ Damages Flow Average Value	年平均被害額の累計＝年平均被害軽減期待額 Annual Media Damage
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	14,576	423	14,153	7,076	0.500	3,538	3,538
	5	0.200	36,902	2,731	34,171	24,162	0.300	7,249	10,787
	10	0.100	51,612	3,904	47,708	40,939	0.100	4,094	14,881
	25	0.040	72,416	13,140	59,276	53,492	0.060	3,210	18,090
	50	0.020	96,886	28,112	68,774	64,025	0.020	1,281	19,371

Table 1.8-2 Annual average damage reduction amount (at social prices)

s/1000

Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total Damages - thousand S/.)			区間平均被害額 ④ Damages Average	区間確率 ⑤ Probability Incremental value	年平均被害額 ④×⑤ Damages Flow Average Value	年平均被害額の累計＝年平均被害軽減期待額 Annual Media Damage
			事業を実施しない場合① With Project ①	事業を実施した場合② With Project ②	軽減額 ③=①−② Mitigated damages ③=①−②				
CHINCHA	1	1.000	0	0	0			0	0
	2	0.500	16,283	430	15,852	7,926	0.500	3,963	3,963
	5	0.200	42,375	4,507	37,868	26,860	0.300	8,058	12,021
	10	0.100	70,525	6,449	64,076	50,972	0.100	5,097	17,118
	25	0.040	95,769	17,698	78,070	71,073	0.060	4,264	21,383
	50	0.020	125,742	33,329	92,413	85,242	0.020	1,705	23,088

(2) Social assessment results

The objective of the social assessment in this study is to evaluate the efficiency of investments in the structural measures using the method of cost-benefit relation (C/B) from the point of view of national economy. To do this, we determined the economic evaluation indicators (C/B 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.

In Tables 1.8-3 and 1.8-4 the costs at private prices and at social prices resulting from this project assessment are shown. It is noted that the project will have enough economic effect.

Table 1.8-3 Social Assessment (at private prices)

流域名	年平均被害軽減額 Gathered Average Annual Benefit	評価期間被害軽減額(15年) Gathered Average Annual Benefit (in 15 years)	事業費 Project Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) Valor Actual Neto (VAN)	Internal Rate of Return (IRR) Tasa Interna de Retorno (TIR)
Chincha	251,818,212	113,716,113	43,965,072	2,444,072	2.88	74,212,307	35%

Table 1.8-4 Social Assessment (costs at social prices)

流域名	年平均被害軽減額 Gathered Average Annual Benefit	評価期間被害軽減額(15年) Gathered Average Annual Benefit (in 15 years)	事業費 Project Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) Valor Actual Neto (VAN)	Internal Rate of Return (IRR) Tasa Interna de Retorno (TIR)
Chincha	300,137,698	135,536,235	35,359,690	1,965,034	4.27	103,764,959	50%

Regarding social evaluation , the project shows a positive economic impact at both the private price and social price in Chincha.

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.

1.9 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. Usually the central government (in this case, the DGIH) assumes 80%, the irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both 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 budget’s data of irrigation commission of Chincha Watershed is shown in Table 1.9-1.

Table 1.9-1 Irrigation Commission's Budget

River	Annual Budget			(In soles)
	2007	2008	2009	Average in 3 years
Chincha	1.562.928,56	1.763.741,29	1.483.108,19	1.603.259

(1) Profitability

We have seen that Chincha River Watershed is sufficiently profitable and sustainable. The amount of investment required is estimated at S/. 44.0 million soles (cost at private prices). It is a cost-effective project with a C/B relation of 2.88, a relatively high IRR of approximately 35% and NPV of S/.74.2 million soles in 15 years.

(2) Operation and maintenance costs

The annual cost of operation and maintenance required for the project, having as base year 2008 is estimated at 188,006 soles, which corresponds to 0.5% of the construction cost of the project in the Chincha river watershed. On the other hand, the operating expenses average in the last four years of irrigation committees is 1,603,259.

When considering that the annual cost of operation and maintenance represents 11.7% of the annual irrigation budget, the project would be sustainable enough because of the financial capacity of these committees to maintain and operate the constructed works.

1.10 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 Chincha 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 chincha 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 Chincha.

(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).

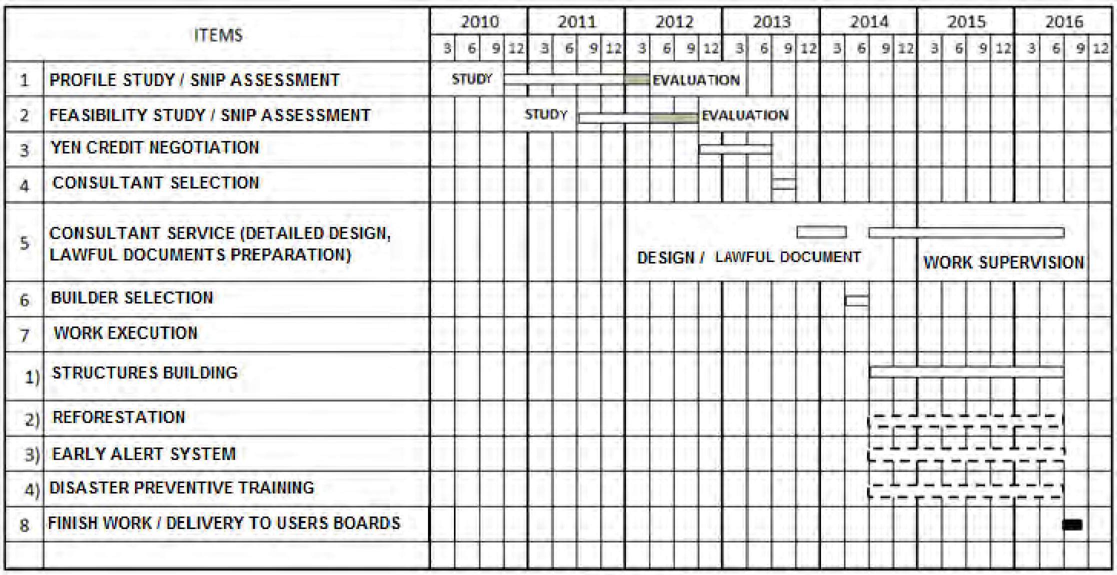
The EAP showed that the environmental impact would be manifested by the implementation of this project in the construction and maintenance stages, mostly, it is not very noticeable, and if it were, it can be prevented or mitigated by appropriately implementing the management plan environmental impact.

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.

1.11 Execution plan

Table 1.11-1 presents the Project execution plan.

Table 1.11-1 Execution plan



1.12 Institutions and management

The institutions and its administration in the investment stage and in the operation and maintenance stage after the investment shown in the figures 1.12-1 and 1.12-2.

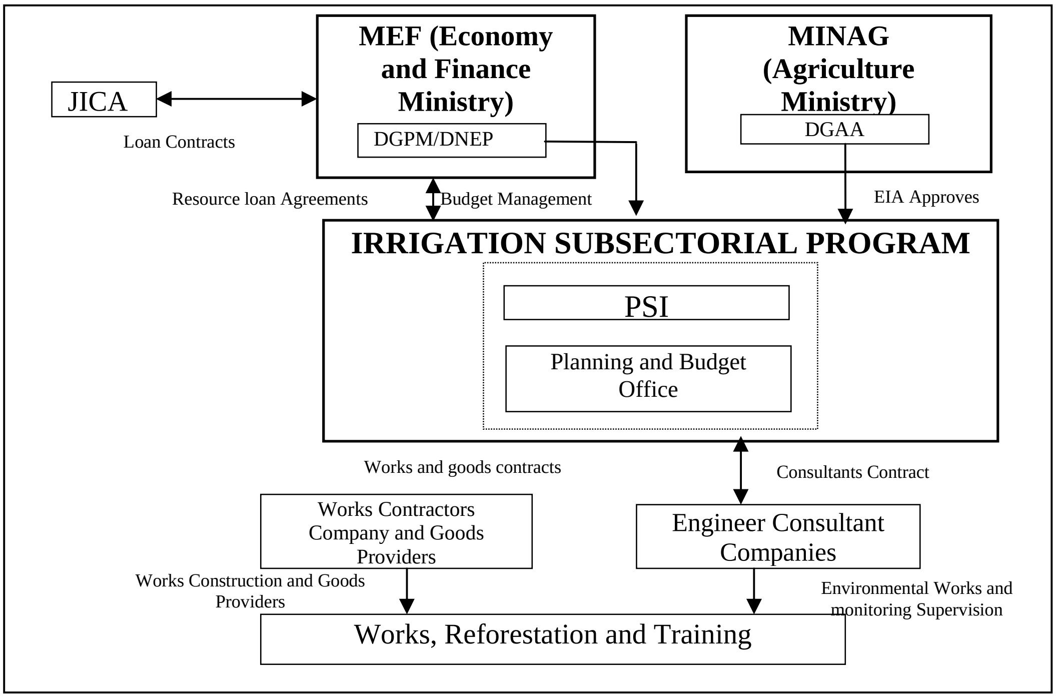


Figure 1.12-1 Institutions related to the project (investment stage)

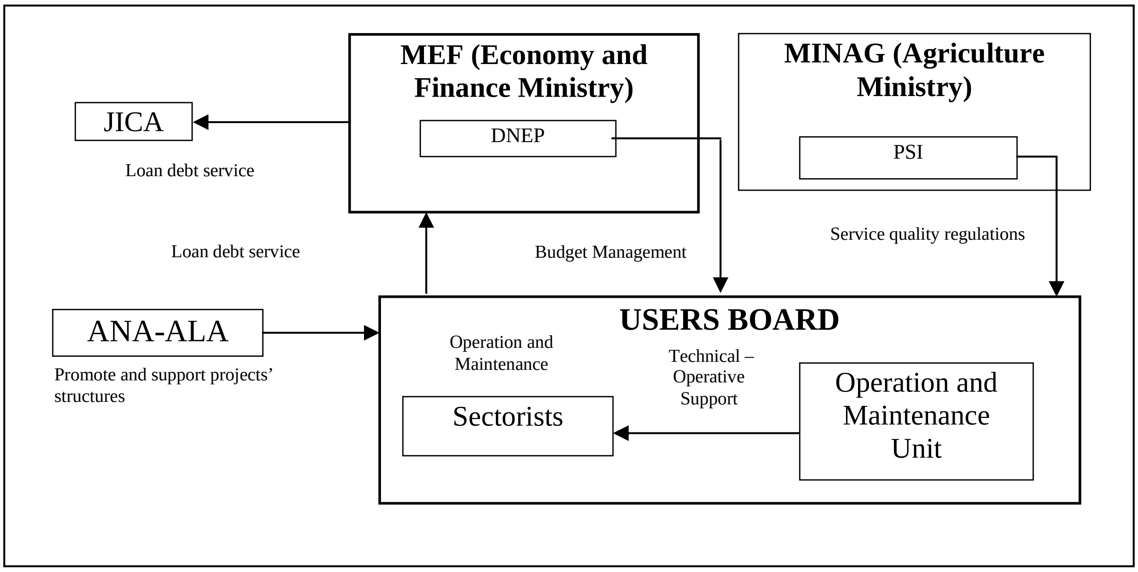


Figure 1.12-2 Institutions related to the project (operation and maintenance stage)

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 areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, bank erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, bank erosion progress and watershed's downstream erosion.	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, road damages prevention, construction of 28 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			

B-1 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.. 26km. 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 10,000 m^3.

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 Social Assessment (at private prices)

流域名	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
Chincha	275,669,025	124,486,667	84,324,667	7,429,667	1.61	47,326,578	20%

Table 1.14-2 Social Assessment (at social prices)

流域名	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
Chincha	334,336,127	150,979,568	67,797,033	5,973,452	2.43	88,942,856	31%

In case of executing flood control works in the watershed, the Projects' cost would elevate to 84.3 million soles, which is a huge amount so that this project could not be adopted for the Project.

(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. The total surface would be approximately 44,000hectares and in order to forest them the required time would be from 14 years and 119.0 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
Chincha	44,075	14	118,964

(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 bank 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.

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 the watershed. This means that its positive impact will be seen in a long time.

Table 1.14-4 Projects' General Costs of the Sediment Control Installations Upstream the Watershed

Watershed	Areas	Bank Protection		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/.)		
Chincha	Totally	381	S/.407	38	S/.1	111	S/.116	S/.524	S/..986
	Prioritized areas	381	S/.407	38	S/.1	66	S/.66	S/.474	S/.892

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 Chincha River, Ica department"

2.2 Formulator and Executor Units

(1) Formulator Unit
Name: Hydraulic Infrastructure General Direction, Agriculture Ministry
Responsible: Orlando Chirinos Hernan Trujillo
General Director of the Water Infrastructure General Direction
Address: Av. Benavides N° 395 Miraflores, Lima 12 - Peru
Phone: (511) 4455457 / 6148154
Email: ochirinos@minag.gob.pe

(2) Executor Unit
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) Administration Office (OA)
- 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)
- 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)
Public Sector's Multiannual Programming General Direction (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 pre-feasibility 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.
The Special Project Chira-Piura, implemented by the Regional Government of Piura also includes the Chira River that is the Area of the current Study.

(5) Irrigation Commission
Currently there are 14 irrigation commissions in the Chincha 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 Chincha 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:	3
Number of Irrigation Commissions:	14
Irrigated Area:	25,629 ha
Beneficiaries:	7,676 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 the Civil Defense National System. 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 this context, the central government has implemented El Niño phenomenon I and II contingency plans in 1997-1998, throughout the Agriculture and Livestock Ministry (MINAG) in order to rebuild water infrastructures devastated by this phenomenon. Next, the Hydraulic Infrastructure General Direction (DGIH) of the Agriculture Ministry (MINAG) began in 1999 the River Channeling and Collection 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 margin protection. In the multiyear PERPEC plan between 2007-2009 it had been intended to execute a total of 206 margin 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 punctual, without giving a full and integral solution to control floods. So, every time floods occur in different places, damages are still happening.

MINAG developed 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 help 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 draft from AOD of 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 Discussions Minutes (hereinafter "M/D") that were signed on January 21 and April 16, 2010. This study was implemented on this M/D.

(2) Progress of Study

The Profile Study Report for this Project at Program's level for nine watersheds of five regions has been 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) 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 going to be 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 an accurate pre-feasibility level and handed DGIH the Program Report of group A and the reports of the five watershed projects by late 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 received through 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 because they belong to a single watershed (Majes-Camana).

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 for the second time the Meeting Minutes (refer to Meetings Minutes Second Amendment about the Initial Report, Lima, July 22nd, 2011)

So, the JICA Study Team began in August the prefeasibility study for the watershed above mentioned, which was completed in late November.

This report corresponds with the pre-feasibility study of the Chincha watershed project, of Group A. The feasibility study wants to be finished by mid-January 2012, and the feasibility study for all selected watersheds around the same dates.

Remember that DGIH processed on July 21st, the SNIP registration of four of the five watersheds (except Yauca), based on projects reports at pre-feasibility level from JICA. DGIH decided to discard Yauca River due to its low impact in economy.

The Project Reports with pre-feasibility level for 4 watersheds (Chira, Cañete , Chincha, Pisco) were submitted to OPI from DGIH, and OPI issued their comments on the reports on September 22, 2011. The revision of the reports is under discussion among OPI, DGIH and JICA Study Team.

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

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.

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
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.

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 Chincha River.

Figure 3.1.1-1 Objective River for the Study

(2) Watershed overall description

The Chincha River runs 170 km to the south of the Capital of Lima with an approximate surface of 3.300km2. It is featured by a middle watershed and narrow lower and high watersheds, its higher altitude is greater than 4.000mosl and this only represents 15% from the total amount. In the lower watershed (Study Area), the river is split into two by a derivation work located approx 25 km upstream the mouth. The river adopts to the northern part, Chico and Matagente names. The middle slope is approx 1/80 and its width varies between 100 and 200mt.

Annual rain is similar to the one in Chincha River Watershed: with 1.000mm at altitudes over 3,000mosl and only 20mm at altitudes smaller than 500mosl.

Regarding vegetation, the upper watershed has puna grass and scrublands and the lower watershed in mainly constituted in 80% by desert and 20% of arable lands. This distribution of vegetal formation is like the Pisco River Watershed, which is next to it. The main product in these lands is cotton and grapes.

3.1.2 Socio-economic conditions of the Study Area

(1) Administrative Division and Surface

The Chincha River is located in the provinces of Chincha in the Ica 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 Chincha River with areas

Región	Provincia	Distrito	Área (km²)
Ica	Chincha	Chincha Alta	238.34
		Alto Laren	298.83
		Chincha Baja	72.52
		El Carmen	790.82
		Tambo de Mora	22.00

(2) Population and number of households

The following Table 3.1.2-2 shows how population varied within the period 1993-2007. From the total 94,439 inhabitants (2007), 82% (77,695 inhabitants) lives in urban areas while 18% (16,744 inhabitants) lived in rural areas. However, in Chincha Baja and El Carmen Districts 58% and 57% respectively, live in rural areas, with more rural areas than other areas.

Population is increasing in all districts.

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
Chincha Alta	59.574	100 %	0	0 %	59.574	49.748	100 %	0	0 %	49.748	1,3 %	0,0 %
Alto Laran	3.686	59 %	2.534	41 %	6.220	1.755	41 %	2.530	59 %	4.285	5,4 %	0,01 %
Chincha Baja	5.113	42 %	7.082	58 %	12.195	3.402	30 %	7.919	70 %	11.321	3,0 %	-0,8 %
El Carmen	5.092	43 %	6.633	57 %	11.725	3.766	43 %	5.031	57 %	8.797	2,2 %	2,0 %
Tambo de Mora	4.230	90 %	495	10 %	4.725	3.176	79 %	868	21 %	4.044	2,1 %	-3,9 %
Total	**77.695**	**82 %**	**16.744**	**18 %**	**94.439**	**61.847**	**79 %**	**16.348**	**21 %**	**78.195**	**1,6 %**	**0,2 %**

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. Every home has between 4.0 and 4.4 members and every family among 3.9 and 4.1 members.

Table 3.1.2-3 Number of households and families

Variables	District				
	Chincha Alta	Alto Laran	Chincha Baja	El Carmen	Tambo de Mora
Population (inhabitants)	59,574	6,220	12,195	11,725	4,725
Number of households	13,569	1,522	2,804	2,696	1,124
Number of families	14,841	1,559	2,997	2,893	1,200
Members per house (person/home)	4.39	4.09	4.35	4.35	4.20
Member per family (person/family)	4.01	3.99	4.07	4.05	3.94

(3) Occupation

Table 3.1.2-4, shows occupation lists of local inhabitants itemized by sector. In Chincha Alta and Tambo de Mora where the population is predominantly urban, there is a low percentage of primary sector, meanwhile in the other districts the primary sector is predominant.

Table 3.1.2-5 Occupation

	Distritct									
	Chincha Alta		Alto Laran		Chincha Baja		El Carmen		Tambo de Mora	
	Personas	%	Personas	%	Personas	%	Personas	%	Personas	%
EAP	23,596	100	2,415	100	4,143	100	3,966	100	1,640	100
Primary Sector	1,889	8.0	1,262	52.3	1,908	46.1	2,511	63.3	334	20.4
Secondary Sector	6,514	27.6	443	18.3	931	22.5	399	10.1	573	34.9
Tertiary Sector	15,190	64.4	710	29.4	1,304	31.5	1,056	26.6	733	44.7

* 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. From the total population, 15.6% (14,721 inhabitants) belong to the poor segment, and 0.3% (312 inhabitants) belong to extreme poverty. Chincha Baja has reached a lower poverty index than the rest, with 10.6% (poor) and 0.2% (extreme poverty).

Table 3.1.2-5 Poverty index

	District											
	Chincha Alta		Alto Laran		Chincha Baja		El Carmen		Tambo de Mora			
	People	%	People	%	People	%	People	%	People	%	Total	%
Regional Population	59,574	100	6,220	100	12,195	100	11,725	100	4,725	100	94,439	100
Poor	9,316	15.6	1,309	21.0	1,296	10.6	1,950	16.6	850	18.0	14,721	15.6
Extreme Poor	214	0.4	30	0.5	22	0.2	35	0.3	11	0.2	312	0.3

(5) Type of housing

The walls of the houses are made 21% of bricks or cement, and 44% of adobe and mud. The floor is made 94% of earth or cement. The public drinking water service is low, with an average of 45%, except for El Carmen and Tambo de Mora, while the sewage service is scarcely 29%. The average electrification rate is 74%.

Table 3.1.2-6 Type of housing

Variable/Indicator	Districts									
	Chincha Alta		Alto Laran		Chincha Baja		El Carmen		Tambo de Mora	
	Housing	%	Housing	%	Housing	%	Housing	%	Housing	%
Name of housings										
Common residents housing	13.569	85,7	1.522	76,1	2.804	93,3	2.696	87,6	1.124	85,3
Walls materials										
Bricks or cement	5.220	38,5	170	11,2	590	21	176	6,5	309	27,5
Adobe and mud	4.817	35,5	891	58,5	1.146	40,9	1.589	58,9	289	25,7
Bamboo + mud or wood	281	2,1	121	8,0	125	4,5	160	5,9	45	4,0
Others	3.251	24,0	340	22,3	943	33,6	771	28,6	481	42,8
Floor Materials										
Soil	5.036	37,1	812	53,4	1.521	54,2	1.547	57,4	604	53,7
Cement	6.454	47,6	680	44,7	1.136	40,5	1.081	40,1	450	40
Ceramics, parquet, quality wood	1.979	14,6	25	1,6	134	4,8	42	1,6	58	5,2
Others	100	0,7	5	0,3	13	0,5	26	1,0	12	1,1
Running water system										
Public network within household	10.321	76,1	705	46,3	1.055	37,6	861	31,9	379	33,7
Public network within building	1.030	7,6	87	5,7	239	8,5	242	9	62	5,5
public use	311	2,3	214	14,1	192	6,8	202	7,5	38	3,4
Sewage										
Public sewage within household	9.244	68,1	167	11	709	25,3	320	11,9	336	29,9
Public sewage within building	748	5,5	60	3,9	77	2,7	31	1,1	61	5,4
Septic Tank	1.441	10,6	621	40,8	1.167	41,6	1.348	50	259	23
Electricity										
Public electric service	10.989	81	811	53,3	2.251	80,3	2.146	79,6	837	74,5
Member quantity										
Common residents housing	**14.841**	**100**	**1.559**	**100**	**2.997**	**100**	**2.893**	**100**	**1.200**	**100**
Appliances										
More than three	7.024	47,3	466	29,9	1.159	38,7	908	31,4	473	39,4
Communication Services										
Phones and mobiles	12.640	85,2	920	59,0	2.182	72,8	1.919	66,3	872	72,7

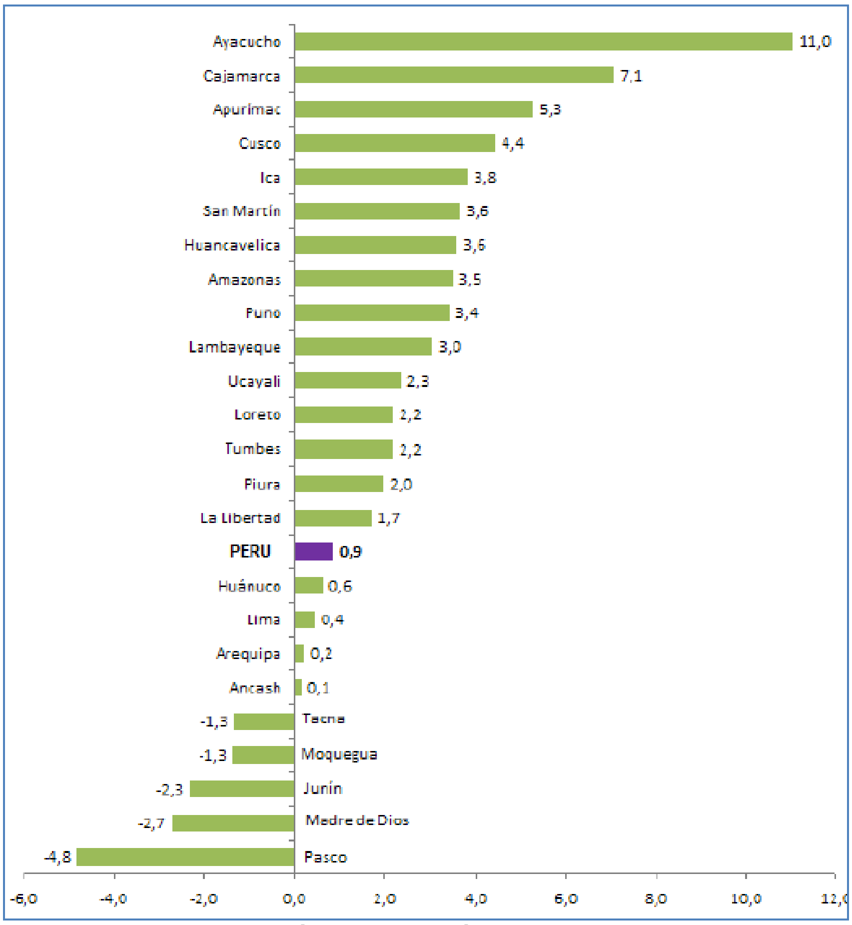
Source: Prepared by JICA Study Team, Statistics National Institute- INEI, 2007 Population and Housing Census.

(6) GDP

Peru's GDP in 2009 was S./392,565,000.000.

The growth rate in the same year was of + 0.9 % compared with the previous year with the poorest level within 11 years.

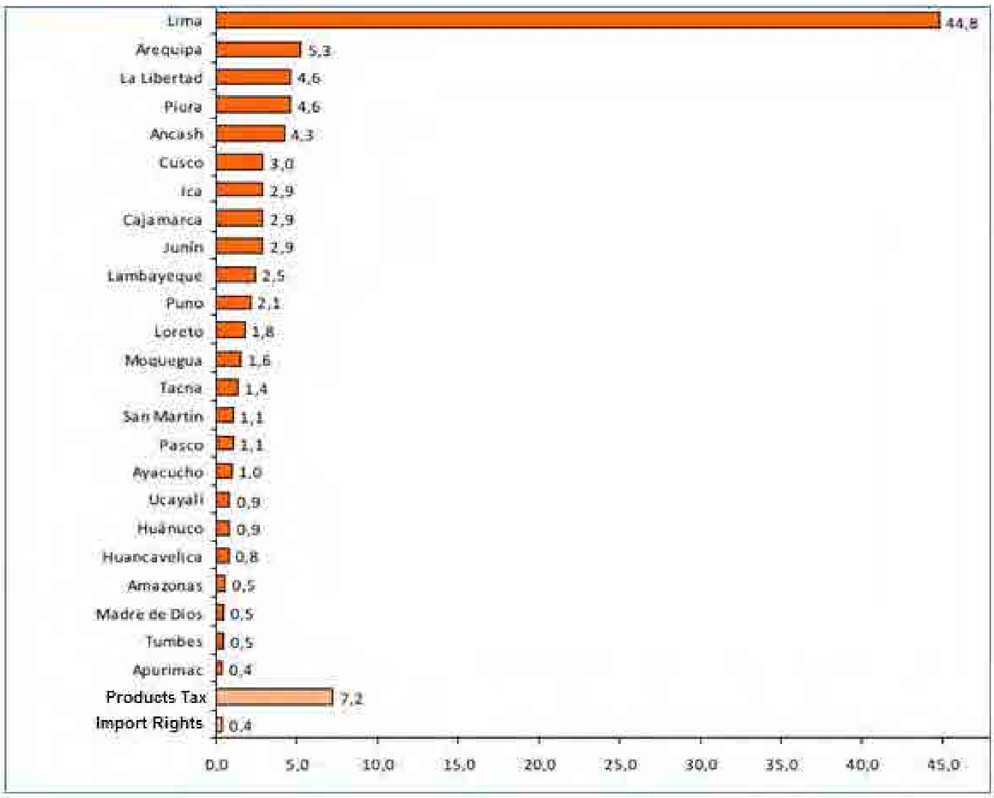
Itemized by regions, Ica registered a growth of 3.8 %, Piura 2.0 %, Lima 04 % and Arequipa 0.2 %. Particularly Ica and Piura regions registered Figures that were beyond the national average.



INEI Source – National Accounts National Direction

Figure 3.1.2-1 Growth rate of GDP per region (2009/2008)

The table below shows the contribution of each region to the GDP. Lima Region represents almost half of the total, that is to say 44.8%. Arequipa contributed with 5.3 %, Piura 4.6 % and Ica 2.9 %. Taxes and duties contributed with 7.2 % and 0.4 %, respectively.

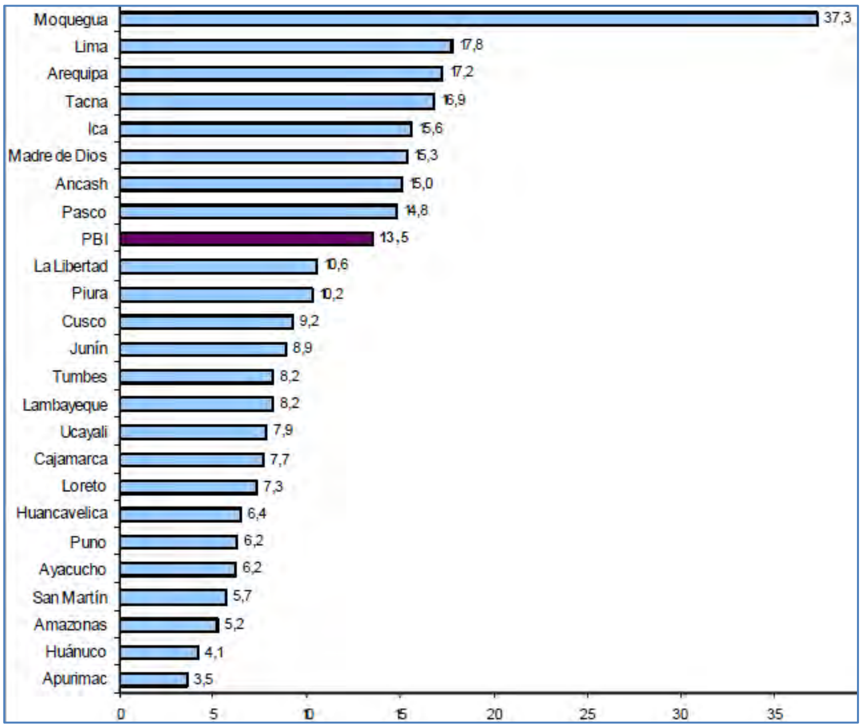


INEI Source – National Accounts National Direction

Figure 3.1.2-2 Region contribution to GDP

The GDP per capita in 2009 was of S/.13,475.

The Table below shows data per region: Lima S/.17,800, Arequipa S/.17,200, Ica S/.15,600 and Piura S/.10,200. The first three regions exceeded the national average, with exception of Piura.



INEI Source – National Accounts National Direction

Figure 3.1.2-3 GDP per capita (2009)

Table 3.1.2-7 shows the variation along the years of the GDP per capita per region, during the last 9 years (2001-2009).

The GDP national average increased in 44% within nine years from 2001 until 2009. The Figures per region are: +83.9 % for Ica, +54.2 % for Arequipa, +48.3 % for Piura y +42.9 % for Lima.

Figures in Table 3.1.2-7 were established taking 1994 as base year.

Table 3.1.2-11 Variation of the GDP per capita (2001-2009)

(1994 Base year, S/.)

Departament	2001	2002	2003	2004	2005	2006	2007P/	2008P/	2009E/	Accumulated Growth 2001-2009 (%)
Cusco	2 194	2 086	2 195	2 565	2 768	3 071	3 340	3 554	3 685	67,9
Ica	4 055	4 259	4 343	4 663	5 214	5 582	6 025	7 265	7 457	83,9
La Libertad	3 162	3 316	3 483	3 410	3 697	4 216	4 586	4 874	4 895	54,8
Ucayali	3 063	3 149	3 203	3 411	3 584	3 754	3 846	4 007	4 039	31,9
Moquegua	10 405	11 967	12 670	13 455	13 882	13 794	13 606	14 201	13 865	33,3
Arequipa	5 387	5 766	5 895	6 143	6 488	6 807	7 786	8 379	8 308	54,2
Apurimac	1 216	1 278	1 334	1 400	1 494	1 619	1 653	1 691	1 770	45,5
Piura	2 733	2 780	2 847	3 049	3 192	3 472	3 780	4 007	4 052	48,3
San Martin	2 026	2 059	2 094	2 232	2 393	2 476	2 655	2 870	2 928	44,5
Ayacucho	1 788	1 870	1 942	1 900	2 045	2 207	2 448	2 640	2 896	61,9
Amazonas	1 835	1 910	1 996	2 081	2 212	2 349	2 510	2 684	2 761	50,5
Madre de Dios	4 441	4 708	4 550	4 846	5 171	5 215	5 617	5 878	5 564	25,3
Cajamarca	2 493	2 731	2 947	2 968	3 165	3 113	2 864	3 094	3 295	32,2
Ancash	4 037	4 703	4 772	4 876	4 999	5 089	5 408	5 852	5 827	44,3
Tumbes	2 744	2 802	2 873	3 018	3 385	3 212	3 427	3 594	3 611	31,6
Lima	6 451	6 579	6 700	6 925	7 284	7 817	8 520	9 314	9 220	42,9
Puno	2 105	2 236	2 234	2 270	2 365	2 460	2 617	2 731	2 800	33,0
Lambayeque	2 941	3 046	3 132	2 959	3 164	3 300	3 615	3 882	3 963	34,8
Junin	3 245	3 311	3 350	3 527	3 505	3 856	4 072	4 379	4 248	30,9
Loreto	2 827	2 917	2 936	2 995	3 079	3 192	3 287	3 402	3 429	21,3
Huánuco	1 678	1 694	1 833	1 866	1 890	1 915	1 942	2 050	2 044	21,8
Pasco	5 137	5 552	5 481	5 634	5 644	6 062	6 711	6 729	6 349	23,6
Tacna	6 004	6 124	6 382	6 643	6 782	6 941	7 256	7 458	7 253	20,8
Huancavelica	2 700	2 632	2 683	2 697	2 864	3 014	2 903	2 959	3 039	12,5
GDP	4 601	4 765	4 890	5 067	5 345	5 689	6 121	6 643	6 625	44,0

INEI Source – National Accounts National Direction

3.1.3 Agriculture

Next is a summarized report on the current situation of agriculture in the Watershed of the Chincha 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 Watersheds of Matagente and Chico Rivers there are 3 irrigation sectors, 14 irrigation commissions with 7,676 beneficiaries. The surface managed by these sectors reaches a total of 25,629 hectares.

Table 3.1.3-1 Basic data of the irrigation commissions

Irrigation Sectors	Irrigation Commissions	Areas under irrigation		Nº of Beneficiaries (Person)	River
		ha	%		
La Pampa	Chochocota	1.624	6 %	277	Matagente
	Belen	1.352	5 %	230	Matagente
	San Regis	1.557	6 %	283	Matagente
	Pampa Baja	4.124	16 %	596	Matagente
Chincha Baja	Matagente	2.609	10 %	421	Matagente
	Chillon	2.258	9 %	423	Matagente
	Rio Viejo	2.054	8 %	367	Matagente
	Chincha Baja	1.793	7 %	351	Matagente
Chincha Alta	Rio Chico	475	2 %	106	Chico
	Cauce Principal	1.644	6 %	456	Chico
	Pilpa	218	1 %	573	Chico
	Ñoco	1.227	5 %	1.428	Chico
	Aceqia Grande	1.077	4 %	1.520	Chico
	Irrigación Pampa de Ñoco	3.616	14 %	645	Chico
Total		**25.629**	100 %	**7.676**	

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 Chincha River Watershed, is increasing as planted area, performance and sales decreased. In the period 2008-2009 profits were of S/.242.249.071. Main crops in this watershed were represented by: cotton, corn, grapes, artichokes and asparagus.

Table 3.1.3-2 Sowing and sales of main crops

	Variables	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Cotton	Planted Area (ha)	10,217	11,493	10,834	11,042	8,398
	Unit performance (kg/Ha)	2,829	2,634	2,664	2,515	2,386
	Harvest (Kg)	28,903,893	30,272,562	28,861,776	27,770,630	20,037,628
	Unit Price (S/./kg)	2.19	2.21	2.82	2.65	1.95
	Sales (S/.)	63,299,526	66,902,362	81,390,208	73,592,170	39,073,375
Corn (yellow)	Planted Area (ha)	3,410	3,631	3,918	4,190	5,148
	Unit performance (kg/Ha)	7,585	7,460	7,640	7,860	8,286
	Harvest (Kg)	25,864,850	27,087,260	29,933,520	32,933,400	42,656,328
	Unit Price (S/./kg)	0.62	0.64	0.80	0.94	0.76
	Sales (S/.)	16,036,207	17,335,846	23,946,816	30,957,396	32,418,809
Grapes	Planted Area (ha)	1,589	1,271	1,344	1,411	1,325
	Unit performance (kg/Ha)	14,420	16,658	13,137	17,029	17,720
	Harvest (Kg)	22,913,380	21,172,318	17,656,128	24,027,919	23,479,000
	Unit Price (S/./kg)	0.92	1.06	1.40	1.54	1.66
	Sales (S/.)	21,080,310	22,442,657	24,718,579	37,002,995	38,975,140
Artichoke	Planted Area (ha)	587	896	993	777	1,426
	Unit performance (kg/Ha)	16,595	18,445	19,525	18,768	18,300
	Harvest (Kg)	9,741,265	16,526,720	19,388,325	14,582,736	26,095,800
	Unit Price (S/./kg)	0.93	1.00	1.10	1.17	1.20
	Sales (S/.)	9,059,376	16,526,720	21,327,158	17,061,801	31,314,960
Asparagus	Planted Area (ha)	903	860	855	776	1,102
	Unit performance (kg/Ha)	6,725	9,892	8,036	7,713	9,343
	Harvest (Kg)	6,072,675	8,507,120	6,870,780	5,985,288	10,295,986
	Unit Price (S/./kg)	2.81	3.08	2.93	3.04	2.79
	Sales (S/.)	17,064,217	26,201,930	20,131,385	18,195,276	28,725,801
Alfalfa	Planted Area (ha)	574	578	651	651	776
	Unit performance (kg/Ha)	16,871	21,645	29,926	39,072	44,161
	Harvest (Kg)	9,683,954	12,510,810	19,481,826	25,435,872	34,268,936
	Unit Price (S/./kg)	0.23	0.23	0.36	0.39	0.40
	Sales (S/.)	2,227,309	2,877,486	7,013,457	9,919,990	13,707,574
Avocado	Planted Area (ha)	347	347	638	703	938
	Unit performance (kg/Ha)	7,268	9,772	9,036	12,221	11,853
	Harvest (Kg)	2,521,996	3,390,884	5,764,968	8,591,363	11,118,114
	Unit Price (S/./kg)	1.30	1.51	1.75	2.08	2.25
	Sales (S/.)	3,278,595	5,120,235	10,088,694	17,870,035	25,015,757
Beets	Planted Area (ha)	408	553	539	522	777
	Unit performance (kg/Ha)	20,134	20,195	19,076	16,856	18,153
	Harvest (Kg)	8,214,672	11,167,835	10,281,964	8,798,832	14,104,881
	Unit Price (S/./kg)	0.16	0.33	0.22	0.44	0.43
	Sales (S/.)	1,314,348	3,685,386	2,262,032	3,871,486	6,065,099
Pumpkin	Planted Area (ha)	346	603	437	444	522
	Unit performance (kg/Ha)	31,021	30,992	30,925	30,582	32,939
	Harvest (Kg)	10,733,266	18,688,176	13,514,225	13,578,408	17,194,158
	Unit Price (S/./kg)	0.38	0.49	0.41	0.56	0.29
	Sales (S/.)	4,078,641	9,157,206	5,540,832	7,603,908	4,986,306
Tangerine	Planted Area (ha)	360	401	405	427	594
	Unit performance (kg/Ha)	25,918	27,493	33,723	31,727	34,887
	Harvest (Kg)	9,330,480	11,024,693	13,657,815	13,547,429	20,722,878
	Unit Price (S/./kg)	0.51	0.52	0.76	0.81	1.06
	Sales (S/.)	4,758,545	5,732,840	10,379,939	10,973,417	21,966,251
Others	Planted Area (ha)	2,434	1,897	2,161	1,830	1,994
Total	Planted Area (ha)	21,175	22,530	22,775	22,773	23,000
	Harvest (Kg)	133,980,431	160,348,378	165,411,327	175,251,877	219,973,709
	Sales (S/.)	142,197,073	175,982,668	206,799,102	227,048,475	242,249,071

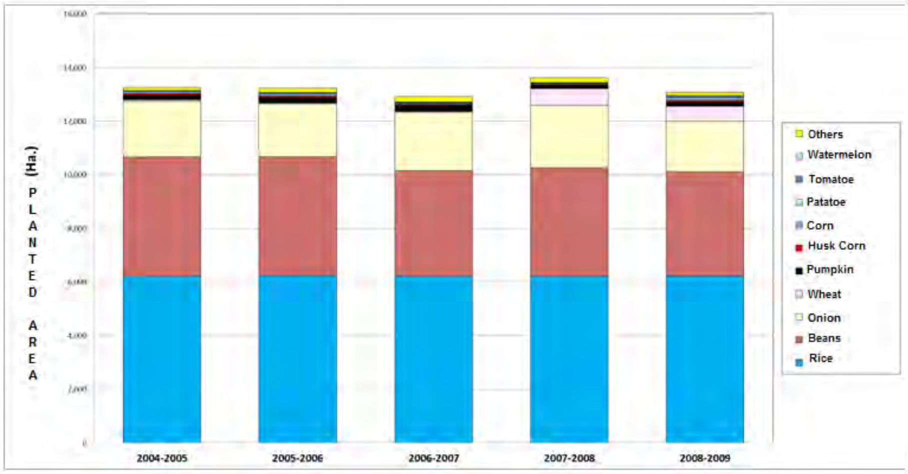


Figure 3.1.3-1 Planted Surface

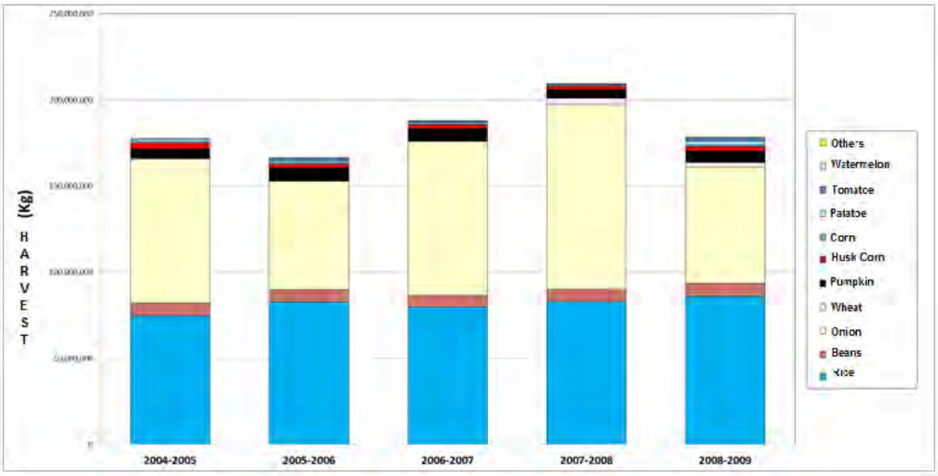


Figure 3.1.3-2 Harvest

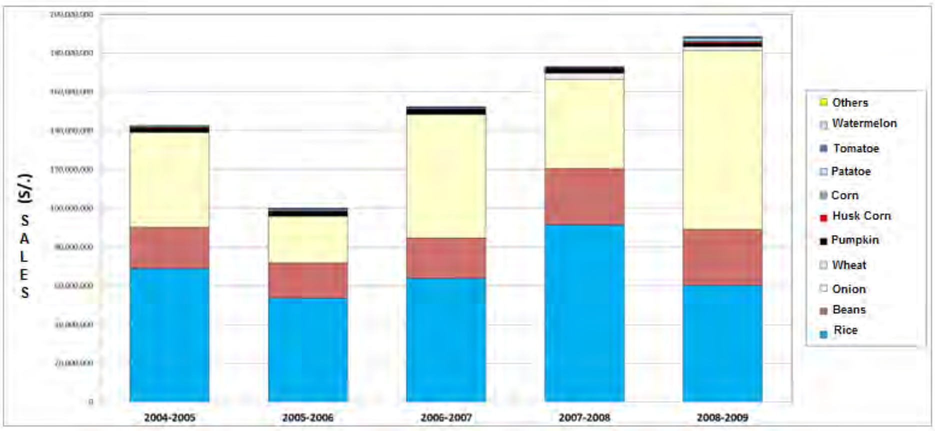


Figure 3.1.3-3 Sales

3.1.4 Infrastructure

(1) Road Infrastructures

Table 3.1.4-1 shows road infrastructures in the watershed of the Chincha River. In total there are 453.27km of roads, 81.39km of them (18.0 %) are national roads, 227.16km (50.1%) regional roads, and 144,72km (31.9%) municipal roads.

From National roads, 40.75km are paved and in good state and the 40.64km that rest are in inadequate conditions.

From National roads, 20.02km are paved and in good state and the 207.14km that rest are in inadequate conditions

From National roads, 25.42km are paved and in good state and the 119.3km that rest are in inadequate conditions

Table 3.1.4-1 Basic data of road infrastructure

(Km)

Roads	Total Length		Paving			
			Asphalted	Compacted	Non-	Soil
National roads	81.39	18.0%	40.75	40.64		
Regional roads	227.16	50.1%	20.02		207.14	
Municipal roads	144.72	31.9%	25.42		70.30	49.00
Total	453.27	100.0%	86.19	40.64	277.44	49.00

(2) PERPEC

Table 3.1.4-2 shows implemented projects by PERPEC between 2006 and 2009.

Table 3.1.4-2 Projects implemented by PERPEC

Nº	Year	Work name	Location				Description			Total cost (S/.)
			Department	Province	District	Town				
1	2006	Coastal defense of Chico River in Canyar	Ica	Chincha	Chincha	Canyar	Dike conformation	0.05	km	50,000.00
2	2006	Coastal defense of Chico River, Partidor Conta area	Ica	Chincha	Alto Laran	Partidos conta	Netting dike with cushion	0.23	Km	187,500.00
3	2007	Coastal defense of right bank Matagente River, ronceros alto area and on the left bank of Chico river in Ayacucho area, in Alto Laran district, Chincha province - Ica Region	Ica	Chincha	Chincha Baja	Chincha Baja	Dike with gavions and /or cushion	2.5	Km	517,979.00
4	2007	Main channel rehabilitation of Ñoco irrigation	Ica	Chincha	Alto Laran	Primeros 5km del canal, Huampullo, bajo y Alto y vuelta el Coche, Tunel a 200m de la Bocatoma	Channel sheathing	0.1	Km	43,109.00
5	2007	Channels rehabilitation of Alto Laran - High part Area	Ica	Chincha	Alto Laran	Huachinga Condores	Channel box rehabilitation	0.4768	Km	130,264.00
6	2007	Pampa Baja, Belen and Chochocota channels cleanliness	Ica	Chincha	El Carmen	Pampa Baja, Belen , Chochocota	Channel cleanliness	12.6278	Km	91,372.00
7	2008	Provisional coastal defense in Matagente River, La Pelota area, Del Carmen district and Ica Department (Contingency)	Ica	Chincha	El Carmen	La Pelota	Dike conformation with dragging material	1.5	Km	107,735.00
8	2008	Left and right banks coastal defense of Chico River, Canyar Area, Chincha Baja district, Chincha Province, Ica Region (Contingency)	Ica	Chincha	Chincha	Canyar	Dike conformation with coating of anti-scouring cushion	850	ml	695,900.00
9	2008	Coastal defense of Matagente River, Punta La Isla - Ronceros Alto - Ganaderos Los Angeles Areas, El Carmen district, Chincha Province, Ica Region (Prevention)	Ica	Chincha	El Carmen	La Isla - Ronceros Alto - Ganaderos Los Angeles	Rockfill dike	1460	ml	583,294.00
10	2009	Coastal defense on the right bank of Chico River, El Taro area, Alto Laran district, Chincha province, Ica region	Ica	Chincha	Alto Larán	Chamorro, Atahualpa	Netting dike of Chico River	200	ml	290,222.00

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	Casos	1,458	470	234	134	348	272
Victims	personas	373,459	118,433	53,370	21,473	115,648	64,535
Victims dof housing	personas	50,767	29,433	8,041	2,448	6,328	4,517
Dead	personas	46	24	7	2	9	4
Partially destroyed housings	Housing	50,156	17,928	8,847	2,572	12,501	8,308
Totally destroyed housings	Housing	7,951	3,757	1,560	471	1,315	848

Source : Compedio estadisticos de SINADECI

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 Ica region, that the presents study is part of.

Table 3.1.5-3 Disasters in the Ica 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											2						2	
Landslide									2	1				1			4	
Avalanche	2		2		5	2				2	1	1	3	1		1	20	
TOTAL SEDIMENT DISASTERS	2	0	2	0	5	2	0	0	2	3	3	1	3	2	0	1	26	2
TOTAL FLOODS	4	4	0	13	14	1	2	0	0	1	1	0	4	6	1	0	51	3

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) Interviews

(Critical conditions)

- The stream has only a capacity of 100m3/s to flow, and when overflowing of 1.200 m3/s happened, the river overflowed
- Basically, the river's water must be derived in a relation 1:1, and this relation is changed when overflowing occurs. If these can be adequately maintained regarding its derivation, the problem would be solved
- There are 2 critical sections: Km15 of Chico River and Km16 of Matagente River
- There is a 16Km section (between Km 10 and 16) of Matagente River that is very sedimented, this may lead to an overflow
- Chico River overflows on curvy section on Km 15
- The overflow water floods very quickly up to the lower watershed due to the local slope
- When the three intakes stop working, the producers can not irrigate their lands
- The three intakes were built in 1936. The derivation works in the upstream extreme was built in 1954
- River has water from January to March; the rest of time, from groundwater
- There are 7 reservoirs at 180km upstream, with a total capacity of $104 \times 10^6 m^{3.}$ The water is collected between January and July and is given since August
- According to the Water Society President, Matagente River overflowing was a

problem more than 20 years ago since he lives in the area. The bed is continuing to rise at a 4 to 5 meters pace in the last 50 years. A dike was built to control overflowing

- The problem takes place annually, since December until the end of March. Every year, 10 floods of 5 to 6 hours each take place (max 12 hours). When floods are frequent, derivation works are obstructed on one side and this overflows water
- It is a elevated bed river
- All the upper watershed area is constituted by collapse area
- The overflow water from the river returns to it through local channels
- Sometimes, channels overflow water leads to flood in Chincha
- Main products are cotton and grapes
- The stream is measures by upstream derivation works

(Other: visited sites by the Study Team)

○ Chamorro Bridge (Matagente River)
  - Finish built in 1985

○ Matagente Bridge (Matagente River)
  - Built to allow a 200m3/s flow (initially projected for 550m^3/s)
  - There is a project to elongate the dike until the flood area downstream

○ Intake (Matagente River)
  - Water intake is between January and March
  - All the water is taken, this River is depleted in this season. Since dam's water is been taken, there is no need to stop flowing downstream

○ Chico River Intake (Chico River)
  - There is a purifying plant, but currently it is not working

(2) Description of the visit to the study sites

Figure 3.1.6-1 shows pictures of main sites visited.

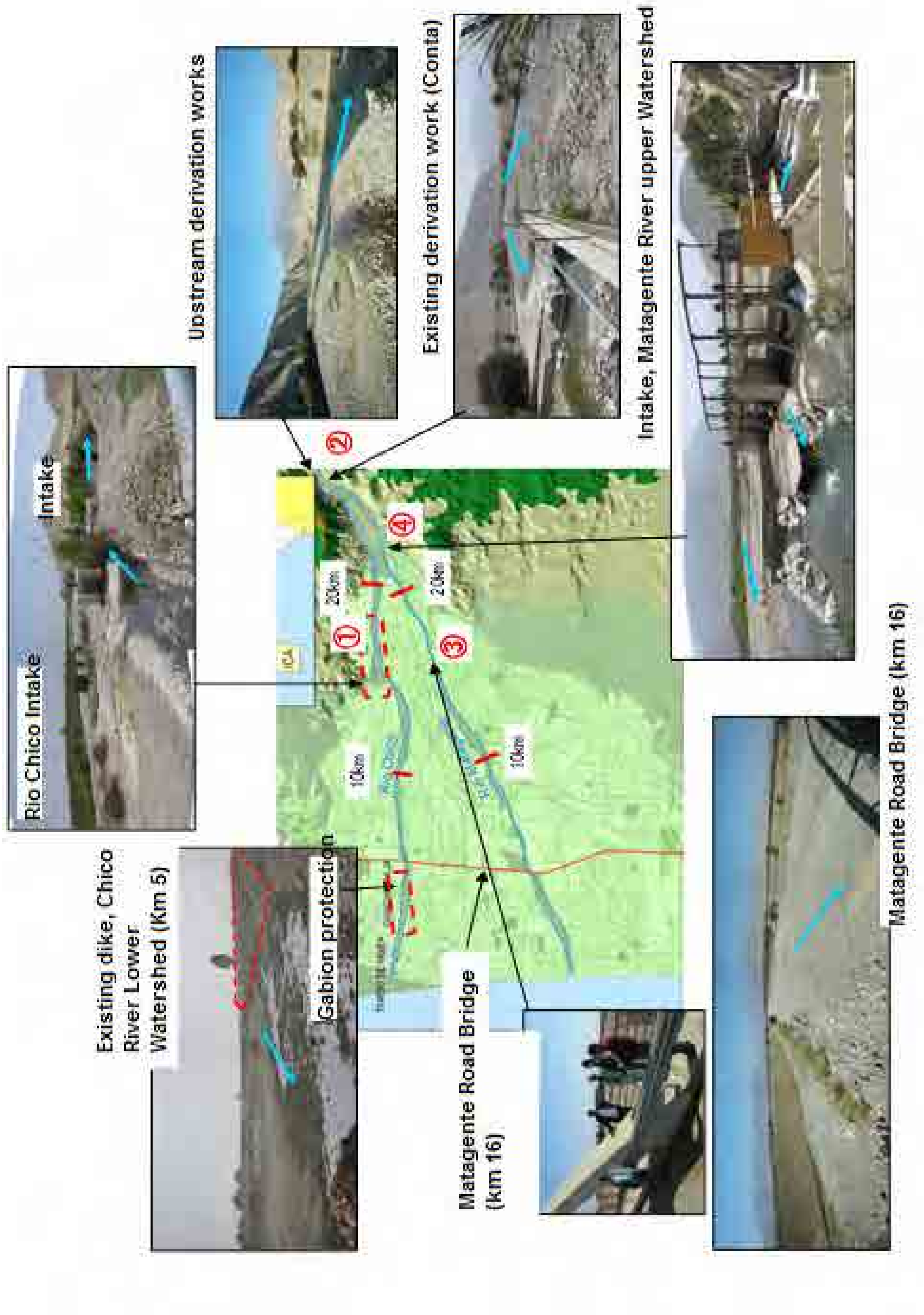


Figure 3.1.1-6 Visit to the Study Site (Chincha River)

(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: Derivation works (Km 24)

Current situation and challenges	・The problem appears annually from December until March. Ten floods of 5 to 12 hours take place. Maximum flow in El Niño reached 1.200 m^3/s. ・According to the design, the river's water shall be derived in a relation of 1:1, and this Lumber is changed when frequent floods take place causing Downstream water overflow.
Main elements to be conserved	・Lower watershed crop area ・Urban Area of Chincha
Basic measures	・Rehabilitation of destroyed installations and existing dikes reinforcement ・Extend longitudinal dike upstream of the intake ・Channels rehabilitation upstream of the intake

Figure 3.1.6-2 Local conditions related with Challenge 1 (Chincha River)

2) Challenge 2: Intake (km 21 of Matagente)

Current situation and challenges	・La toma de agua se realiza entre enero y marzo. La obra fue construida en 1936. ・Es una de las bocatomas más importantes de la zona. ・El delantal de la bocatoma se encuentra gravemente destruido, pudiendo destruir la misma presa de no tomarse medidas adecuadas.
Main elements to be conserved	・Lower basin crop land (main products: cotton and grapes)
Basic measures	・Compact the bed immediately Downstream the deteriorate intake, repair the longitudinal dike and reinforce the existing dike

Figure 3.1.6-3 Local conditions related with Challenge 2 (Chincha River)

3) Challenge 3: Intake (Rio Chico, km 15)

Current situation and challenges	・Water intake is in January through March. This was built in 1936 ・In the past water has overflow on the left margin ・Channel width is reduced near the intake, gathering overflows in this area
Main elements to be conserved	・Lower basin crop land (main products: cotton and grapes)
Basic measures	・Rehabilitate the existing dike (repair and reinforce deteriorate parts of the dam) ・Stable scour of overflows through increase and rehabilitation of channels

Figure 3.1.6-4 Local conditions related with Challenge 3 (Chincha River)

3.1.7 Current situation of vegetation and reforestation

(1) Current Vegetation

The most recent information about the classification of vegetation is that carried out by FAO on 2005, with the collaboration of National Institute of Natural Resources of the Ministry of Agriculture (INRENA[1] in Spanish). According In this study the 1995 Forest Map was used as database and its Explanatory Guide prepared by INRENA and the Forest General Direction. Likewise, the National Planning Institute and the National Bureau of Natural Resources Evaluation (ONERN in Spanish) prepared the Budget, Evaluation and Use of Natural Resources of the Coast which describes the classification of the vegetation and the coast flora.

Pursuant to the 1995 Forest Map and its explanations, the Chincha watershed extends from the coast to the Andean mountains; usually, featuring different vegetal coverage according to the altitude. From coast up to the 2,500msnm (Cu, Dc) have scarce vegetation. Some meters above in altitude, some scrubland can be noticed. Among 2500 and 3500 m.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. Although, 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 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 base don 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 3.7.2-1). Then, the addition of each ecologic life zone's surface, outstanding the coastal desert (Cu, Pj) dry bushes (Ms) and puna grass (Cp, Pj) was calculated. In Table 3.1.7-3 it is shown the percentage of each ecologic area. It is observed that the desert occupies 30% of the total area, 10% or 20% 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,

[1] Subsequently, INRENA was dissolved and its functions were assumed by the Wild Forest and Fauna General Direction.

due to which the surface of these bushes is not wide. So, natural conditions of the four watersheds of Chincha River 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 (Chincha River watershed)

Watersheds	Vegetation								
	Cu	Dc	Ms	Msh	Mh	Cp	Pj	N	Total
(Surface: hectares)									
Chincha River	169,98	1.010,29	642,53	365,18	0,00	854,74	261,17	0,00	3,303,89
(Percentage of the watershed surface: %)									
Chincha River	5,1	30,6	19,4	11,1	0,0	25,9	7,9	0,0	100,0

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

Table 3.1.7-3 Area and percentages of each classification of vegetation gathered (Chincha river watershed)

Watershed	Ecologic Zones					
	Desert,etc. (Cu, Dc)	Dry bushes (Ms)	Bushes (Msh, Mh)	Grass (Cp, Pj)	Snowy (N)	Total
(Percentage: %)						
Chincha	35.7	19.4	11.1	33.8	0.0	100.0

(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 Ica Region, data are 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)
Ica	2.093.457	-	-	-

Source: National Reforestation Plan, INRENA, 2005

The variation of the distribution of vegetation was analyzed per watershed, comparing the SIG to the 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 (Msh, Mh), puna grass (Cp) and Ice-capped (N) increased.

Table 3.1.7-5 Changes in the areas of distribution of vegetation from 1995 to 2000 (Chincha river Watershed)

Watershed	Vegetation Formation								
	Cu		Cu		Cu		Cu		Cu
(Surface of the vegetation cover: hectare)									
Chincha	-5,09	-19,37	-95,91	86,85	3,55	-5,54	35,51	−	3.303,89
Current Surface (b)	169,98	1,010,29	642,53	365,18	0,00	854,74	261,17	0,00	3.303,89
Percentage of current surface (a/b) %	-3,0	-1,9	-14,9	+23,78	−	-0,6	+13,6	−	

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

(4) Current situation of forestation

As indicated before, the climate conditions of Chincha River watershed do not improve high trees species development, so natural vegetation is not distributed; this only happens in the banks were the freatic water table is near the surface.

So, due to the difficult situation of finding a good spot to grow trees is why reforestation great projects have not happened in this area. There is no reforest project known with commercial aims.

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
Ica	2.213	20	159	159	89	29	61	15	4	1	2.750

Source: National Reforestation Plan, INRENA, 2005

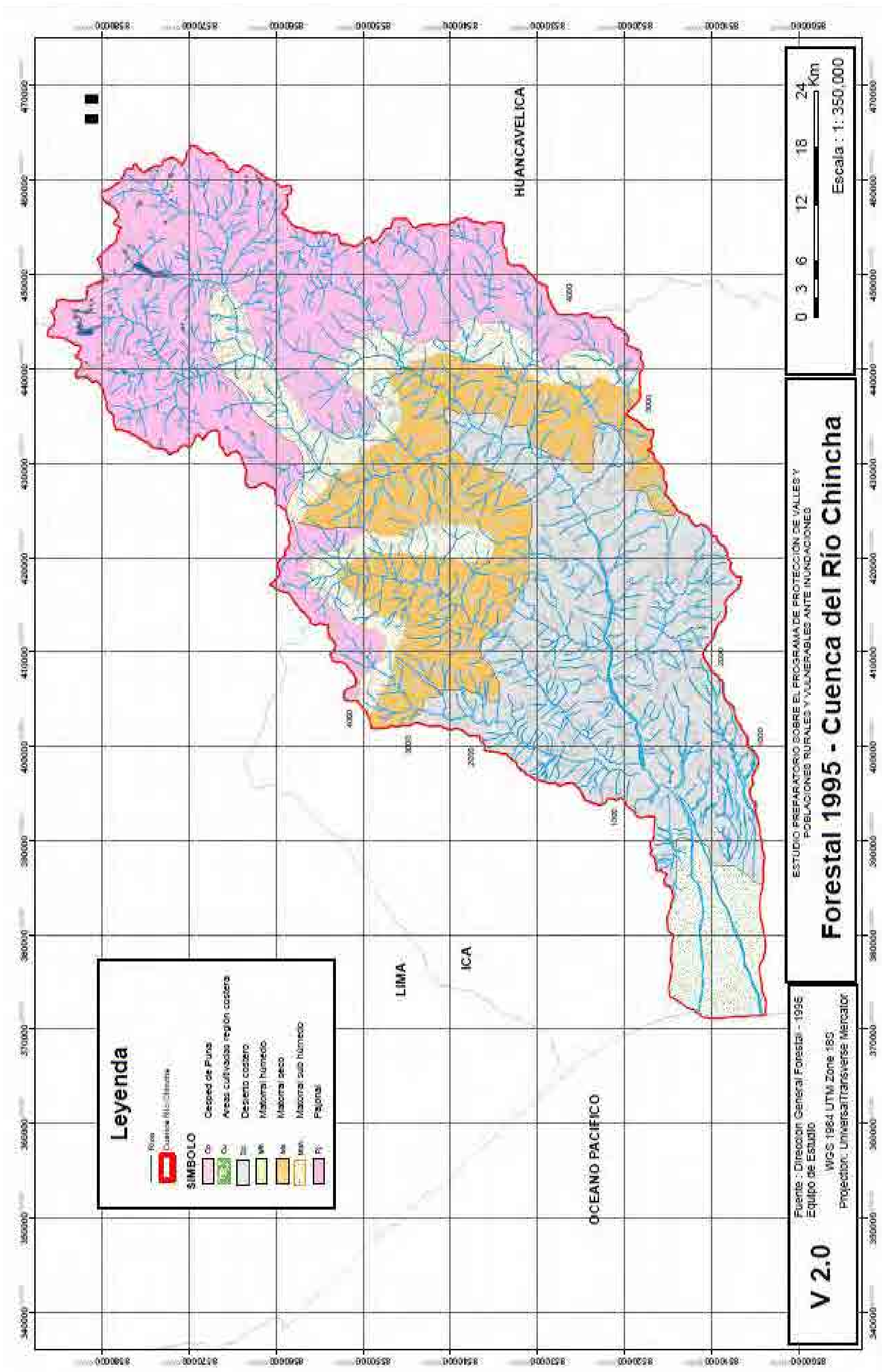


Figure 3.1.7-1 Chincha River Forestry Map

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 Chincha River watershed.

Table 3.1.8-2 Surface according to altitude

Altitude	Area (k m^2)

(msnm)	Chincha
0 – 1000	435,6
1000 – 2000	431,33
2000 – 3000	534,28
3000 – 4000	882,39
4000 – 5000	1019,62
5000 – More	0,67
TOTAL	3303,89
Maximum Altitude	5005,00

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

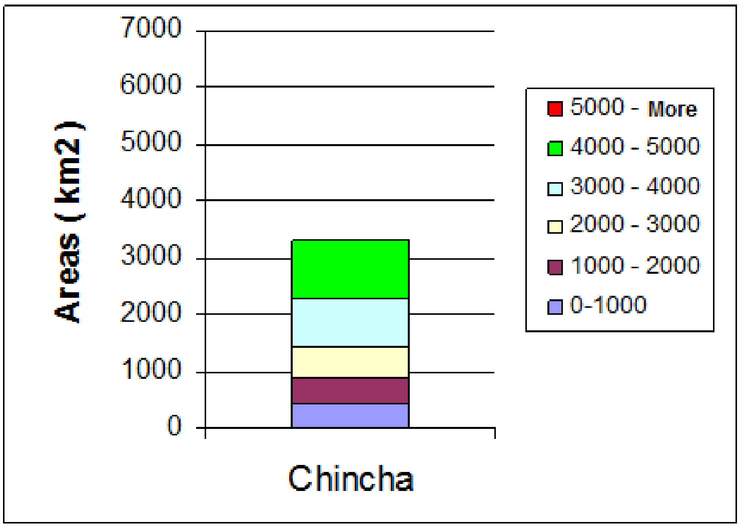


Figure 3.1.8-1 Surface according to altitude

ii) Zoning according to slopes

Table3.1.8-3 and Figure 3.1.8-2 show the slopes in Chincha River watershed. In Chincha slopes of more than 35° represent more than 50% of the total surface. The more pronounced topography, the more sediments production value. So, more sediment is produced.

Table 3.1.8-3 Slopes and surface

Watershed slope (%)	Chincha	
	Area (km^2)	Area (km^2)
0 - 2	90,62	90,62
2 - 15	499,68	499,68
15 - 35	1019,77	1019,77
More than 35	1693,82	1693,82
TOTAL	3303,89	3303,89

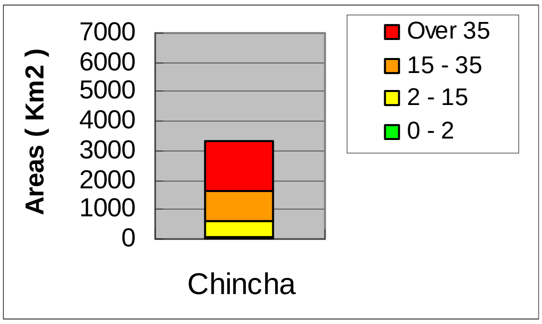


Figure 3.1.8-2 Slopes and surface

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.

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

River-bed slope (%)	Chincha
0,00 - 1,00	5,08
1,00 - 3,33	177,78
3,33 - 16,67	1250,82
16,67 - 25,00	458,76
25,00 - 33,33	255,98
33,33 – More	371,8
TOTAL	2520,22

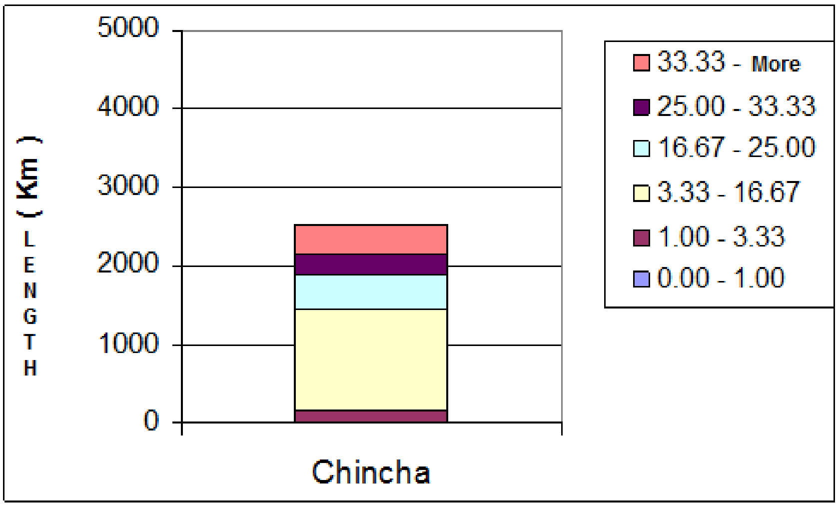


Figure 3.1.8-3 River-bed Slope and total length of streams

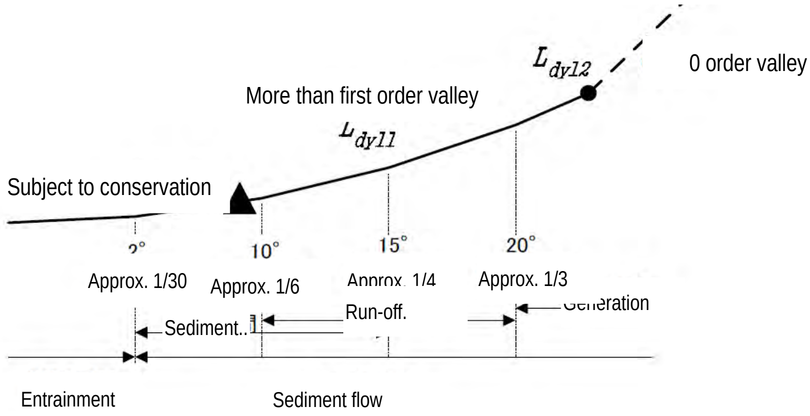


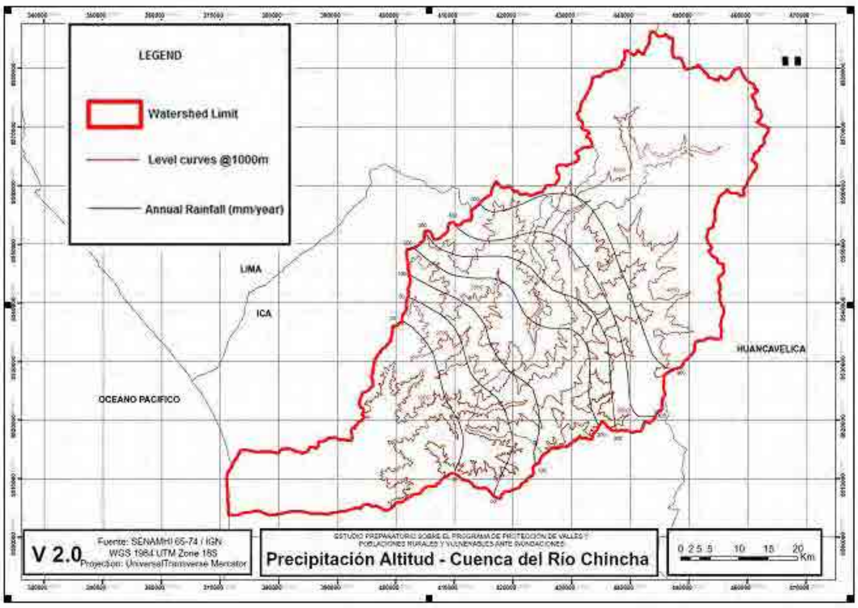
Figure 3.1.8-4 River-bed slope and sediment movement pattern

2) 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 Chincha 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 is between 750 and 100 m.a.s.l.

3) 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.

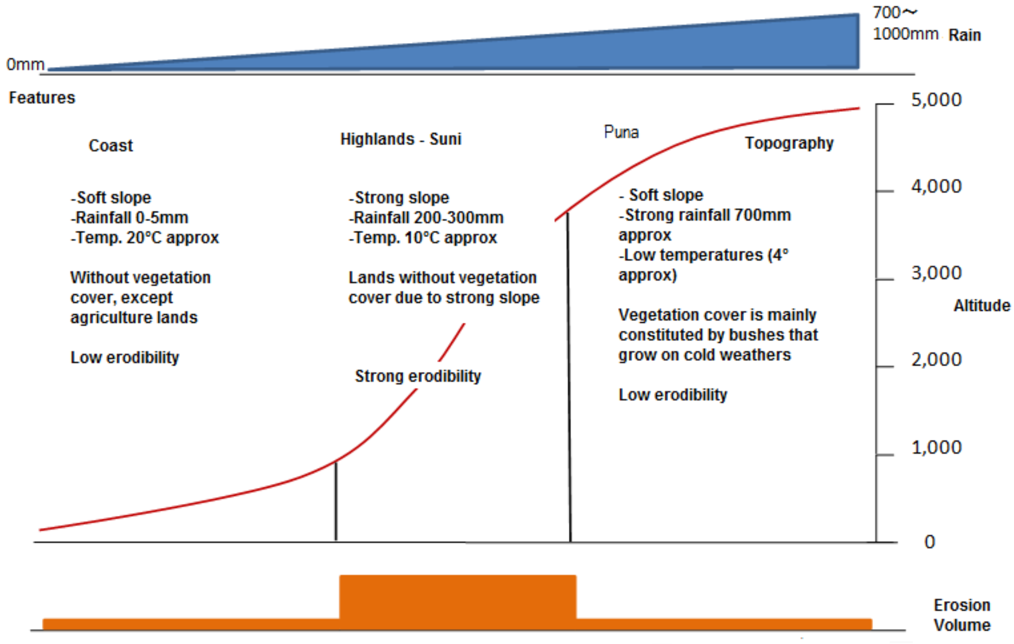


Figure 3.1.8-6 Relation between the erosion volume and the different causes

(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.

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 Chincha river watershed

Altitude	SLOPES 0-2	2 - 15	15 - 35	More than 35	Total
0 - 1000	78.15	80.09	148.11	129.25	435.6
Ratio	18%	18%	34%	30%	100%
1000 - 2000	0	50	234.91	146.42	431.33
Ratio	0%	12%	54%	34%	100%
2000 - 3000	0	47.83	64.87	421.58	534.28
Ratio	0%	9%	12%	79%	100%
3000 - 4000	0	32.12	256.02	594.25	882.39
Ratio	0%	4%	29%	67%	100%
4000 - 5000	12.47	289.52	315.65	401.98	1019.62
Ratio	1%	28%	31%	39%	100%
5000 - More	0	0.12	0.21	0.34	0.67
Ratio	0%	18%	31%	51%	100%
Total	90.62	499.68	1019.77	1693.82	3303.89
Ratio	3%	15%	31%	51%	100%

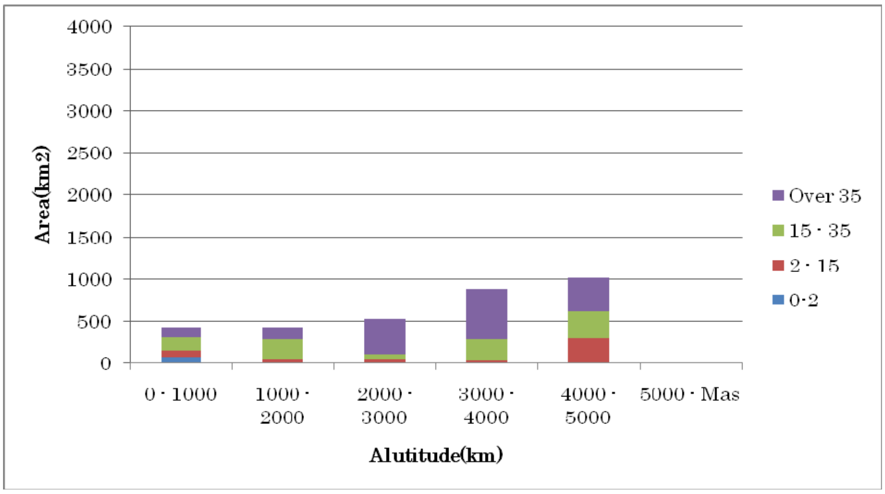


Figure 3.1.8-7 Slopes according to altitudes of Chincha River

(4) Production of sediments

1) Results of the geological study

- 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 balsitic soil collapsed

Figure 3.1.8-9 Sediment production of sedimentary rocks

Figura 3.1.8-10 Invasión de cactus

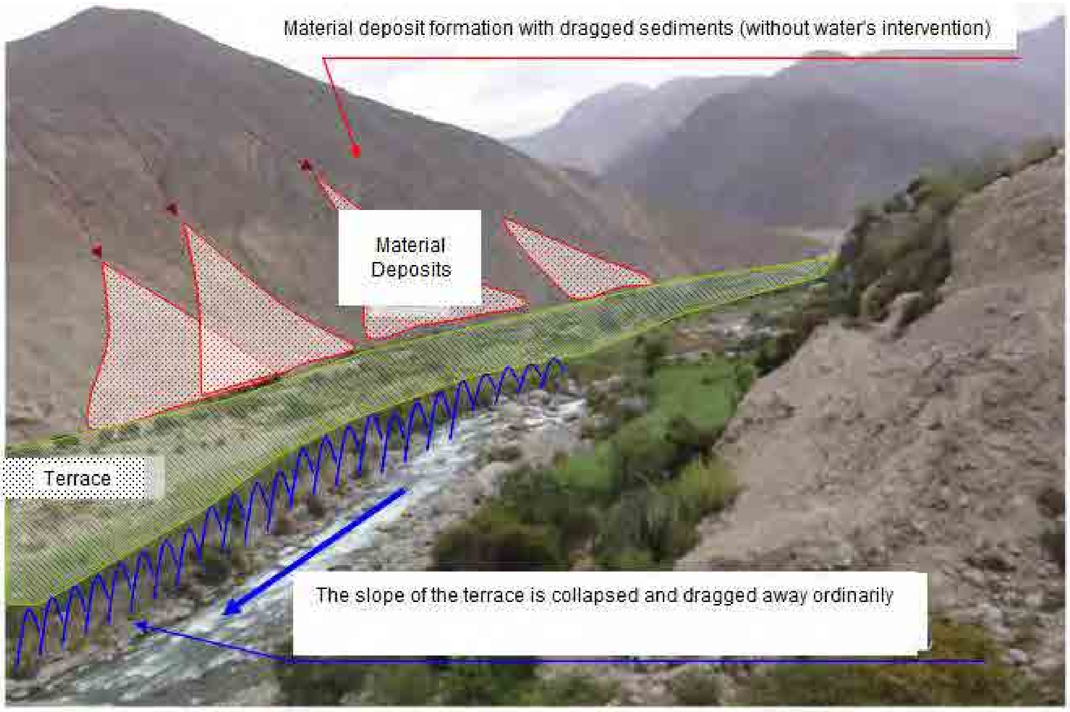


Figure 3.1.8-11 Stream sediment movement

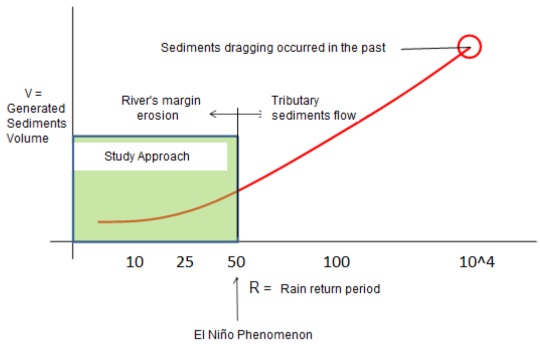
2） Sediments movement (in the stream)

In ravines, terraces are developed. 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)

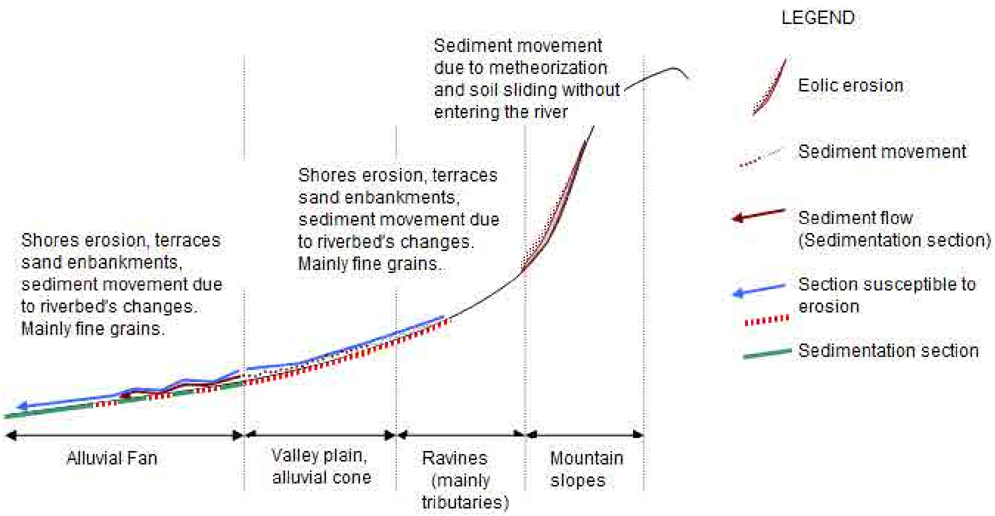


Figure 3.1.8-12 Production and entrainment of sediments in an ordinary year

(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

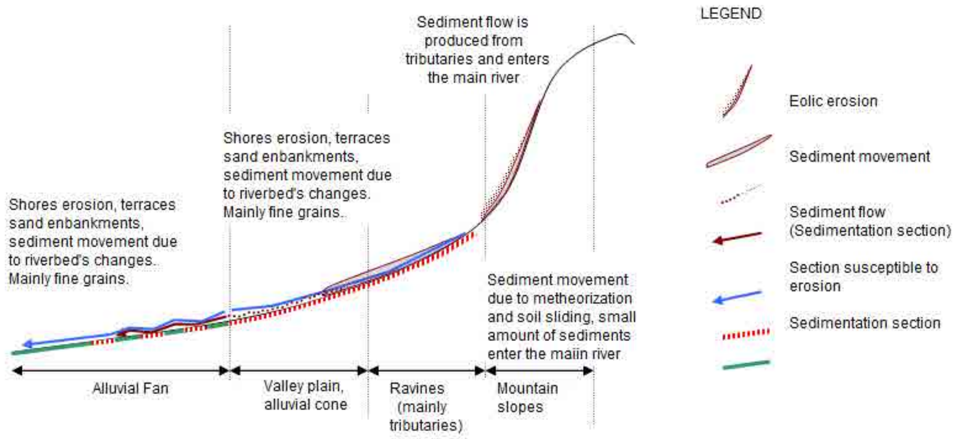


Figure 3.1.8-13 Production and entrainment of sediments during the torrential rainfall of magnitude similar to that of El Niño (1:50 year return period)

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

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, once a few thousand 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.

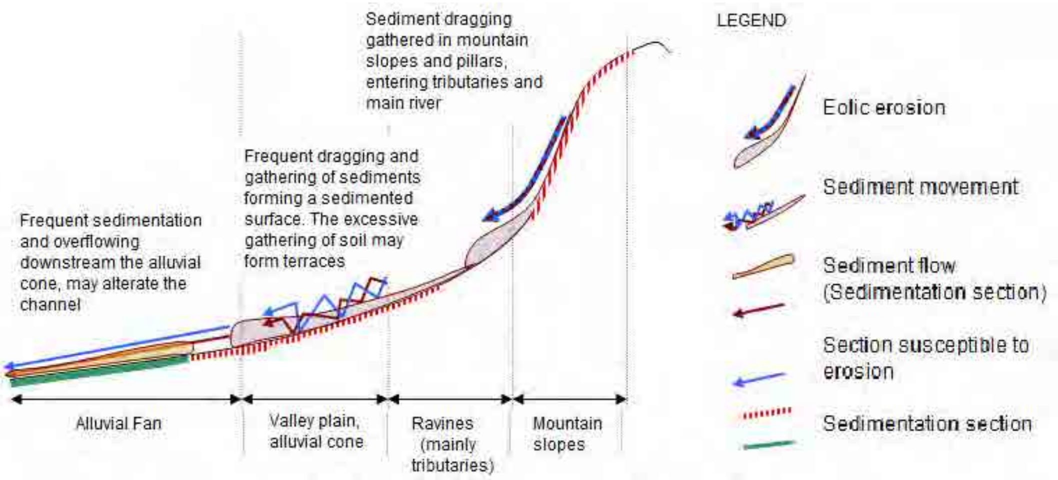


Figure 3.1.8-21 Production of sediments in large overflowing (geologic scale)

3.1.9 Run off analysis

(1) Rainfall data

1) Current rainfall monitoring system

The current rainfall data collection system used for the discharge analysis was reviewed; besides, the necessary rainfall data was collected and processed for such analysis. Rainfall data was obtained from SENAMHI and ELECT.PERU.

Tables 3.1.9-1~2 and Figure 3.1.9-1 indicate the rainfall monitoring points and the data collected according to the period in Chincha River watershed.

In Chincha river watershed rainfall monitoring is performed in 14stations (including those currently non-operative), for a maximum period of 31 years since 1980 until 2010.

Table 3.1.9-1 List of rainfall monitoring stations (Chincha river watershed)

STATION NAME	STATION CODE	Watershed	Station Type	Begin Activities	Years of observ.	POLITICAL LOCATION			Geographical LOCATION			RESPONSIBLE INSTITUTION	OBSERVATION
						Dpto	Prov	Dist	Lat	Length	Altitude		
CONTA	203501	San Juan	H-Lm	1922	80	Ica	Chincha	Chincha Alta	13°27'	75°58'	320	JUNTA USUARIOS	OPERATIVE
FONAGRO	130791	San Juan	MAP	1986	17	Ica	Chincha	Chincha Baja	13° 28'	76° 08'	50	SENAMHI	OPERATIVE
SAN JUAN DE CASTROVIRREYNA	156114	San Juan	PLU	1966	37	Huancavelica	Castrovirreyna	San Juan	13° 12'	75° 38'	2150	SENAMHI	OPERATIVE
SAN JUAN DE YANAC	156113	San Juan	PLU	1964	37	Ica	Chincha	Chavin	13° 13'	75° 47'	2400	SENAMHI	OPERATIVE
HUACHOS	151503	San Juan	PLU	1980	23	Huancavelica	Castrovirreyna	Huachos	13° 14'	75° 32'	2680	SENAMHI	OPERATIVE
VILLA DE ARMAS	110641	San Juan	CO	1964	27	Huancavelica	Castrovirreyna	Arma	13° 08'	75° 32'	3600	SENAMHI	OPERATIVE
SAN PEDRO DE HUACARPANA	156115	San Juan	CO	1964	34	Ica	Chincha	S.P.Huacarpana	13° 03'	75° 39'	3680	SENAMHI	OPERATIVE
LAGUNA HUICHINGA	110632	San Juan	PLU	1980	18	Huancavelica	Castrovirreyna	Aurahua	13°02"	75°34"	3480	SENAMHI	PARALIZED
TANTARA	110633	San Juan	PLU	1980	18	Huancavelica	Castrovirreyna	Tantará	13°14"	75°37"	2890	SENAMHI	PARALIZED
CHUNCHO	110631	Mantaro	PLU	1945	23	Lima	Yauyos	Tupe	12°45'	75°31'	4695	IRRIG-SAN JNUAN	PARALIZED
BERNALES	110650	Pisco	CO	1964	39	Ica	Pisco	Humay	13° 45'	75° 57'	250	SENAMHI	OPERATIVE
HUANCANO	110639	Pisco	CO	1964	39	Ica	Pisco	Huancano	13° 36'	75° 37'	1006	SENAMHI	OPERATIVE
TICRAPO	110643	Pisco	PLU	1964	39	Huancavelica	Castrovirreyna	Ticrapo	13° 23'	75° 26'	2174	SENAMHI	PARALIZED
TOTORA	110644	Pisco	PLU	1964	39	Huancavelica	Castrovirreyna	Castrovirreyna	13° 08'	75° 19'	3900	SENAMHI	PARALIZED

Table 3.1.9-2 Period of rainfall data collection (Chincha river watershed)

CHINCHA	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
HUACHOS																					■	■	■	■	■	■
VILLA DE ARMAS								■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
CONTA																										
FONAGRO (CHINCHA)																										
SAN JUAN DE YANAC																										
SAN PEDRO DE HUACARPANA																										
SAN PEDRO DE HUACARPANA 2						■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■			
TOTORA							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
TICRAPO					■	■	■	■	■	■	■	■	■	■	■	■		■	■	■		■	■	■	■	
COCAS					■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■				

CHINCHA	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
HUACHOS	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
VILLA DE ARMAS		■	■	■	■	■	■	■	■	■	■	■	■												
CONTA																		■	■	■	■	■	■	■	■
FONAGRO (CHINCHA)	■	■	■	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SAN JUAN DE YANAC				■	■					■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
SAN PEDRO DE HUACARPANA												■	■	■	■	■	■	■	■	■	■	■	■	■	■
SAN PEDRO DE HUACARPANA 2	■		■	■	■	■			■	■	■														
TOTORA	■	■	■																						
TICRAPO	■	■	■	■																					
COCAS																									

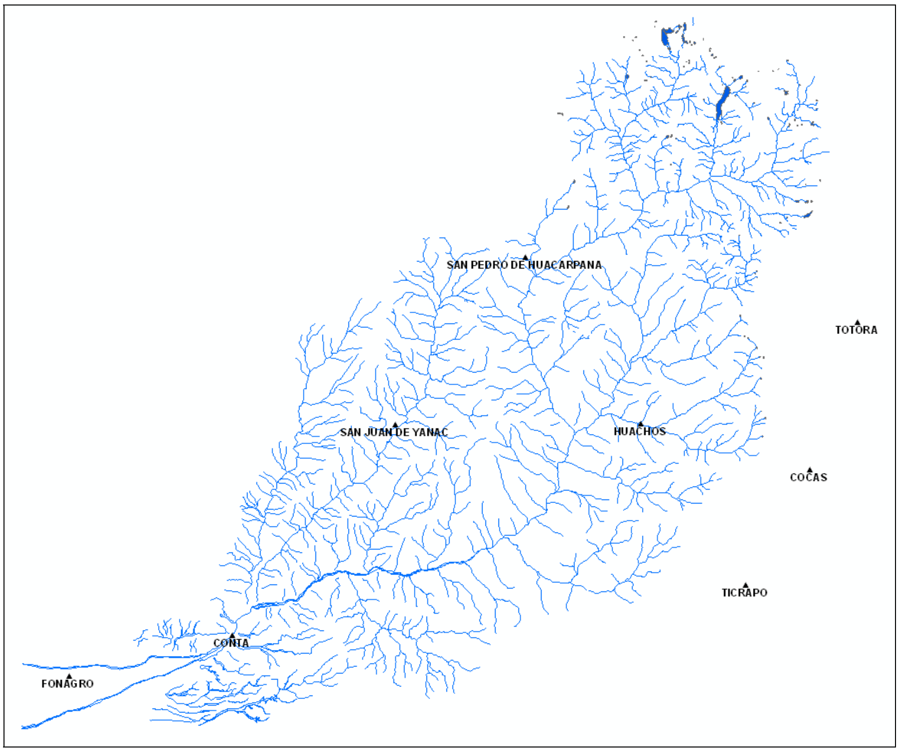


Figure 3.1.9-1 Monitoring stations location map
(Chincha River watershed)

2) Isohyet map

Annual rain isohyets maps are described next (average of 10 years) elaborated by SENAMHI using data recovered in the period 1965-1974.

Figure 3.1.9-2 shows a map of the isohyet of Chincha River watershed.

In the Chincha River Watershed is observed that the considerable variation of the annual rainfall depending on the zones, with a minimum of 25mm and a maximum of 900 mm approximately. The rainfall is lower on the lower watershed and it increases as the altitudes get near the upper watershed, increasing the altitudes.

The annual rainfall in the low watershed, subject to the control of floods, is almost null, ranging 25mm.

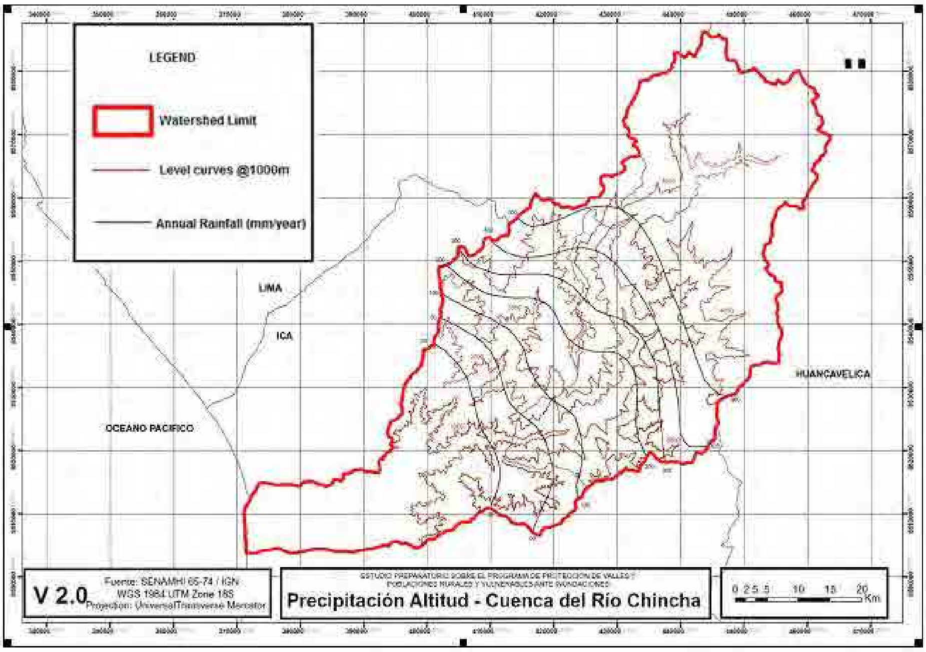


Figure 3.1.9-2 Isohyet Map (Chincha River watershed)

(2) Rainfall analysis

1) Methodology

The statistic hydrologic calculation was made using the rainfall data collected from several stations, to determine the rainfall with 24 hour return period in every station.

Several models of distribution of return periods were tested and the most adequate one was adopted. Thus, the precipitation with 24 hours return period was determined with this model.

The statistic hydrologic models were.

- Normal distribution (Normal)
- Log-Normal distribution
- Log-Normal distribution of 2-parameters
- Log-Normal distribution of 2 or 3 parameters
- Log Pearson Type III distribution
- Gumbel distribution (Gumbel)
- General distribution of extreme value

2) Results of the rainfall analysis of return period– t

The rainfall of several stations are shown below and the reference point of each watershed, according to return periods.

Table 3.1.9-3 shows the monitoring points and the rainfall with 24 hour return period in the reference point (Conta Station). Figure 3.1.9-3 shows the map of isohyets of rainfall with 50 year return period.

Table 3.1.9-3 Rainfall with 24 hour return period
(Chincha river watershed)

Station Name	Return Period T [YEARS]						
	PT_2	PT_5	PT_10	PT_25	PT_50	PT_100	PT_200
COCAS	22.0	30.0	34.0	38.0	40.0	42.0	43.0
CONTA	1.0	2.0	4.0	6.0	9.0	13.0	18.0
FONAGRO	1.0	2.0	3.0	4.0	5.0	7.0	8.0
HUACHOS	24.0	31.0	36.0	42.0	48.0	53.0	59.0
SAN JUAN DE YANAC	11.0	18.0	23.0	30.0	34.0	39.0	44.0
SAN PEDRO DE HUACARPANA	23.0	29.0	32.0	35.0	36.0	37.0	38.0
TICRAPO	20.0	31.0	37.0	45.0	50.0	55.0	60.0
TOTORA	24.0	29.0	32.0	36.0	38.0	40.0	42.0
VILLA DE ARMAS	28.0	40.0	47.0	56.0	62.0	68.0	73.0

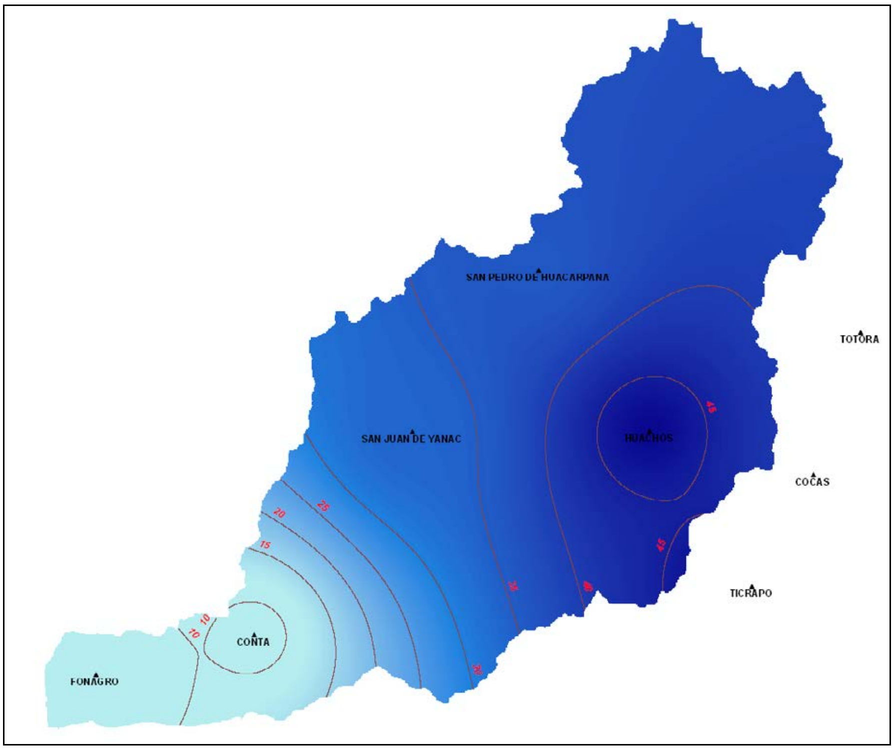


Figure 3.1.9-3 Map of isohyets of a 50 years period rainfall (Chincha river watershed)

Table 3.1.9-4 24 Hours rainfall for different return periods

(Reference spot: Conta Station)

Return Period (years)	Maximum Precipitation of 24 hours (mm)
5	23,40
10	27,39
25	32,22
50	35,56
100	39,06

Table 3.1.9-5 Pluviograph of different return periods

Years	Hours										Total Precipitation (mm)
	1	2	3	4	5	6	7	8	9	10	
5	1	2	2	4	3	2	2	2	1	1	19
10	1	2	3	4	3	3	2	2	1	1	22,0
25	1	2	3	5	4	3	3	2	2	1	25,9
50	1	3	4	5	4	3	3	2	2	1	28,6
100	2	3	4	6	4	4	3	3	2	1	31,4

(3) Discharge flow analysis

1) Flow monitoring

The current flow data collection system used in the discharge analysis was reviewed, and the necessary flow monitoring data were collected and processed for such analysis. The flow data have been obtained mainly from the DGIH, irrigation commissions, Water National Authority (ANA) and the Chira-Piura Special Project.

2) Analysis of discharge flow

The statistic hydrological calculation was made using the data of the maximum annual discharge collected and processed in the reference points, to determine the flow with different probabilities. Table 3.1.9-6 shows the probable flow with return periods between 2 and 100 years.

Table 3.1.9-6 Probable flow in control points

(m^3/s)

Rivers	Return periods					
	2 years	5 years	10 years	25 years	60 years	100 years
Río Chincha Conta	179	378	536	763	951	1.156

3) Analysis of flooding flow with t-years return periods

(a) Methodology

The probable flooding flow was analysed using the HEC-HMS model, with which the hyetograph or return periods was prepared, and the peak flow was calculated.

For the rainfall used in the analysis, the hyetograph of several periods prepared in the rainfall analysis was used. Hyetography was determined taking as reference the flow peak in the discharge analysis.

For the Chira River, the regulator effect of floods of Poechos Dam was taken into account, which is located in the upper watershed.

(b) Analysis results

Table 3.1.9-5 shows the flow of flooding with return periods between 2 and 100 years of the Chincha river watershed.

Likewise, Figure 3.1.9-4 shows the hydrographical map of probable flood in the Chincha river watershed.

It can be noticed that the numbers in Tables 3.1.9-6 and 3.1.9-7 are similar. So, for the following flood analysis the figures of Table 3.1.9-7 were decided to be used because they match the hydrograph.

Table 3.1.9-7 Flood flow according to the return periods
(Peak flow: Reference point)

(m^3/s)

	Return period					
Rivers	2 years	5 years	10 years	25 years	50 years	100 years
Chincha Conta	203	472	580	807	917	1.171

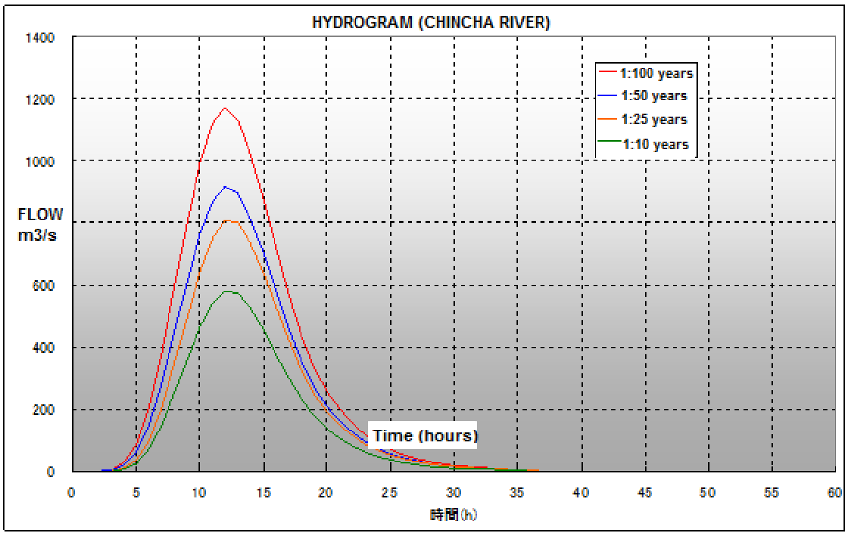


Figure 3.1.9-4 Hydrograph of Chincha river

3.1.10 Analysis of inundation

(1) River surveys

Prior to the flood analysis, the transversal survey or Chincha 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			
Chincha river	No.	6	
2. Dikes transversal survey			250m Interval, only one bank
Chincha river	km	50	2 rivers x 25 km
3. River transversal survey			500m Interval
Cañete river	km	38.0	95 lines x 0.4km
4. Benchmarks			
Type A	No.	6	Every control point
Type B	No.	50	25km x one point/km

(2) Flood analysis methods

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

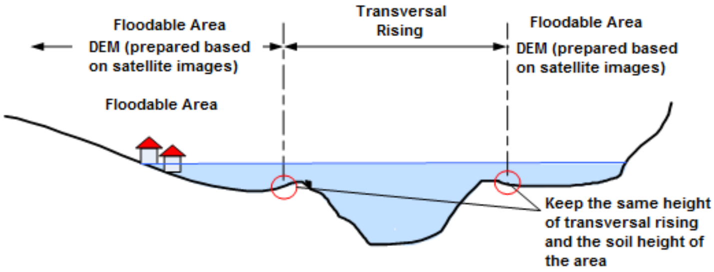
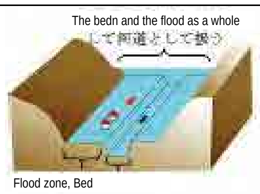
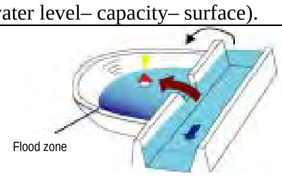
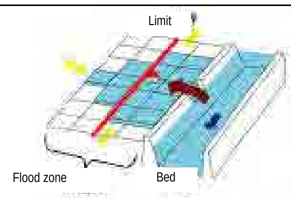


Figure 3.1.10-1 Idea of unidimensional model

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.

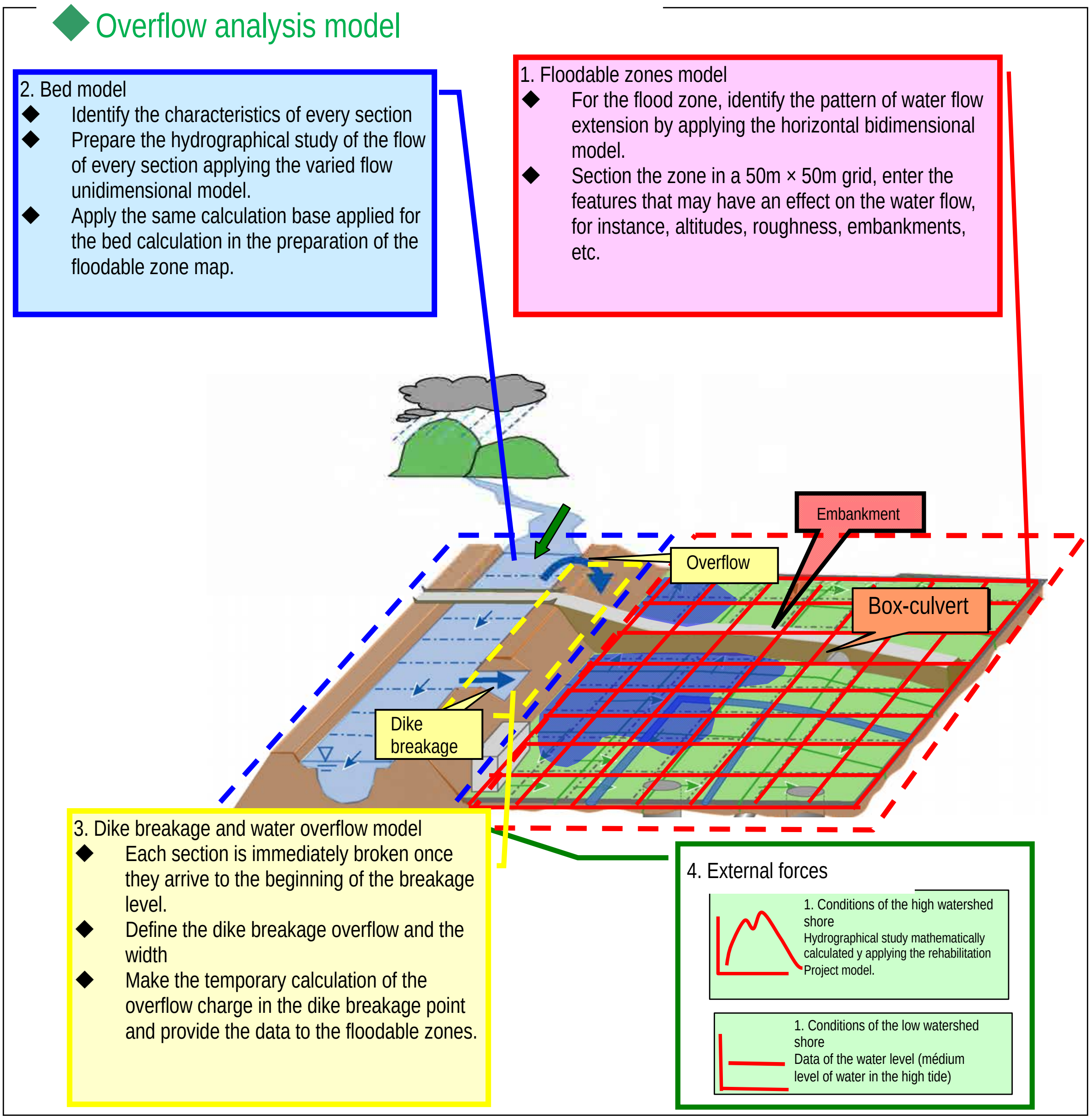


Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge capacity analysis

The current discharge capacity of the beds 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, which allow evaluating in what points of the Chincha river watershed flood may happen and what magnitude of flood flow may they have.

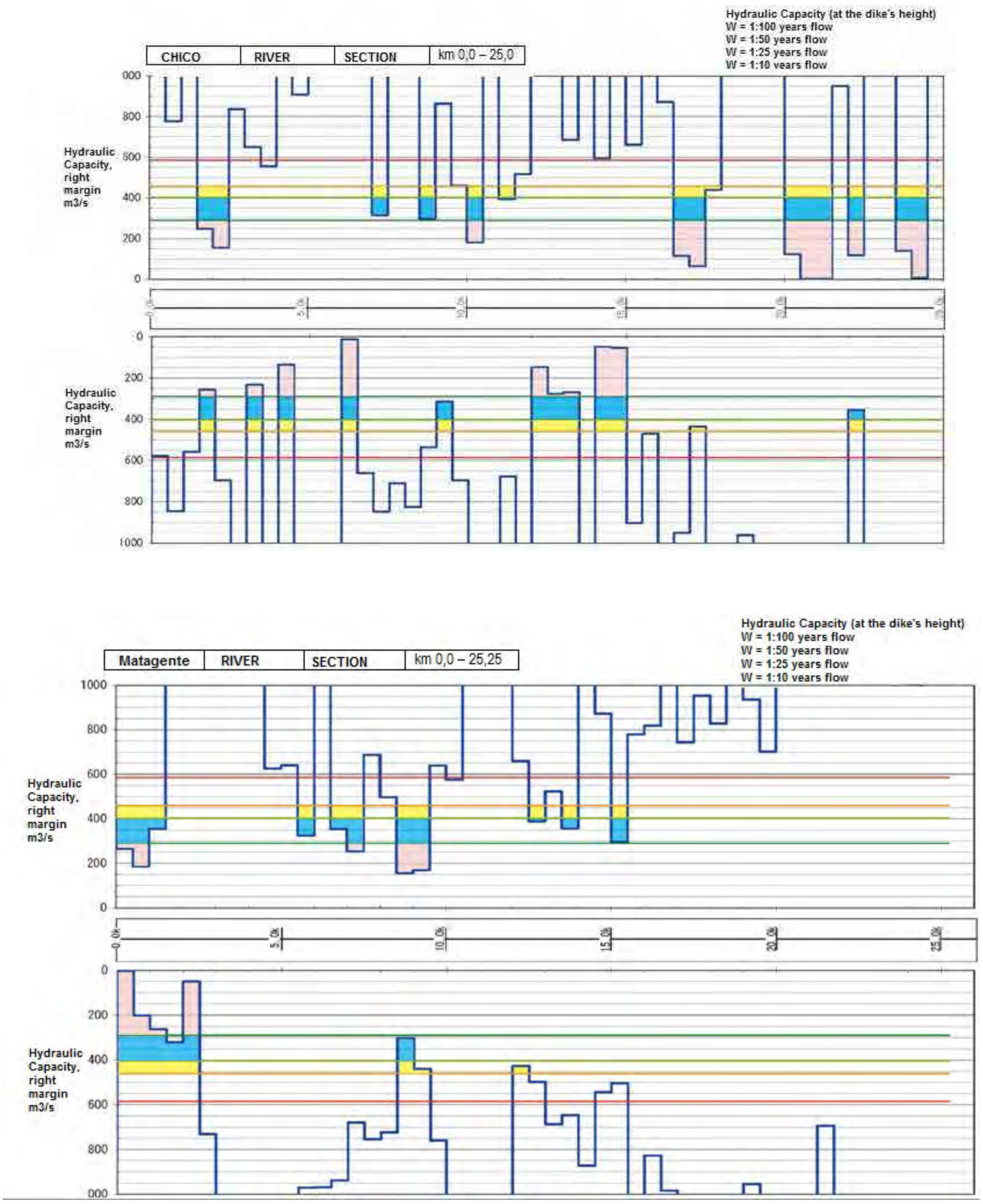


Figure 3.1.10-3(1) Current discharge capacity of Chincha Rivers

(4) Inundation area

As a reference, Figures 3.1.10-5 and 3.1.10-6 show the results of the inundation area calculation in the watershed compared to the flooding flow with a 50 year return period.

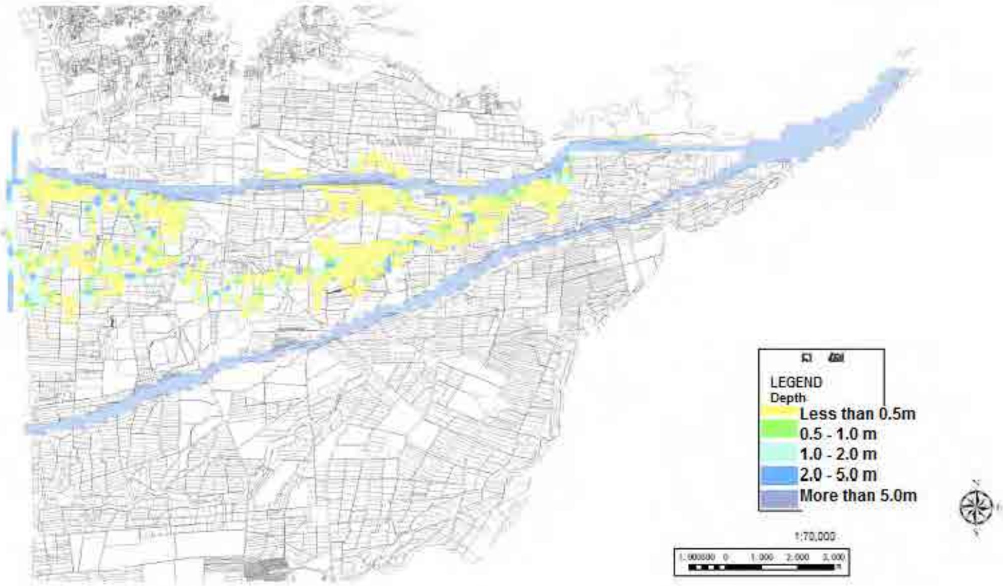


Figure 3.1.10-5 Inundation area of Chincha river – Chico (50 year period floods)

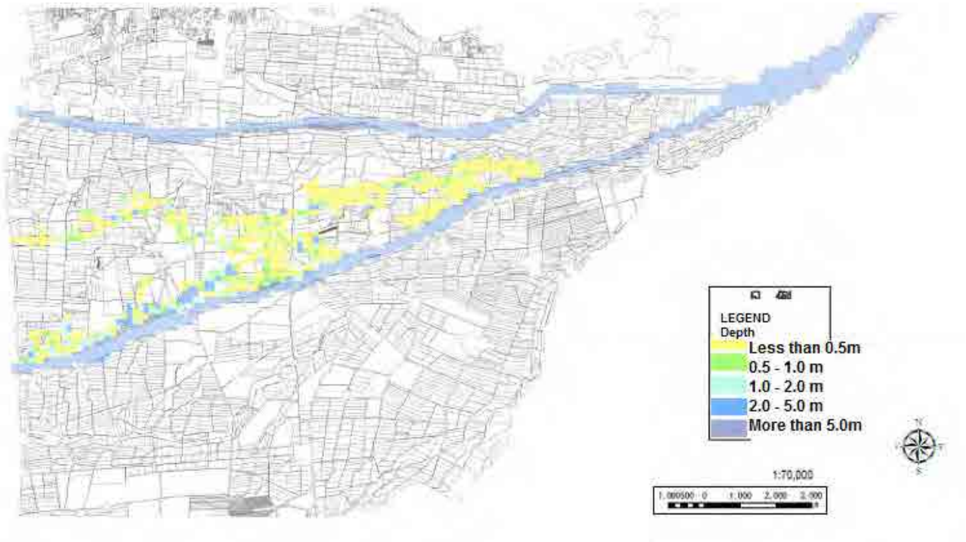


Figure 3.1.10-6 Inundation area of Chincha river – Matagente (50 year period floods)

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 Chincha 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	2.4 Lack of dikes	3.4 Lack of repair works and referral making	4.4 Lack of monitoring and collection of hydrological data

	levee			
	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's 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.

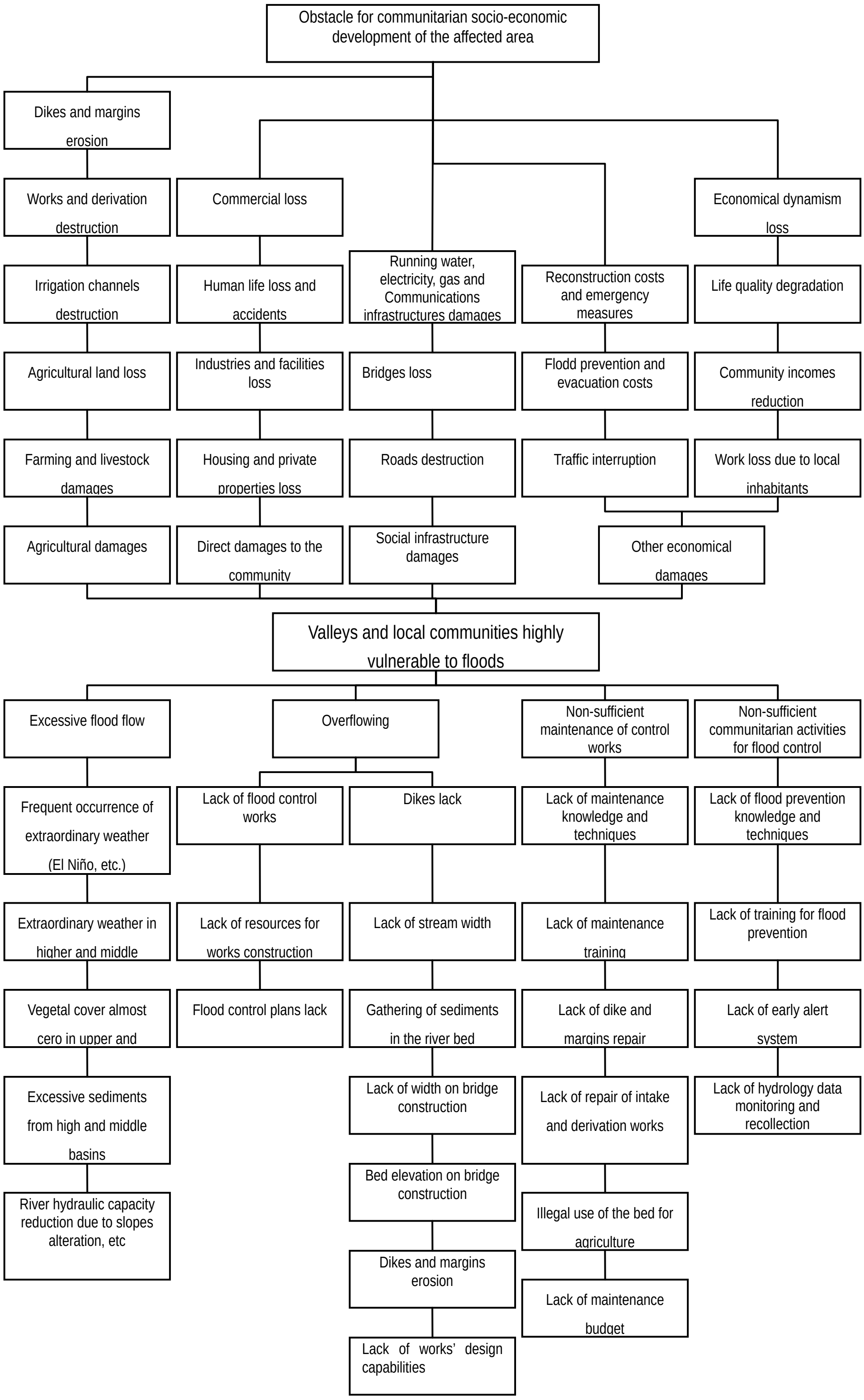


Figure 3.2.4-1 Causes and effects diagram

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.

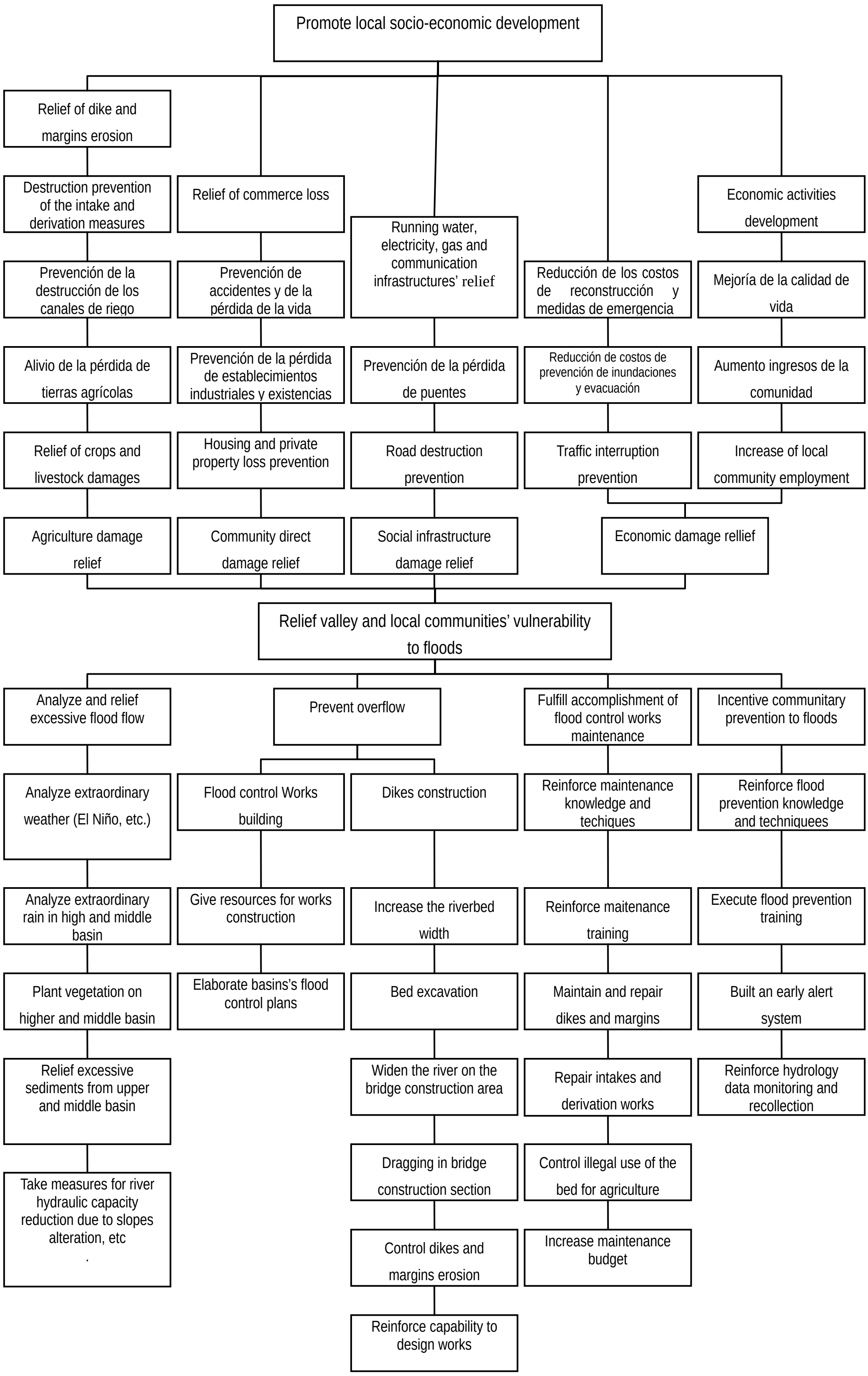


Figure 3.3.3-1 Measures - objectives – impacts diagram