Ministry of Agriculture
Republic of Peru

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

FINAL REPORT
MAINREPORT
I-1 PROGRAM REPORT
(TEMPORARY VERSION)

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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Location Map

Abbreviation

Abbreviation	Official Name or meaning
ANA	Autoridad Nacional del Agua(Water National Authority)
ALA	Autoridad Local del Agua(Water Local Authority)
B/C	Cost-Benefit Ratio(Cost-Benefit relation)
GDP(PBI)	Producto Bruto Interno(PBI)(Gross Domestic Product)
GIS	Sistema de información geográfica (Geographic Information System)
DGAA	Dirección General de Asuntos Ambientales(Environmental Affairs General Direction)
DGFFS	Dirección General de Forestal y de Fauna Silvestre (Forestry and Fauna General Direction)
DGIH	Dirección General de Infraestructura Hidráulica (Hydraulic Infrastructure General Direction)
DGPI(previous DGPM)	Dirección General de Política de Inversiones (Investment Policy General Direction), (Dirección General de Programación Multianual del Sector Público)(Public Sector Multiannual Program General Direction)
DGETP(previous DNEP)	Dirección General de Endeudamiento y Tesoro Público (Public Indebtedness National Direction), Dirección Nacional de Endeudamiento Público
DRA	Dirección Regional de Agricultura (Agriculture Regional Direction)
EIA	Estudio de impacto ambiental (Environmental Impact Assessment - EIA)
FAO	Organización de las Naciones Unidas para la Agricultura y la Alimentación (Food and Agriculture Organization of the United Nations)
F/S	Estudio de Factibilidad (Feasibility Study)
GORE	Gobiernos Regionales (Regional Governments)
HEC-HMS	Sistema de Modelado Hidrológico del Centro de Ingeniería Hidrológica (Hydrologic Model System from the Hydrology Engineer Center)
HEC-RAS	Sistema de Análisis de Ríos del Centro de Ingeniería Hidrológica (Hydrologic Engineering Centers River Analysis System)
IGN	Instituto Geográfico Nacional (National Geographic Institute)
IGV	Impuesto General a Ventas (TAX)

INDECI	Instituto Nacional de Defensa Civil (Civil defense National Institute)
INEI	Instituto Nacional de Estadística (Statistics National Institute)
INGEMMET	Instituto Nacional Geológico Minero Metalúrgico (Metallurgic Mining Geologic National Institute)
INRENA	Instituto Nacional de Recursos Naturales (Natural Resources National Institute)
IRR	Tasa Interna de Retorno (Internal Rate of Return - IRR)
JICA	Agencia de Cooperación Internacional del Japón (Japan International Cooperation Agency)
JNUDRP	Junta Nacional de Usuarios de los Distritos de Riego del Perú (Peruvian Irrigation Disctrict Users National Board)
L/A	Acuerdo de Préstamo (Loan Agreement)
MEF	Ministerio de Economía y Finanzas (Economy and Finance Ministry)
MINAG	Ministerio de Agricultura (Agriculture Ministry)
M/M	Minuta de Discusiones (Minutes of Meeting)
NPV	VAN (Valor Actual Neto) (NET PRESENT VALUE)
O&M	Operación y mantenimiento (Operation and maintenance)
OGA	Oficina General de Administración (Administration General Office)
ONERRN	Oficina Nacional de Evaluación de Recursos Naturales (Natural Resources Assessment National Office)
OPI	Oficina de Programación e Inversiones (Programming and Investment Office)
PE	Proyecto Especial Chira-Piura (Chira-Piura Special Project)
PES	PSA (Pago por Servicios ambientales) (Payment for Environmental Services)
PERFIL	Estudio del Perfil (Profile Study)
Pre F/S	Estudio de prefactibilidad (Pre-feasibility Study)
PERPEC	Programa de Encauzamiento de Ríos y protección de Estructura de Captación (River Channeling and Protection of Collection Structures Program)
PRONAMACHIS	Programa Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos (Water Basins Management and Soil Conservation National Program)
PSI	Programa Sub Sectorial de irrigaciones (Sub-Sectorial Irrigation Program)
SCF	Factor de conversión estándar (Standard Conversion Factor)
SENAMHI	Servicio Nacional de Meteorología y Hidrología (Meteorology and

	Hydrology National Service)
SNIP	Sistema Nacional de Inversión Pública (Public Investment National System)
UE	Unidad Ejectora(Execution Units)
UF	Unidades Formuladoras (Formulator Units)
VALLE	Llanura aluvial, llanura de valle (Alluvial Plain, Valley Plain)
VAT	Impuesto al valor agregado (Value added tax)

THE PREPARATORY STUDY

ON

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

FINAL REPORT

I-1 MAIN REPORT

PROGRAM REPORT

(TEMPORARY VERSION)

Table of Contents

1. EXECUTIVE SUMMARY

1.1 Project Name

"Protection program for valleys and rural communities vulnerable to floods"

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 1.3-2 the values at each point, taking as example Cañete River are shown in the Table -4.2-2. The current height of the dike or the ground is greater than the required height of the dike, at certain points. In these, the difference between supply and demand is considered null. For the result details of each watershed's calculation, see each watershed project report or Annex 4 "Flood Control Plan".

According to this Table, the biggest gap between the supply and demand is in Cañete river and Majes-Camana river and followed by Pisco river. Instead, this gap is reduced in Chincha river.

Table 1.3-1 Demand and supply analysis

(Unit: m)

Watersheds	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
Chincha							
Chico	144.81	145.29	144.00	0.80	144.80	0.40	0.45
Matagente	133.72	133.12	132.21	0.80	133.01	0.29	0.36
Pisco	219.72	217.26	214.82	1.00	215.82	0.63	0.76
Majes-Camana	401.90	405.19	399.43	1.20	400.63	0.85	0.65

1.4 Technical Proposal

1.4.1 Structural Measures

Structural measures are a subject that must be analyzed in the flood control plan covering the entire watershed. The analysis results are presented in section 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) (present DGPI) of the Ministry of Economy and Finance (MEF) recommends a comparative analysis of different return periods: 25, 50 and 100 years for the urban area and 10, 25 and 50 years for rural and agricultural land.

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

It was confirmed that the flood discharge with return period of 50 years in each 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 each basin. The results are that the more the return periods of flood increase the more inundation area and damage amount increase in each basin except Chira 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 twenty three (23) critical points (with the highest score in the assessment) that require flood protection measures.

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

1.4.2 Non-Structural Measures

(1) Reforestation and vegetation recovery

1) Basic policies

The reforestation plan and vegetation recovery that meets the objective of this project can be divided into: i) reforestation along river structures, and ii) reforestation in the upper watershed. The first has a direct effect on flood prevention expressing its impact in a short time, while the second one requires high cost and a long period for its implementation, as indicated later in the section 1.14 (2) "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) 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 length and area of reforestation along river structures are 45.4km, and 38.7ha respectively in the objective 4 basins.

(2) Sediment control plan

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

Fluctuation analysis of the river bed has showed that in Chincha and Pisco rivers sediment accumulation has strong incidence. So, it is recommended to execute a sediment control plan in the alluvial fan for these rivers.

The set of priority works for flood control include a retarding basin at km 34.5 of Pisco River, which will have a retardation effect. Also, for Chincha River, a diversion weir of the rivers Chico and Matagente is planned to be built. This diversion work includes training dike and channel consolidation work. These flood protection works will also be used to control sediments.

1.4.3 Technical Support

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

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

Technical assistance will cover the 4 watersheds of this Project: Cañete, Chincha, Pisco and Majes-Camana.

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 each watershed, governments employees (provincial and district), local community representatives, local people etc...

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

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

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

1.5 Project Cost

In the Table 1.5-1 the costs of this Project according to watershed is shown. The cost of the 4 watersheds is around million soles.
The consulting cost is estimated for all 4 watersheds, and distributed to each watershed in proportion to construction cost. And the administration cost is estimated for all 4 watersheds

and distributed to each watershed in proportion to the total of construction cost, consulting cost and land acquisition cost.

Table 1.5-1 Project costs according to watershed

1.6 Social Assessment Results

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

The benefits of the evaluation period were estimated, from the first 15 years since the start of the project. Because, from these 15 years, two are from the work execution period, the evaluation was conducted for the 13 years following the completion of works. Below the social assessment results for this Project based on the above economic evaluation indicators are shown.The variability of 4 watersheds project can be clearly confirmed in the table.

Table 1.6-1 Social assessment results

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

i) Contribution to local economic development to alleviate the fear to economic activities suspension and damages
ii) Contribution to increase local employment opportunities thanks to the local construction project
iii) Strengthening the awareness of local people regarding damages from floods and other disasters
iv) Contribution to increase from stable agricultural production income, relieving flood damage
v) Rise in farmland prices

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

1.7 Sustainability Analysis

This project will be co-managed by the central government (through the DGIH), irrigation committees and regional governments, and the project cost will be covered with the respective contributions of the three parties. As to the shearing ratio of the project cost, refer to the clause 1.11. On the other hand, the operation and maintenance (O & M) of completed works is taken by the irrigation committees. Therefore, the sustainability of the project is depends on the profitability of the project and the ability of O & M of irrigation committees.

The profitability of the project is high enough as described in the clause 1.6 so that the sustainability of the project is guaranteed.

In the Table 1.7-1 the budget data from last year of the irrigation commissions is shown.

Table 1.7-1 Irrigation Commission's budget

Rivers	Annual Budget (Unit/ S)			
	2007	2008	2009	2010
Cañete	2,355,539.91	2,389,561.65	2,331339.69	2,608,187.18
Chincha	1,562,928.56	1,763,741.29	1,483,108.19	-
Pisco	1,648,019.62	1,669,237.35	1,725,290.00	1,425,961.39
Majes-Camana	-	1,867,880.10	1,959,302.60	1,864,113.30
Total	5,566,488.09	7,690,420.39	7,499,040.48	5,898,261.87

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

The percentage of O/M cost to the annual budget of irrigation committee is highest in Majes-Camana(36.2%) followed by Chincha (29.3%) and Pisco (22.2%) and lowest in Cañete (11.1%). And the percentage of O/M cost to the annual flood damage reduction amount is 2% ～4%, which is very low. Although the percentage of O/M cost to the annual budget is relatively high, the percentage of O/M cost to the yearly average damage reduction amount is very low. Since the benefit of agriculture increases due to the reduction of flood damage, it is possible enough that the irrigation committees will bear the O/M cost. The technical capacity of irrigation committee for O/M seems to be enough by the technical assistance of MINAG and regional government because the flood prevention facilities such as embankment, bank protection and weir are familiar structures to the committee

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

Irrigation Committee	Annual Budget(1,000soles)	O/M Cost(1,000 soles)	Percentage of O/M cost(%)	Average Yearly Damage Reduction(1,000soles)	Percentage of O/M cost(%)
	①	②	③=②/①	④	⑤=②/④
Cañete	2,331	260	11.1	12,274	2.1
Chincha	1,483	435	29.3	20,532	2.1
Pisco	1,725	383	22.2	17,844	2.1
Majes-Camana	1,959	710	36.2	17,704	4.0
Total	7,499	1,788	23.8	68,354	2.6

1.8 Environmental Impact

(1) Procedure of environmental impact assessment

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

First, the Project holder applies for the Project classification, by submitting the Preliminary Environmental Assessment (PEA). The relevant sector assesses and categorizes the Project. The Project’s PEA that is categorized under Category I becomes an EID, and those Projects categorized under Category II or III should prepare an EIA-sd or EIA-d, as applicable.

The preliminary environmental assessment (EAP) for 5 watersheds of Chira, Cañete, Chincha, Pisco and Yauca was carried out between December 2010 and January 2011and for Majes-Camana between September 2011 and October 2011 by a consulting firm registered in the Ministry of Agriculture (CIDES Ingenieros S.A.). EAP for the proceeding 5 watersheds was submitted to DGIH January 25, 2011 and for Majes-Camana December 20, 2011 by JICA Study Team and from DGIH to DGAA July 19, 2011 and January 4, 2012 respectively.

DGAA examined EAP for 5 watersheds and issued approval letter of Category I. Therefore, no further environmental impact assessment is required for three watersheds of Cañete, Chincha and Pisco. The projects in Chira and Yauca are excluded from the Project by DGIH. The last watershed of Majes-Camana was also examined by DGAA and categorized as Category I as well as the previous 3 watersheds on August 16, 2012.

(2) Results of environmental impact assessment

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

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

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

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

1.9 Institutions and Management

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

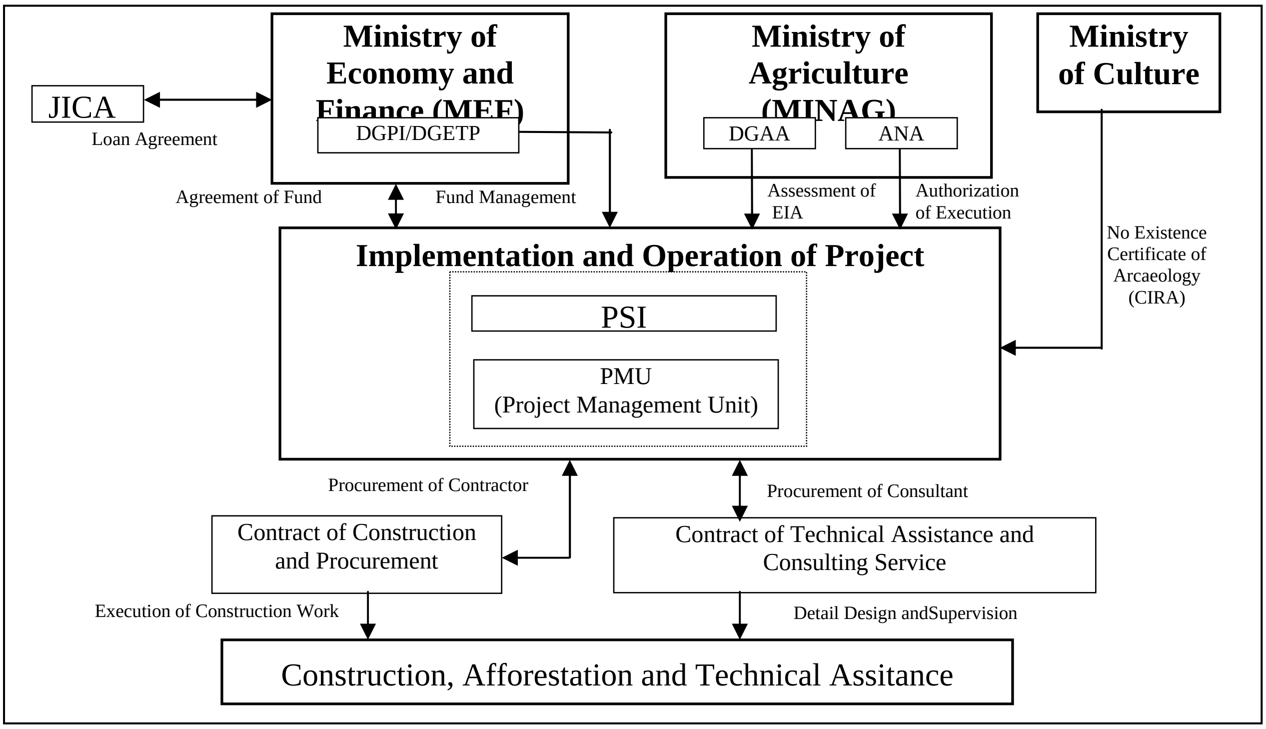


Figure 1.9-1 Related Agencies in Implementation Stage of Project

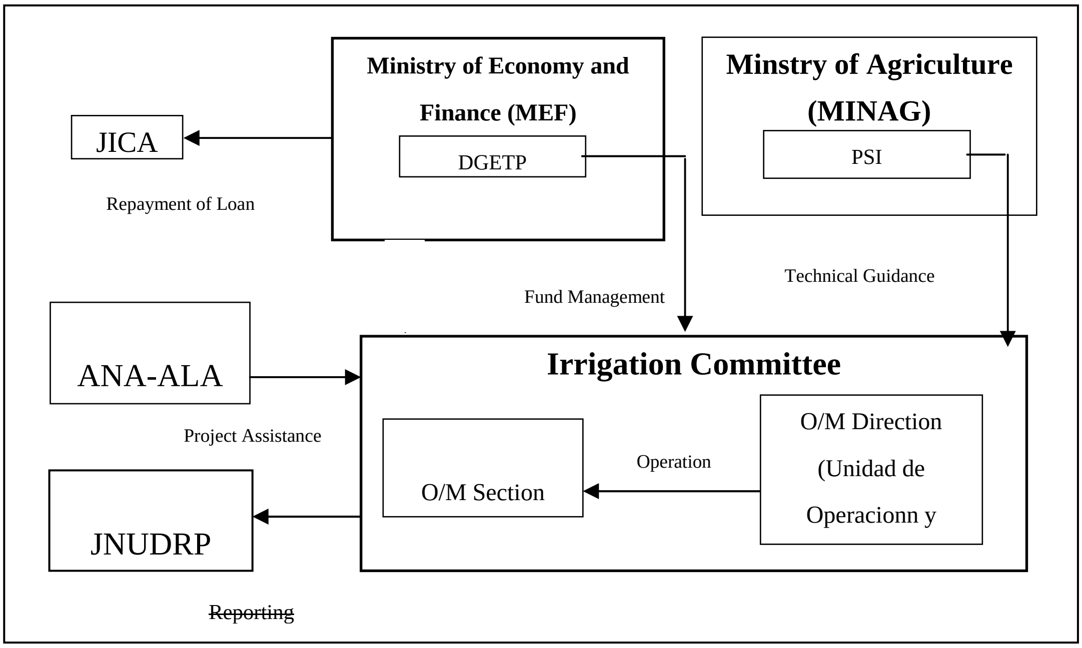


Figure 1.9-2 Related Agencies in Operation Stage of Project

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

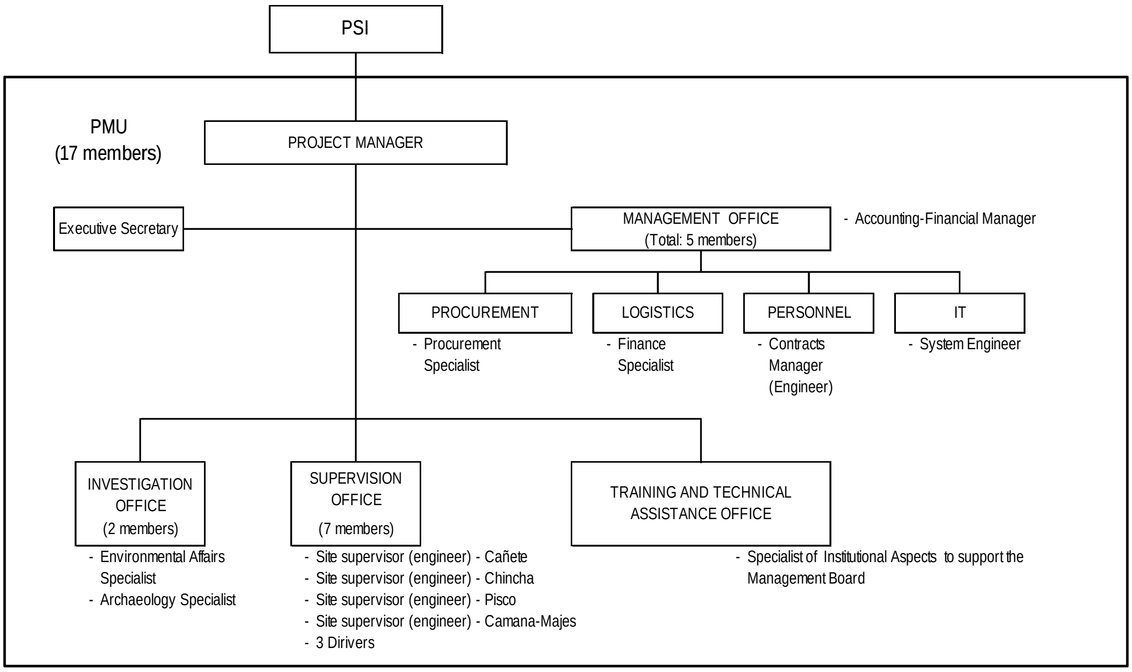


Figure-1.9-3 Organization of PMU

1.10 Execution Plan

Table 1.10-1 presents the Project execution plan.

Table 1.10-1 Execution plan

	Item	2010–2018 (3, 6, 9, 12)	Months
1	Profile Study/SNIP Appraisal	Study, Appraisal	28
2	Feasibility Study/SNIP Appraisal	Study, Appraisal	27
3	Loan Appraisal		6
4	Selection of Consultant		10
5	Project Management Unit		45
6	Consulting Services		45
1)	Detailed Design		6
2)	Tender Preparation, Assistance		15
3)	Supervision		24
7	Selection of Contractor, Contract		15
8	Implementation		
1)	Structural Measures		24
2)	Vegetation		24
3)	Disaster Education/Capacity Building		24
4)	Land Acquisition		27
9	Completion/Inauguration		-

1) Employment of Consultants

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

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

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

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

2) Procurement of contractor

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

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

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

iii) The International Competitive Bidding: ICB is to be applied.

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

1.11 Financial Planning

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

Table 1.11-1 Financial planning in implementation of project

1.12 Conclusion and Recommendation

1.12.1 Conclusion

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

1.12.2 Recommendation

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

(1) Recommendation on implementation of this project

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

2) Structural measures
- Basic policy of flood control
- Problems for flood control planning in Cañete, Chincha, Pisco and Majes-Camana rivers
- Problems in design and construction work

- Construction work period is to be 9 months from April to December considering transition period to dry season from May to November
- Stability of embankment
  - ✓ Requirement of stability analysis and infiltration analysis in the detail design stage
  - ✓ Method of compaction of embankment and supervision
- Reduction of bank protection cost which occupies 80% of construction cost
- Balance of embankment volume and excavation volume
- Hydraulic model experiment in diversion weir in Chincha river

3) Non-structural measures

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

4) Disaster prevention education/capacity development

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

(2) Recommendation for future flood control plan in Peru

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

1.13 Logical Framework of the Project

Table 1.13-1 Logical framework of the project

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

1.14 Middle and Long Term Plans

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

(1) Flood Control General Plan

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

Flood water level was calculated in 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.. 226km. 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 40,000 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 Project cost and social assessment of the general flood control plan (private prices costs)

流域名 Basin	年平均被害軽減額 Annual Average Damage Reduction	評価期間被害軽減額(15年) Damage Reduction in Evaluation Period(15years)	事業費 Project Cost	維持管理費 O&M Cost	B/C Cost Benefit Ration	NPV Net Present Value	IRR(%) Internal Return of Rate
Cañete	181,369,899	81,903,051	104,475,371	8,236,962	0.86	-13,204,737	7%
Chincha	292,863,416	132,251,314	84,324,667	7,429,667	1.71	55,091,224	21%
Pisco	241,380,602	109,002,695	110,779,465	9,420,215	1.08	7,808,090	11%
Majes-Camana	292,262,168	131,979,802	426,465,039	26,889,287	0.34	-252,832,589	-

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

流域名 Basin	年平均被害軽減額 Annual Average Damage Reduction	評価期間被害軽減額(15年) Damage Reduction in Evaluation Period(15years)	事業費 Project Cost	維持管理費 O&M Cost	B/C Cost Benefit Ration	NPV Net Present Value	IRR(%) Internal Return of Rate
Cañete	267,429,377	120,765,806	83,998,198	6,622,517	1.58	44,299,144	19%
Chincha	349,827,412	157,975,125	67,797,033	5,973,452	2.55	95,938,413	32%
Pisco	249,965,955	112,879,671	89,066,690	7,573,853	1.39	31,519,208	16%
Majes-Camana	295,026,234	133,227,999	342,877,891	21,618,987	0.43	-176,161,163	-

In case of executing flood control works in all the watersheds, the Projects' cost would elevate to 765.4 million soles, which is a huge amount. Regarding social prices costs, the project's economic impact in Majes-Camana Watershed does not justify this reimbursement.

(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 each watershed is shown. These were calculated based on forestry plan of Chincha River (refer to Annex-7 Afforestation and Vegetation Recovery Plan, 3.2 Long Term Plan). The total surface would be approximately 520,000hectares and in order to forest them the required time would be from 14 to 98 years and 1,390 million soles. To sum up, the Project has to cover an extensive area, with an investment of much time and at a high price (refer to Table-3.2-4).

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
Chincha	44.075	14	118,964
Pisco	53,938	17	145,586
Camana-Majes	307,210	98	829,201
TOTAL	515,337	—	1,390,963
Chincha Project Cost per hectare: ＝ 2.699,13 (soles /ha) (Example: Cañete Watershed) 110.114 / 44.075 x 14 = 35 (years) 110.114 x 2.699,13 = 297.212.406 (ha)			

(3) Sediment control plan

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

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

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

Watersheds	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/.)		
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
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
Pisco	Totally	269	S/.287	27	S/.1	178	S/.209	S/.497	S/.935
	Prioritized areas	269	S/.287	27	S/.1	106	S/.126	S/.414	S/.779
Majes-Camana	Totally	264	S/.282	26	S/.1	123	S/.165	S/.448	S/.843
	Prioritized areas	264	S/.282	26	S/.1	81	S/.105	S/.388	S/.730
Total	Totally	1,239	S/.1,323	123	S/.4	613	S/.771	S/.2,098	S/.3,948
	Prioritized areas	1,239	S/.1,323	123	S/.4	412	S/.525	S/.1,852	S/.3,485

2. GENERAL ASPECTS

2.1 Name of the Project

"Protection program for valleys and rural communities vulnerable to floods"

2.2 Formulator and Executor Units

(1) Formulator Unit (UF)

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

(2) Executor Unit (UE)

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

2.3 Involved Entities and Beneficiaries Participation

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

(1) Agriculture Ministry (MINAG)

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

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

1) General Administration Office (OGA)
- Manages and executes the program's budget

- Establishes the preparation of management guides and financial affairs

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

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

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

(2) Economy and Finance Ministry (MEF)

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

(3) Japan International Cooperation Agency (JICA)

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

(4) Regional Governments (GORE)

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

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

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

There are several irrigation commissions in the 4 watersheds of the 3 regions, who have a great expectation for the performance of dike repair works, margin protection, intakes, etc. that were damaged in floods. In Table 2.3-1 basic data of each watershed's commission is shown (to have more details refer to 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.

Table 2.3-1 Summary of Irrigation Committee

River	Number of Irrigation Committee	Number of Irrigation Sector	Irrigation area(ha)	Beneficiaries (person)
Cañete	7	42	22,242	5,843
Chincha	3	14	25,629	7,676
Pisco	6	19	22,468	3,774
Majes-Camana	34	83	14,301	5,907
Total	50	158	84,640	23,200

The irrigation users organization is composed of irrigation committees, and which are composed of irrigation sectors those have same irrigation channels.

(6) Meteorology and Hydrology National Service (SENAMHI)

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

(7) Civil Defense National Institute (INDECI)

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

(8) Water National Authority (ANA)

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

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

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

(9) Agriculture Regional Directorates (DRA's)

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

1) Develop, approve, assess, implement, control and manage national agriculture policies, sectorial plans as well as regional plans and policies proposed by municipalities
2) Control agriculture activities and services fitting them to related policies and regulations, as well as on the regional potential
3) Participate in the sustainable management of water resources agreeing with the watershed's general framework, as well as the policies of the Water National Authority (ANA)
4) Promote the restructure of areas, market development, export and agricultural and agro-industrial products consumption
5) Promote the management of: irrigation, construction and irrigation repair programs, as well as the proper management and water resources and soil conservation

2.4 Framework

2.4.1 Background

(1) Study Background

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

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

MINAG planned a "Valley and Rural Populations Vulnerable to Floods Protection Project" for nine watersheds of the five regions. However, due to the limited availability of experiences, technical and financial resources to implement a pre-investment study for a flood control project of such magnitude, MINAG requested JICA's assistance to implementation this study. In response to this request, JICA and MINAG held discussions under the premise of implementing it in the preparatory study scheme to formulate a loan from JICA, about the content and scope of the study, the implementation's schedule, obligations and commitments of both parties, etc. expressing the conclusions in the Minutes of Meeting (hereinafter "M/M") that were signed on January 21 and April 16, 2010. This study has been implemented in accordance with this M/M

(2) Progress of Study

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

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

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

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

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

JICA accepted this request and decided to perform the mentioned watershed study modifying the Minutes of Meeting for the second time (refer to Second Amendment of Minutes of Meetings on the Inception Report, Lima, July 22nd, 2011). In accordance with the amendment, the JICA Study Team began in August the Profile Study with the accuracy of pre-feasibility study for the watershed above mentioned, which was completed in the end of November.

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

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

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

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

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

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

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

The process of the above is as shown in the Table-2.4.1-1.

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

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

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

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

(1) Water Resources Law N° 29338

1) Article 75 .- Protection of water

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

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

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

2) Article 119 .- Programs flood control and flood disasters
The National Authority, together with respective Watershed Board, promotes integral programs for flood control, natural or manmade disasters and prevention of flood damages or other water impacts and its related assets. This promotes the coordination of structural, institutional and necessary operational measures.

Within the water planning, the development of infrastructure projects for multi-sectorial advantage is promoted. This is considered as flood control, flood protection and other preventive measures.

(2) Water Resources Law Regulation N° 29338

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

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

(3) Water Regulation

1) 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.

2) 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 4 Watersheds in 3 regions.

Figure 3.1.1-1 Selected Rivers for the Study

(2) Watersheds overall description

The rivers of the objective watersheds for this study are born in the Andes and cruise through mountains covered with volcanic lava, run the valleys (composed of sand and gravel) between 100 and 500 meters wide, and lead to the Pacific Ocean after flowing down alluvial fans. The slopes are marked ranging from 1/30 and 1/100 in the valleys and between 1/100 and 1/300 in the alluvial fan. Such rivers are sabo river so-called in Japan which means they require some measures of sediment and erosion control. In the both side of river almost every area has agricultural activities. The flow carries large amounts of sediment from the Andes forming plural sandbars. The flow direction is changing and highly volatile. You cannot handle the Peruvian rivers with unique criteria, as these are characterized by climate variations, irregular flow, and steep slopes. In any case, we can say that these rivers are causing serious damage by seasonal extraordinary flood (December-March) and also periodically by the influence of El Niño phenomenon, etc.

1) Cañete river

The Cañete River runs 130km to the south of the Capital of Lima and it is the closest river to this city among the four rivers chosen. Its area covers 6,100 km^2. It's characterized by the small width of its lower watershed and for the great extension of the middle and upper watershed. Approximately, 50% of the watershed it is located above 4,000 m.a.s.l and only 10% below 1,000 m.a.s.l. The lower watershed, which is the study area, where the river has a slope approximately of 1/90 with a 200 meters of average width.

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

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

2) Chincha river

The Chincha River runs 170 km to the south of the Capital of Lima with an approximate surface of 3,300km2 which is smallest among other objective watersheds and is located adjacent to Cañete River and Pisco River.

It is featured by a wide area in middle watershed and narrow lower and upstream watersheds, its higher altitude is greater than 4,000 m.a.s.l and this area only represents 15% from the total amount. In the lower watershed (Study Area), the river is split into two by a diversion weir located approx. 25 km upstream the mouth. The river north side is called , Chico and south side Matagente . The average slope is approx. 1/80 and its width varies between 100 and 200m.

Annual rain is similar to the one in Chincha River Watershed: with 1,000mm at altitudes over 3,000 m.a.s.l and only 20mm at altitudes smaller than 500 m.a.s.l .

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) Pisco river

Pisco River runs approximately 200 km from the capital Lima, and borders the Chincha River watershed to the north. The the watershed area is about 4,300 km2 which is average among the four selected watersheds in this study. It is an elongated watershed, and altitudes over 4,000 m occupy 20% of the total. The river flows in the lower watershed with an average gradient of 1/90 and its width varies between 200 and 600 meters.

The annual rainfall around 500 mm at altitudes greater than 4,000 m and 10 mm at altitudes less than 1,000 meters. Thus, the average flow rate is reduced compared with Chira and Cañete River. Regarding the vegetation, the upper watershed is occupied in large part by grassland, and the lower and middle watersheds of deserts. In the lower watershed, also have farmlands on both river sides.

4) Majes-Camana river

The Majes – Camana River runs 700 km to the south of the Capital of Lima. It is the river running at the most southern part of all the rivers object of the present Study and belongs to the Arequipa Region. The watershed area is of 17,000 km^2 approximately and 60% of it is located above 4,000 m.a.s.l. The area objective of the Project is approximately 100km from the river mouth, which is below 2,000 m.a.s.l , representing 20% of the total surface of the watershed.

The limit between Majes and Camana is located approximately 40 km from the river mouth. From this point downstream the river is called “Camana” and “Majes” from this limit upstream. The slope of the riverbed is approximately 1/200 in Camana and 1/100 in Majes. Its width varies between 100 and 200 meters in Camana and between 200 and 500 meters in Majes. The river is wider in the upper part because, while in the lower part (Camana) the water course has been stabilized with dikes built by the irrigation commission, in the upper watershed (Majes) there are no sufficient dikes constructed.

Annual rainfalls show a clear tendency to increase in upper areas. This trend is such that they are of approximately 50 mm below 1,000 m.a.s.l and more than 500 mm above 4,000 m.a.s.l. The flow is abundant and the superficial water (fluvial) does not run out even in dried seasons.

As to vegetation, upper areas of more than 4,000 m.a.s.l represent 60% of the total area and are covered by wet grasslands, while the lower areas below 2,000 m.a.s.l are desert. Flat lands along the river are being used, mostly for agriculture, particularly for irrigated rice crops.

3.1.2 Socio-Economic Conditions of the Study Area

(1) Cañete river watershed

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). Especially the primary sector in Nuevo Imperial、San Luis occupies as high as 56.5% and 49.7%.

Table 3.1.2-4 Occupation

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

* Sector primario: agricultura, ganadería, forestal y pesca; secundario: minería, construcción, manufactura; terciario servicios y otros

4) Poverty index

Table 3.1.2-5, shows the poverty index. 34,7% of the districts' population (41,840 inhabitants) belongs to the poor segment, and 3,1% (3,793 inhabitants) belong to extreme poverty. Particularly, the Nuevo Imperial district stands out for its high poverty percentage with 42,8%, and 4,6% of extreme poverty.

Table 3.1.2-5 Poverty index

	Distrito											
	San Vicente		Cerro Azul		Imperial		Nuevo Imperial		San Luis			
	People	%	People	%	People	%	People	%	People	%	Total	%
Regional 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 3.1.2-6 Type of housing

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

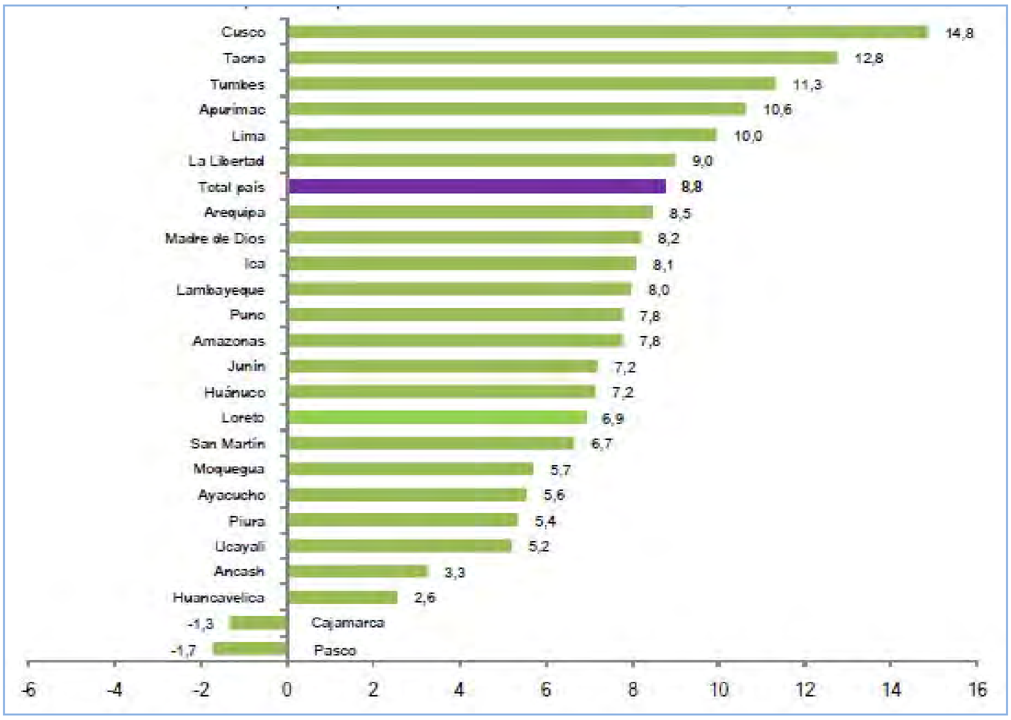
Source: Prepared by JICA Study Team, Statistics National Institute- INEI, 2007 Population and Housing Census.

6) GDP

Peru's GDP in 2010 was US$ 153.919.000.000.

The growth rate in the same year was of + 8.8 % compared with the previous year.

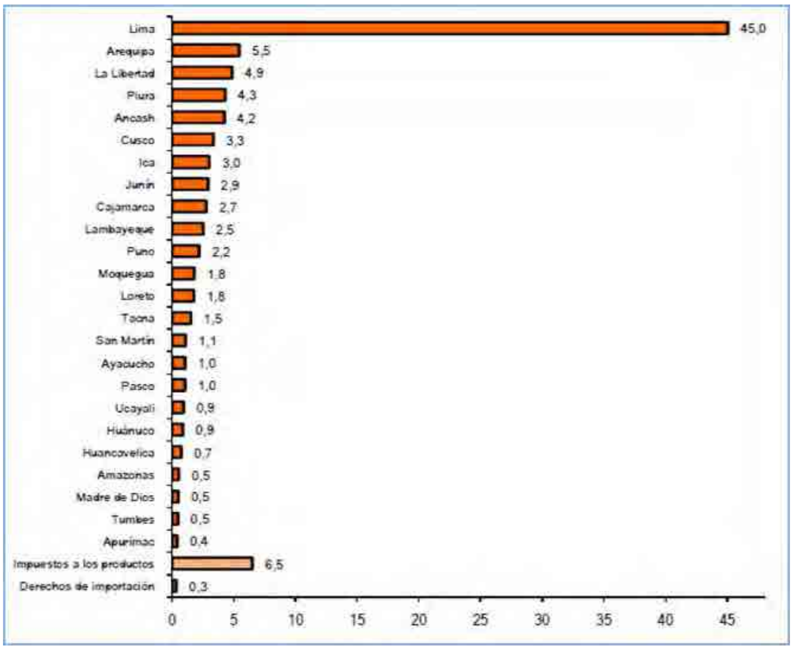
Itemized by regions, Ica registered a growth of 8.1 %, Piura 5.4 %, Lima 10.0 % and Arequipa 8.5 %. Particularly Lima regions registered Figures that were beyond the national average.



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

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

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

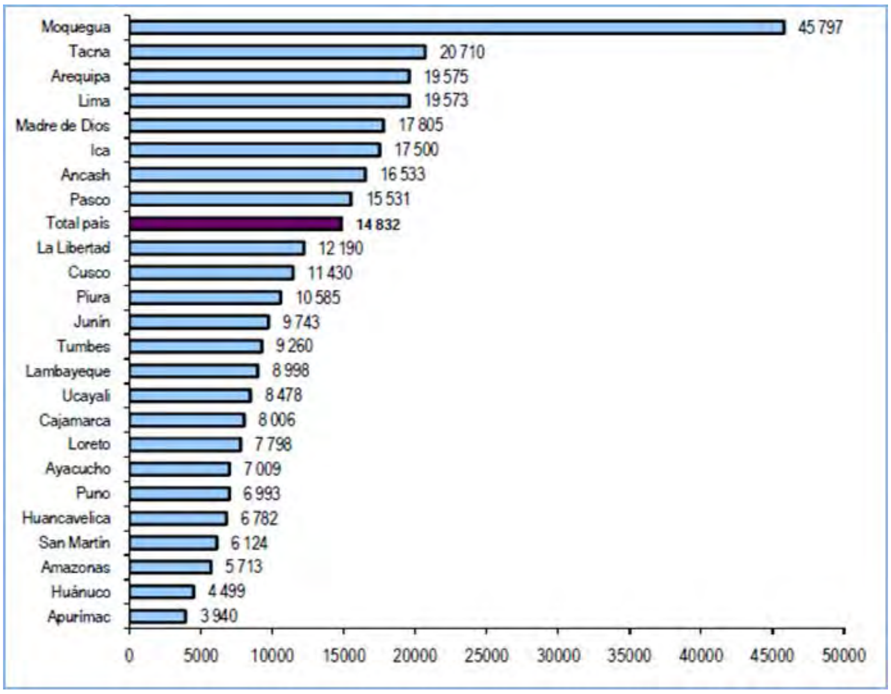


Fuente INEI – Dirección Nacional de Cuentas Nacionales-2010、国立統計局 ーINEIと中央準備銀行 ーBCR

Figure 3.1.2-2 Region contribution to GDP

The GDP per capita in 2010 was of S/.14,832 (5,727 US$).

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



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

Figure 3.1.2-3 GDP per capita (2010)

Table 3.1.2-7 shows the variation along the years of the GDP per capita per region, during the last 10 years (2001-2010).

The GDP national average increased in 54.8% within 10 years from 2001 until 2010. The Figures per region are: +96.6 % for Ica, +65.5 % for Arequipa, +55.2 % for Piura y +54.8 % for Lima.

Figures in Table 3.1.2-7 were established taking 1994 as base year.

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

(1994 Base year, S/.)

Departamento	2001	2002	2003	2004	2005	2006	2007P/	2008P/	2009P/	2010E/	Variacion acumulada 2001-2010 (%)
Total pais	**4 601**	**4 765**	**4 890**	**5 067**	**5 345**	**5 689**	**6 121**	**6 643**	**6 625**	**7 124**	**54.8**
Amazonas	1 835	1 910	1 996	2 081	2 212	2 349	2 510	2 684	2 761	2 959	61,3
Ancash	4 037	4 703	4 772	4 876	4 999	5 089	5 408	5 852	5 824	5 979	48,1
Apurimac	1 216	1 278	1 334	1 400	1 494	1 619	1 653	1 691	1 770	1 946	60,0
Arequipa	5 387	5 766	5 895	6 143	6 488	6 807	7 786	8 379	8 307	8 917	65,5
Ayacucho	1 788	1 870	1 942	1 900	2 045	2 207	2 448	2 640	2 896	3 020	68,9
Cajamarca	2 493	2 731	2 947	2 968	3 165	3 113	2 864	3 094	3 295	3 235	29,8
Cusco	2 194	2 086	2 195	2 565	2 768	3 071	3 340	3 554	3 685	4 202	91,5
Huancavelica	2 700	2 632	2 683	2 697	2 864	3 014	2 903	2 959	3 039	3 090	14,4
Huánuco	1 678	1 694	1 833	1 866	1 890	1 915	1 942	2 050	2 044	2 170	29,4
Ica	4 055	4 259	4 343	4 663	5 214	5 582	6 025	7 265	7 457	7 973	96,6
Junín	3 245	3 311	3 350	3 527	3 505	3 856	4 072	4 379	4 248	4 520	39,3
La Libertad	3 162	3 316	3 483	3 410	3 697	4 216	4 586	4 874	4 895	5 269	66,6
Lambayeque	2 941	3 046	3 132	2 959	3 164	3 300	3 615	3 882	3 963	4 240	44,2
Lima	6 451	6 579	6 700	6 925	7 284	7 817	8 520	9 314	9 219	9 990	54,8
Loreto	2 827	2 917	2 936	2 995	3 079	3 192	3 287	3 402	3 430	3 621	28,1
Madre de Dios	4 441	4 708	4 550	4 846	5 171	5 215	5 617	5 878	5 564	5 862	32,0
Moquegua	10 405	11 967	12 670	13 455	13 882	13 794	13 606	14 201	13 863	14 503	39,4
Pasco	5 137	5 552	5 481	5 634	5 644	6 062	6 711	6 729	6 349	6 187	20,4
Piura	2 733	2 780	2 847	3 049	3 192	3 472	3 780	4 007	4 059	4 241	55,2
Puno	2 105	2 236	2 234	2 270	2 365	2 460	2 617	2 731	2 800	2 992	42,1
San Martín	2 026	2 059	2 094	2 232	2 393	2 476	2 655	2 870	2 928	3 075	51,8
Tacna	6 004	6 124	6 382	6 643	6 782	6 941	7 256	7 458	7 256	8 067	34,4
Tumbes	2 744	2 802	2 873	3 018	3 385	3 212	3 427	3 594	3 611	3 957	44,2
Ucayali	3 063	3 149	3 203	3 411	3 584	3 754	3 846	4 007	4 040	4 190	36,8

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

(2) Chincha river watershed

1) Administrative Division and Surface

The Chincha River is located in the provinces of Chincha in the Ica Region.

Table 3.1.2-8 shows the main districts surrounding this river, with their corresponding surface.

Table 3.1.2-8 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 3.1.2-9 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 3.1.2-9 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 3.1.2-10 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 3.1.2-10 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 3.1.2-11, 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 3.1.2-11 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 3.1.2-12 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 3.1.2-12 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 3.1.2-13 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

Refer to (1) Cañete Watershed

(3) Pisco river watershed

1) Administrative division and surface

The Pisco River is located in the Pisco province, Ica Region.

Table 3.1.2-14 shows the main districts surrounding this river, with their corresponding surface.

Table 3.1.2-14 Districts surrounding Pisco river with areas

Region	Province	District	Area (㎢)
Ica	Pisco	Pisco	24.92
		San Clemente	127.22
		Tupac Amaru	55.48
		San Andres	39.45
		Humay	1,112.96
		Independencia	273.34

2) Population and number of households

The following Table 3.1.2-15 shows how population varied within the period 1993-2007. In 2007, from 119.975 inhabitants, 89% (106.394 inhabitants) lived in urban areas while 11% (13.581 inhabitants) lived in rural areas.

Population is increasing in all districts. However, the population tends to decrease, except in Humay and Independencia.

Table 3.1.2-15 Variation of the urban and rural population

District	Total Population 2007					Total Population 1993					Variation (%)	
	Urban	%	Rural	%	Total	Urban	%	Rural	%	Total	Urban	Rural
Pisco	54.677	99	320	1	54.997	51.639	99	380	1	52.019	0,4	-1,2
San Clemente	18.849	98	475	2	19.324	13.200	93	1.002	7	14.202	2,6	-5,2
Túpac Amaru Inca	14.529	99	147	1	14.676	9.314	98	228	2	9.542	3,2	-3,1
San Andrés	11.495	87	1.656	13	13.151	10.742	86	1.789	14	12.531	0,5	-0,6
Humay	3.099	57	2.338	43	5.437	2.016	46	2.331	54	4.347	3,1	0,0
Independencia	3.745	30	8.645	70	12.390	1.630	19	7.004	81	8.634	6,1	1,5
Total	**106.394**	**89**	**13.581**	**11**	**119.975**	**88.541**	**87**	**12.734**	**13**	**101.275**	**1,3**	**0,5**

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

Table 3.1.2-16 shows the number of households and members per home in 2007. Each house has between 3.8 and 4.4 people, according to the district. Each family has an average between 3,7 and 4,1 people.

Table 3.1.2-16 Number of households and families

Variables	District					
	Pisco	San Clemente	Túpac Amaru Inca	San Andrés	Humay	Independencia
Population (inhabitants)	54,997	19,324	14,676	13,151	5,437	12,390
Number of households	12,483	4,837	3,609	3,087	1,409	3,062
Number of families	13,356	5,163	3,828	3,206	1,455	3,204
Members per household (person/home)	4.41	4.00	4.07	4.26	3.86	4.05
Members per family (person/family)	4.12	3.74	3.83	4.10	3.74	3.87

3) Occupation

Table 3.1.2-17, shows occupation lists of local inhabitants itemized by sector. In Humay and Independencia, there is a predominance of primary sector accounts for more than 70% of the occupation. In the remaining districts, the largest percentage is concentrated in the tertiary sector.

Table 3.1.2-17 Occupation

	District											
	Pisco		San Clemente		Túpac Amaru Inca		San Andrés		Humay		Independencia	
	People	%	People	%	People	%	People	%	People	%	People	%
EAP	19,837	100	7,027	100	5,057	100	4,406	100	2,011	100	4,451	100
Primary Sector	1,657	8.4	2,381	33.9	1,065	21.1	1,429	32.4	1,512	75.2	3,234	72.7
Secondary Secto	4,866	24.5	1328	18.9	1,366	27.0	767	17.4	93	4.6	259	5.8
Tertiary Sector	13,313	67.1	3,318	47.2	2,626	51.9	2,207	50.1	406	20.2	958	21.5

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

4) Poverty index

Table 3.1.2-18 shows poverty rate. 18.7% of the population (22,406 inhabitants) belongs to the poor segment, and 0.4% (493 people) to the extreme poverty segment. Pisco is noted for its low poverty rate and extreme poverty from 15.8% and 0.3% respectively, compared to other districts.

Table 3.1.2-18 Poverty index

	District													
	Pisco		San Clemente		Túpac Amaru Inca		San Andrés		Humay		Independencia			
	People	%	People	%	People	%	People	%	People	%	People	%	Total	%
Regional Populatior	54,997	100	19,324	100	14,676	100	13,151	100	5,437	100	12,390	100	119,975	100
In poverty	8,716	15.8	4,455	23.1	3,042	20.7	2,613	19.9	1,024	18.8	2,556	20.6	22,406	18.7
In extreme poverty	172	0.3	126	0.7	69	0.5	39	0.3	22	0.4	65	0.5	493	0.4

5) Type of housing

The walls of the houses are built 45% of bricks or cement, and 19% of adobe and mud. The floor is made 87% of earth or cement.

The public drinking water service in Humay and Independence is low, with 25%. Except these two districts, the coverage of this service is 45% on average. Meanwhile, sewage service is 48% on average, but again and Independence Humay shows a low coverage of 11% and 13% respectively. The electrification reaches 65% on average.

Table 3.1.2-19 Type of housing

Variable/Indicator	Districts											
	Pisco		San Clemente		Túpac Amaru Inca		San Andrés		Humay		Independencia	
	Hogares	%	Hogares	%	Hogares	%	Hogares	%	Hogares	%	Hogares	%
Name of housings												
Common residents housing	12.483	83,7	4.837	84,1	3.609	90	3.087	88,2	1.409	79,9	3.062	87,8
Walls materials												
Bricks or cement	7.600	60,9	1.339	27,7	1.198	33,2	2.088	67,6	65	4,6	401	13,1
Adobe and mud	1.008	8,1	1.780	36,8	284	7,9	159	5,2	644	45,7	1.621	52,9
Bamboo + mud or wood	623	5,0	80	1,7	99	2,7	113	3,7	76	5,4	298	9,7
Others	3.252	26,1	1,638	33,9	2.028	56,2	727	23,6	624	44,3	742	24,2
Floor Materials												
Soil	4.199	33,6	2,552	52,8	2.244	62,2	894	29	899	63,8	1.896	61,9
Cement	5.752	46,1	2,109	43,6	1.179	32,7	1.749	56,7	438	31,1	997	32,6
Ceramics, parquet, quality wood	2.320	18,6	136	2,8	131	3,6	361	11,7	40	2,8	147	4,8
Others	212	1,7	40	0,8	55	1,5	83	2,7	32	2,3	22	0,7
Running water system												
Public network within household	8.351	66,9	2,359	48,8	2.226	61,7	1.928	62,5	266	18,9	706	23,1
Public network within building	726	5,8	302	6,2	255	7,1	352	11,4	355	25,2	67	2,2
public use	645	5,2	109	2,3	163	4,5	30	1	3	0,2	139	4,5
Sewage												
Public sewage within household	7.771	62,3	1,729	35,7	1.712	47,4	1.941	62,9	157	11,1	410	13,4
Public sewage within building	526	4,2	113	2,3	79	2,2	201	6,5	178	12,6	26	0,8
Septic Tank	977	7,8	1,532	31,7	587	16,3	302	9,8	250	17,7	1.623	53
Electricity												
Public electric service	8.933	71,6	2,975	61,5	2.043	56,6	2.342	75,9	949	67,4	1.283	41,9
Member quantity												
Common residents housing	**13.356**	**100**	**5,163**	**100**	**3.828**	**100**	**3.206**	**100**	**1.455**	**100**	**3.204**	**100**
Appliances												
More than three	5.976	44,7	1,426	27,6	1.086	28,4	1.417	44,2	402	27,6	553	17,3
Communication Services												
Phones and mobiles	11.385	85,2	3,401	65,9	2.795	73,0	2.579	80,4	630	43,3	1.719	53,7

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

6) GDP

Refer to (1) Cañete Watershed

(4) Majes-Camana river watershed

1) Administrative division and surface

The Majes – Camana River is located in the provinces of Castilla and Camana in the Arequipa Region. Table 3.1.2-20 shows the main districts surrounding this river, with their corresponding surface.

Table 3.1.2-20 Districts surrounding the Majes – Camana river with areas

Region	Province	District	Area (Km^2)
Arequipa	Castilla	Uraca	713.83
		Aplao	640.04
		Huancarqui	803.65
	Camana	Camana	11.67
		Nicolas de Pierola	391.84
		Mariscal Caceres	579.31
		Samuel Pastor	113.4
		Jose Maria Quimper	16.72

2) Population and number of households

The following Table 3.1.2-21 shows how population varied within the period 1993-2007. In 2007, from 44.175 inhabitants, 91% (40.322 inhabitants) lived in urban areas while 9% (3.853 inhabitants) lived in rural areas.

Population is increasing in all districts. However, while the urban area registers an annual medium increase of 2,8% to 3,4%, exceeding the national average, the rural area experiments a decrease of -1,3% to -6,6%.

Table 3.1.2-21 Variation of the urban and rural population

Province	District	2007 Total Population					1993 Total Population					Variation (%)	
		Urban	%	Rural	%	Total	Urban	%	Rural	%	Total	Urban	Rural
Castilla	Uraca	2,664	37%	4,518	63%	7,182	1,953	29%	4,698	71%	6,651	2.20%	-0.30%
	Aplao	4,847	45%	4,004	55%	8,851	2,928	35%	5,334	65%	8,262	3.70%	-2.00%
	Huancarqui	1,191	18%	254	82%	1,445	1,047	65%	555	35%	1,602	0.90%	-5.40%
Total		**8,702**	**49.80%**	**8,776**	**50.20%**	**17,478**	**5,928**	**36%**	**10,587**	**64%**	**16,515**	**2.80%**	**-1.30%**
Camana	Camana	14,642	1%	116	99%	14,758	13,284	94%	809	6%	14,093	0.70%	-13.00%
	Nicolas de Pierola	5,362	88%	703	12%	6,065	4,688	88%	613	12%	5,301	1.00%	1.00%
	Mariscal Caceres	4,705	86%	758	14%	5,463	2,562	67%	1,253	33%	3,815	4.40%	-3.50%
	Samuel Pastor	12,004	91%	1,138	9%	13,142	2,285	26%	6,501	74%	8,786	12.60%	-11.70%
	Jose Maria Quimper	3,609	76%	1,138	24%	4,747	2,426	74%	870	26%	3,296	2.90%	1.90%
Total		**40,322**	**91.30%**	**3,853**	**8.70%**	**44,175**	**25,245**	**72%**	**10,046**	**28%**	**35,291**	**3.40%**	**-6.60%**

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

Table 3.1.2-22 -23 shows the number of households and members per home in 2007. Apparently Huancarqui has fewer members per household (3,36 persons) while Jose Maria Quimper has a greater number with 4,4; remaining districts vary between 3,6 and 4,1 persons.

The number of members per family is around 4,1 persons, with exception of Nuevo Imperial, with a lower Figure of 3,77.

Table 3.1.2-22 Number of households and families in Castilla

Variables	District		
	Uraca	Aplao	Huancarqui
Population (inhabitants)	7,182	8,851	1,445
Number of households	1,760	2,333	430
Number of families	1,887	2,416	434
Members per household (persons/household)	4.08	3.79	3.36
Members per family (persons/family)	3.81	3.66	3.33

Table 3.1.2-23 Number of households and families in Camana

Variables	District				
	Camana	Nicolas de Pierola	Mariscal Caceres	Samuel Pastor	Jose Maria Quimper
Population (inhabitants)	14,758	6,065	5,463	13,142	4,747
Number of households	3,845	1,680	1,394	3,426	1,078
Number of families	4,066	1,738	1,448	3,554	1,108
Members per household (persons/househol	3.84	3.61	3.92	3.84	4.4
Members per family (persons/family)	3.63	3.49	3.77	3.7	4.28

3) Occupation

Table 3.1.2-24, shows occupation lists of local inhabitants itemized by sector.

It highlights the primary sector in all districts representing between 23 and 65% of the economically active population (EAP).

Table 3.1.2-24 Occupation in Castilla

EAP	District					
	Uraca		Aplao		Huancarqui	
	persons	%	Persons	%	Persons	%
Economically Active Pop. 1/	3,343	100	3,618	100	649	100
a) Primary sector	2,174	65.03	1,966	54.34	413	63.64
b) Secondary sector	160	4.79	251	6.94	40	6.16
c) Tertiary sector	1,009	30.18	1,401	38.72	196	30.2

Source: National Institute of Statistics - INEI, 2007 Population and Housing Census.
1/ Primary sector: agriculture, livestock, forest and fishery; secondary: mining, construction, manufacturing; tertiary: services and others

Table 3.1.2-25 Occupation in Camana

PEA	District									
	Samuel Pastor		Camana		Jose Maria Quimper		Mariscal Cáceres		Nicolas de Pierola	
	persons	%	persons	%	persons	%	persons	%	persons	%
Economically Active Pop. 1/	5,237	100	6,292	100	1,463	100	1,888	100	2,348	100
a) Primary sector	1,749	33	1,469	23	548	37	1,181	63	1,125	48
b) Secondary sector	624	12	473	8	127	9	88	5	167	7
c) Tertiary sector	2,864	55	4,350	69	788	54	619	33	1,056	45

Source: National Institute of Statistics –INEI, 2007 Population and Housing.

1/ Primary sector: agriculture, livestock, forest and fishery; secondary: mining, construction, manufacturing; tertiary: services and others

4) Poverty index

Table 3.1.2-26, -27 shows the poverty index. 25 % to 27 % of the districts' population belongs to the poor segment, and 3,8% to 4,4% belong to extreme poverty. Particularly, the Huancarqui district stands out for its high poverty percentage with 33,1%, and 6,9% of extreme poverty.

Table 3.1.2-26 Poverty index in Castilla

Variable /Indicator	District (Castilla)							
	Aplao		Huancarqui		Uraca		Total	
	Persons	%	Persons	%	Persons	%	Persons	%
Total Population (inhab.)	8,851		1,445		7,182		17,478.00	100
Poor	2,153	24.3	480	33.1	1,731	24.1	4,364	25
Extreme Poverty	358	4.1	98	6.9	305	4.3	761	4.4

Table 3.1.2-27 Poverty index in Camana

Variable /Indicator	District (Canana)											
	Mariscal Caceres		Samuel pastor		Nicolas de Pierola		Jose Maria Quimper		Camana		Total	
	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%	Persons	%
Total Population (inhab)	5,463		13,142		6,065.00		4,747.00		14,758.00		44,175.00	100
Poor	1,927	35.2	4,410.00	33.5	1,494.00	24.6	979	24.9	3,013.00	20.4	11,823	26.8
Extreme Poverty	391	7.4	629	4.9	221	3.8	140	3.7	303	2.1	1,684	3.8

5) Type of housing

Tables 3-1.2-28 and 3-1.2-29 show data on Castilla and Camana housing. The walls of the houses in Castilla are made 46% of bricks or cement, and 43% of adobe and mud. The floor is made 96% of earth or cement. The public drinking water service covers 50%, while the sewage service is scarcely 45,5% in Huancarqui. The average electrification rate is 86%.

In Camana, walls are made 65% bricks or cement, and 4% with adobe and mud. The floor is made of 98% earth or cement. The public drinking water service covers more than 50% while the sewage service is less than 50%, with exception of Camana. The average electrification rate is 84%.

Table 3.1.2-28 Type of housing in Castilla

Variable/Indicator	Districts					
	Uraca		Aplao		Huancarqui	
	Households	%	Households	%	Households	%
Number of Households						
Common houses with residents	1,760	86	2,333	75.3	430	63
Wall material						
Brick or cement	999	56.8	820	35.1	106	24.7
Adobe and mud	195	11.1	1,067	45.7	237	55.1
With walls of quincha and wood	521	29.6	332	14.2	78	18.1
Other	45	2.6	114	4.9	9	2.1
Floor material						
Earth	687	39	831	35.6	195	45.3
Cement	996	56.6	1,381	59.2	226	52.6
Tile, terrazzo tile, parquet or polished wood, wood, boards	71	4	106	4.5	7	1.6
Other	6	0.3	15	0.6	2	0.5
Drinking water system						
Public service in the house	1,216	69.1	1,483	63.6	255	59.3
Public service out of the house but within the building	86	4.9	228	9.8	20	4.7
Public sink	115	6.5	34	1.5		
Sewage and latrine service						
Public sewage service in the house	472	26.8	705	30.2	193	44.9
Public sewage service within the building	26	1.5	58	2.5	4	0.9
Cesspit/ latrine	753	42.8	875	37.5	153	35.6
Houses with lighting system						
Public network	1,505	85.5	1,790	76.7	340	79.1
HOUSEHOLD						
Households in special houses with present occupants	**1,887**	**100**	**2,416**	**100**	**434**	**100**
Head of household						
Man	1,477	78.3	1,839	76.1	335	77.2
Woman	410	21.7	577	23.9	99	22.8
Home appliances						
Has three or more home appliances or equipment	541	28.7	683	28.3	113	26
Information and communication service						
Has landline telephone or mobile	1,353	71.7	1,301	53.8	242	55.8

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

Table 3.1.2-29 Type of housing in Camana

Variable/Indicador	Samuel Pastor		Camana		Jose Maria Quimper		Mariscal Caceres		Nicolas d
	Households	%	Households	%	Households	%	Households	%	Households
Number of Households									
Common houses with residents	3,426	69.7	3,845	90.7	1,078	74.7	1,394	70	1,680
Wall material									
Brick or cement	1,956	57.1	2,942	76.5	674	62.5	664	47.6	986
Adobe and mud	66	1.9	175	4.6	20	1.9	28	2	78
With walls of quincha and wood	716	20.9	427	11.1	226	21	172	12.3	419
Other	688	20.1	301	7.8	158	14.7	530	38	197
Floor material									
Earth	1,780	52	961	25	487	45.2	841	60.3	792
Cement	1,432	41.8	2,335	60.7	547	50.7	530	38	806
Tile, terrazzo tile, parquet or polished wood, wood, boards	154	4.5	514	13.4	38	3.5	16	1.1	70
Other	60	1.8	35	0.9	6	0.6	7	0.5	12
Drinking water system									
Public service in the house	1,987	58	3,028	78.8	732	67.9	774	55.5	957
Public service out of the house but within the building	231	6.7	236	6.1	108	10	160	11.5	323
Public sink	851	24.8	164	4.3	13	1.2	9	0.6	57
Sewage and latrine service									
Public sewage service in the house	1,466	42.8	2,816	73.2	181	16.8	243	17.4	778
Public sewage service within the building	104	3	246	6.4	24	2.2	5	0.4	208
Cesspit/latrine	1,144	33.4	360	9.4	526	48.8	763	54.7	463
Houses with lighting system									
Public network	2,734	79.8	3,556	92.5	935	86.7	1,017	73	1,284
HOUSEHOLD									
Households in special houses with present occupants	**3,554**	**100**	**4,066**	**100**	**1,108**	**100**	**1,448**	**100**	**1,738**
Home appliances									
Has three or more home appliances or equipment	997	28.1	1,902	46.8	360	32.5	304	21	524
Information and communication service									
Has landline telephone or mobile	2,297	64.6	3,586	88.2	790	71.3	654	45.2	1,073

Source:

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

3.1.3 Agriculture

Next is a summarized report on the current situation of agriculture in 4 Watersheds, including irrigation commissions, crops, planted area, performance, sales, etc.

(1) Cañete river

1) Irrigation Sectors

Table 3.1.3-1 shows basic data on the irrigation commissions. In the Cañete River Watershed there are 42 irrigation sectors, 7 irrigation commissions with 22,242 beneficiaries. The surface managed by these sectors reach a total of 5,843 hectares.

Table 3.1.3-1 Basic data of the irrigation commissions

Irrigation Sectors	Irrigation Commissions	Areas under irrigation ha	%	Nº of Beneficiaries (People)	River
Roma Rinconada. La Huerta Lateral A Cantera Almenares Lateral B Lateral T Túnel Grande Quebrada Ihuanca Cantagallo-U Campesina Caltopa Caltopilla	Canal Nuevo Imperial	7.883	35	2.202	Cañete
Casa Pintada Sn Isidro Cerro Alegre Huaca Chivato Conde Chico Ungara Josefina Sta. Gliceria	Canal Viejo Imperial	3.715	17	1.080	
Tres Cerros Montejato La Quebrada Hualcara Cerro de Oro Chilcal	Canal María Angola	1.785	8	470	
Montalván-Arona-La Qda.-Tupac Lúcumo - Cuiva - Don Germán Lateral 74-La Melliza-Sta Bárbara Casa Blanca - Los Lobos	Canal San Miguel	3.627	16	860	
Lúcumo - Cuiva - Don Germán Huanca Media Huanca Baja Huanca Alta	Canal Huanca	2.301	10	421	
Gr.9.2 lateral 4 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	Canal Pachacamilla	928	4	234	
Palo Herbay Alto	Canal Palo Herbay	2.003	9	576	
Total		**22.242**	**100**	**5.843**	

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

2) Main crops

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

In the Cañete River Watershed, in 2005 and 2007 the planted area, performance and sales decreased, but later increased so that during the period of 2009 levels of 2004-2005 were recovered. The profits of 2008-2009 were of S/.219,095,280. Main crops in this watershed were represented by: corn, cotton, beets, grapes and fresh corn.

Table 3.1.3-3 Sowing and sales of main crops

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

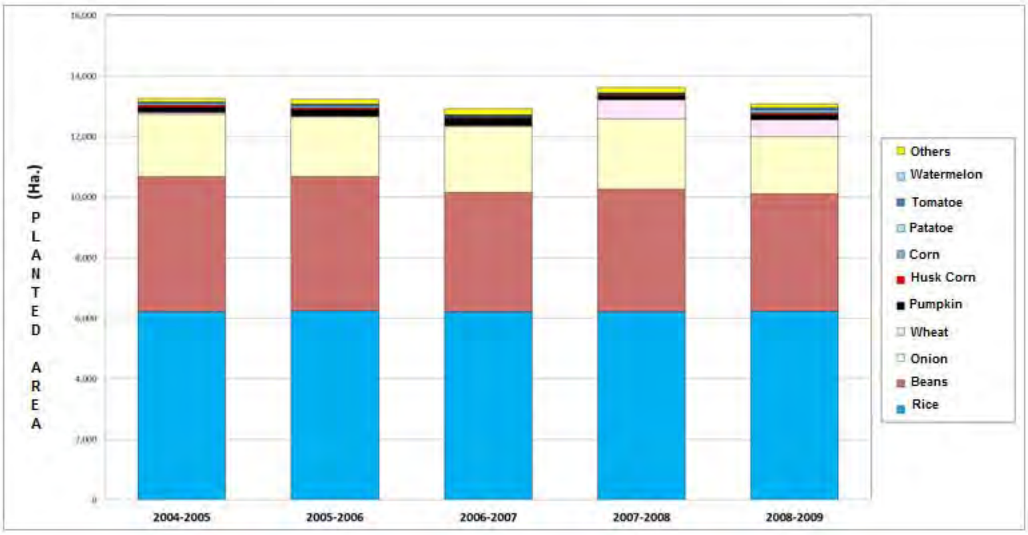


Figure 3.1.3-1 Planted surface

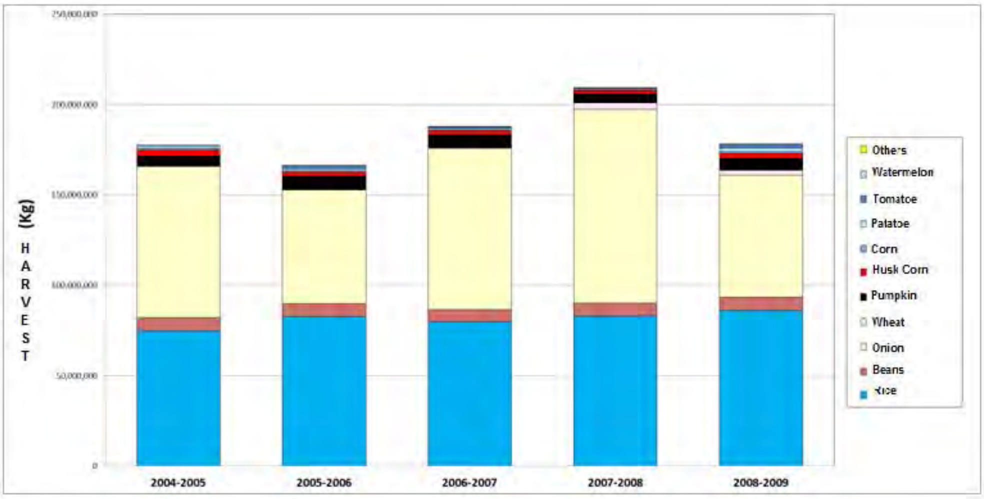


Figure 3.1.3-2 Harvest

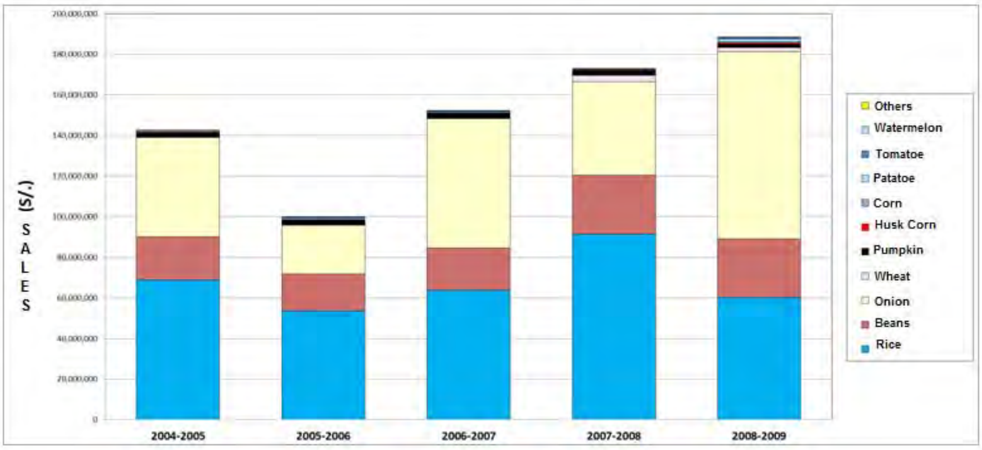


Figure 3.1.3-3 Sales

(2) Chincha river

1) Irrigation Sectors

Table 3.1.3-4 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 3.1.3-4 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 3.1.3-5 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 3.1.3-5 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

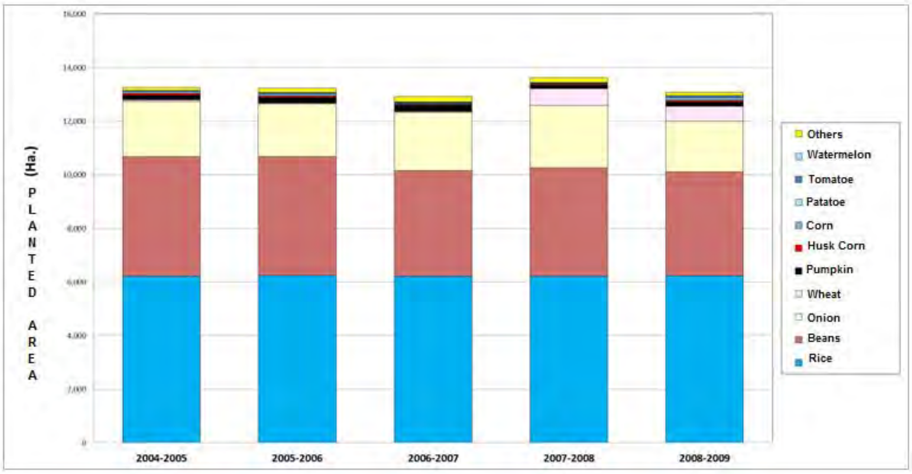


Figure 3.1.3-4 Planted surface

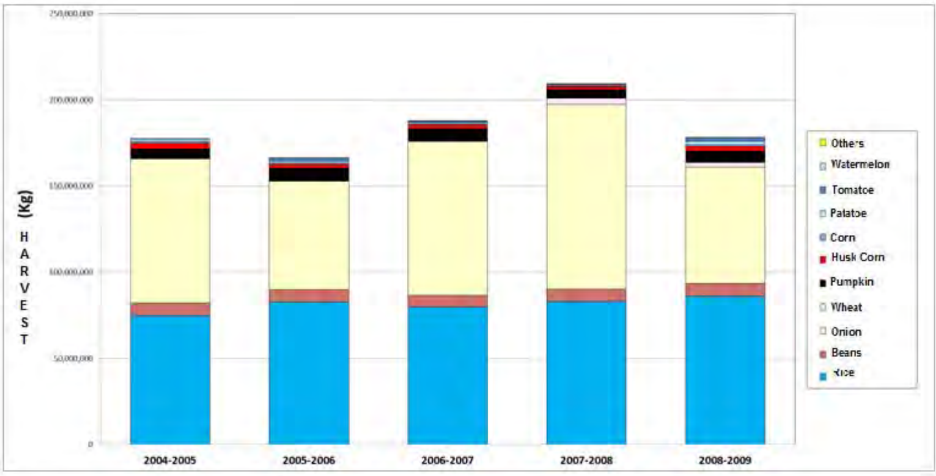


Figure 3.1.3-5 Harvest

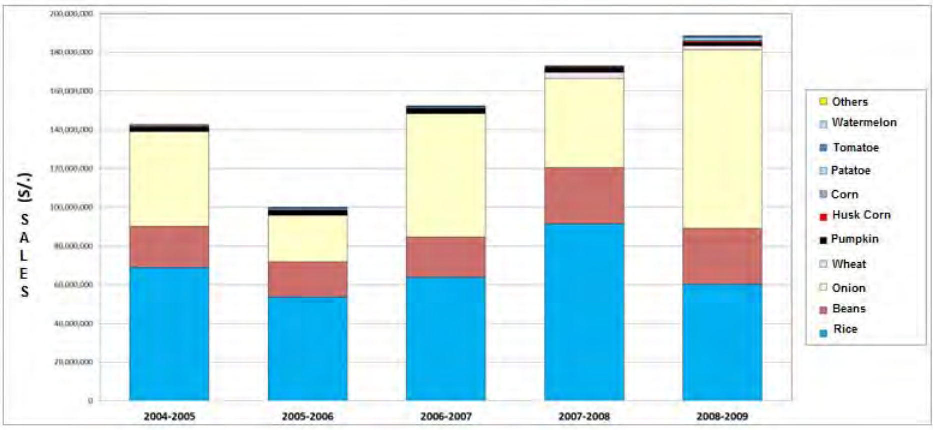


Figure 3.1.3-6 Sales

(3) Pisco river

1) Irrigation Sectors

Table 3.1.3-6 shows basic data on the irrigation commissions of the Pisco River. In the watershed of the Pisco River there are 19irrigation sectors, 6 irrigation commissions with 3,774 beneficiaries. The surface managed by these sectors amounts 22,468 hectares.

Table 3.1.3-6 Basic data of the irrigation commissions

Irrigation Sectors	Irrigation Commissions	Areas under irrigation		Nº of Beneficiaries (People)	River
		ha	%		
Pisco	Casalla	2.276	10	513	Pisco
	El Pueblo Figueroa	756	3	138	
	Caucato	1.612	7	325	
	Chongos	453	2	74	
Independencia	Agua Santa - El Porvenir	469	2	63	
	Francia	931	4	126	
	Montalván	1.596	7	275	
	Manrique	1.555	7	288	
Chacarilla	Condor	1.970	9	315	
Dadelso					
Jose Olaya					
Mencia					
San Jacinto					
Urrutia					
Cabeza de Toro	Cabeza de Toro	6.123	27	633	
Murga	Murga - Casaconcha	1.383	6	273	
	La Floresta	303	1	51	
	Bernales	1.286	6	294	
	Miraflores	129	1	35	
	Chunchanga	460	2	75	
Humay	San Ignacio	333	1	56	
	Montesierpe	449	2	118	
	Pallasca Tambo Colorado	145	1	65	
	Huaya Letrayoc	238	1	57	
Total		**22.468**	**100**	**3.774**	

Source: Prepared by JICA Study Team, Users Board of Pisco, October 2011

2) Main crops

Table 3.1.3-7 shows the variation between 2004 and 2009 of the planted surface and the performance of main crops. In the Pisco River Watershed the planted area tends to be maintained or reduced due to crop surface reduction because of cotton. Instead of this, the area of alfalfa and corn (yellow) is increasing. The revenue was S/.132,512,157 in 2008-2009, which is the lousiest level reached in the last five years. This reduction is due mostly for the reduction of cotton crop and the low transaction price.

The main crops in this watershed are cotton, alfalfa and corn (yellow).

Table 3.1.3-7 Sowing and sales of main crops

	Variables	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Cotton	Planted Area (ha)	16,598	15,586	13,300	13,536	7,771
	Unit performance (kg/Ha)	2,123	1,923	2,104	2,209	2,166
	Harvest (Kg)	35,237,554	29,971,878	27,983,200	29,901,024	16,831,986
	Unit price (S/./kg)	2.13	2.18	2.81	2.76	1.95
	Sales (S/.)	75,055,990	65,338,694	78,632,792	82,526,826	32,822,373
Alfalfa	Planted Area (ha)	2,817	2,941	2,966	3,739	4,133
	Unit performance (kg/Ha)	31,965	29,626	30,485	24,078	25,770
	Harvest (Kg)	90,045,405	87,130,066	90,418,510	90,027,642	106,507,410
	Unit price (S/./kg)	0.10	0.10	0.10	0.10	0.10
	Sales (S/.)	9,004,541	8,713,007	9,041,851	9,002,764	10,650,741
Corn (yellow)	Planted Area (ha)	1,065	1,410	2,377	2,447	4,167
	Unit performance (kg/Ha)	7,289	6,960	8,197	8,665	8,262
	Harvest (Kg)	7,762,785	9,813,600	19,484,269	21,203,255	34,427,754
	Unit price (S/./kg)	0.60	0.63	0.77	0.85	0.73
	Sales (S/.)	4,657,671	6,182,568	15,002,887	18,022,767	25,132,260
Corn	Planted Area (ha)	813	2,188	1,272	1,605	2,088
	Unit performance (kg/Ha)	13,279	10,511	11,579	11,672	9,672
	Harvest (Kg)	10,795,827	22,998,068	14,728,488	18,733,560	20,195,136
	Unit price (S/./kg)	0.63	0.46	0.79	0.73	0.80
	Sales (S/.)	6,801,371	10,579,111	11,635,506	13,675,499	16,156,109
Asparagus	Planted Area (ha)	648	663	720	1,028	980
	Unit performance (kg/Ha)	6,654	7,231	6,491	4,375	4,788
	Harvest (Kg)	4,311,792	4,794,153	4,673,520	4,497,500	4,692,240
	Unit price (S/./kg)	3.13	3.02	3.65	2.65	2.79
	Sales (S/.)	13,495,909	14,478,342	17,058,348	11,918,375	13,091,350
Tangelo	Planted Area (ha)	311	331	367	367	367
	Unit performance (kg/Ha)	26,463	24,033	26,432	27,109	26,608
	Harvest (Kg)	8,229,993	7,954,923	9,700,544	9,949,003	9,765,136
	Unit price (S/./kg)	0.52	0.56	0.59	0.55	0.51
	Sales (S/.)	4,279,596	4,454,757	5,723,321	5,471,952	4,980,219
Paprika	Planted Area (ha)	223	354	461	310	209
	Unit performance (kg/Ha)	5,058	5,068	5,490	5,864	5,849
	Harvest (Kg)	1,127,934	1,794,072	2,530,890	1,817,840	1,222,441
	Unit price (S/./kg)	4.64	3.45	5.67	5.33	4.02
	Sales (S/.)	5,233,614	6,189,548	14,350,146	9,689,087	4,914,213
Tomatoe	Planted Area (ha)	306	349	307	258	293
	Unit performance (kg/Ha)	71,395	54,399	57,824	65,525	60,604
	Harvest (Kg)	21,846,870	18,985,251	17,751,968	16,905,450	17,756,972
	Unit price (S/./kg)	0.97	0.83	0.76	1.08	0.86
	Sales (S/.)	21,191,464	15,757,758	13,491,496	18,257,886	15,270,996
Grapes	Planted Area (ha)	136	174	192	218	230
	Unit performance (kg/Ha)	8,640	11,429	10,332	17,345	19,504
	Harvest (Kg)	1,175,040	1,988,646	1,983,744	3,781,210	4,485,920
	Unit price (S/./kg)	1.66	1.88	2.21	1.95	2.00
	Sales (S/.)	1,950,566	3,738,654	4,384,074	7,373,360	8,971,840
Lima beans	Planted Area (ha)	103	253	136	97	163
	Unit performance (kg/Ha)	1,055	1,062	1,230	1,212	1,020
	Harvest (Kg)	108,665	268,686	167,280	117,564	166,260
	Unit price (S/./kg)	3.34	2.80	2.95	3.65	3.14
	Sales (S/.)	362,941	752,321	493,476	429,109	522,056
Others	Planted Area (ha)	615	907	989	518	1,644
Total	Planted Area (ha)	23,635	25,156	23,087	24,123	22,045
	Harvest (Kg)	180,641,865	185,699,343	189,422,413	196,934,048	216,051,255
	Sales (S/.)	142,033,663	136,184,761	169,813,897	176,367,624	132,512,157

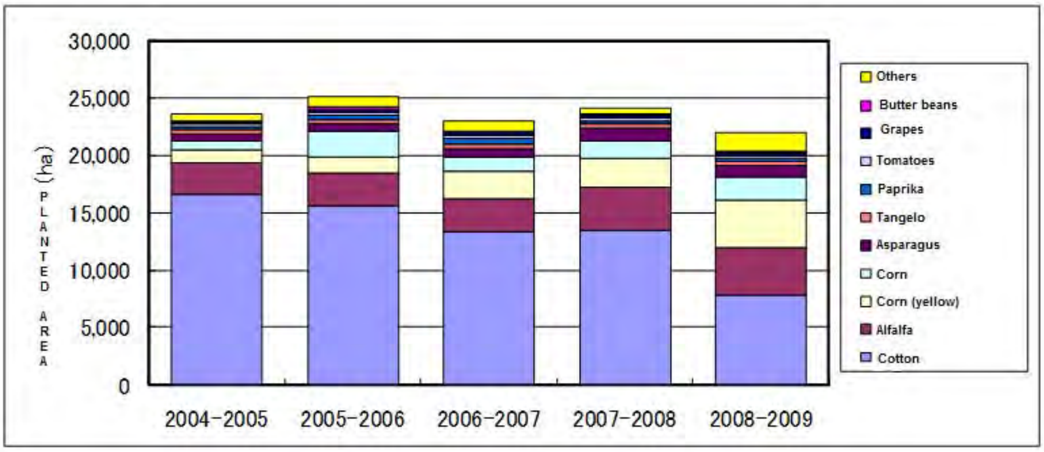


Figure 3.1.3-7 Planted surface

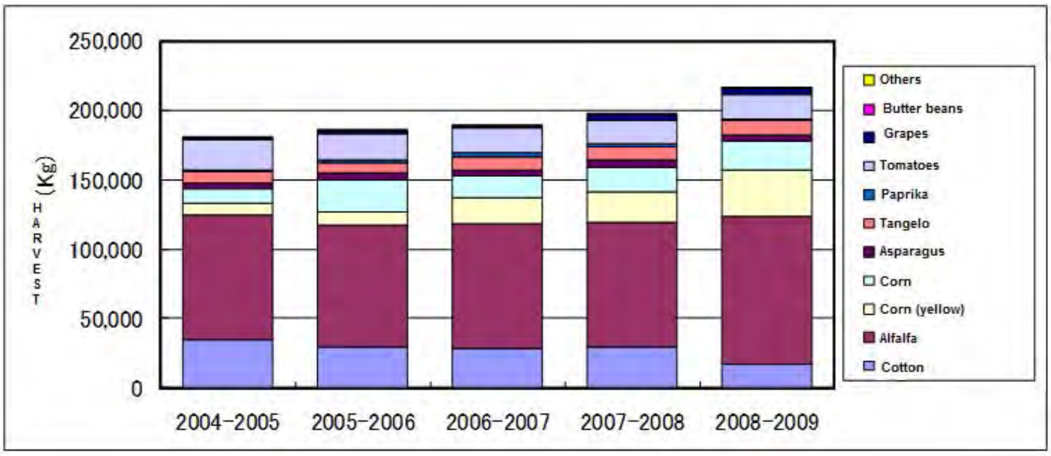


Figure 3.1.3-8 Harvest

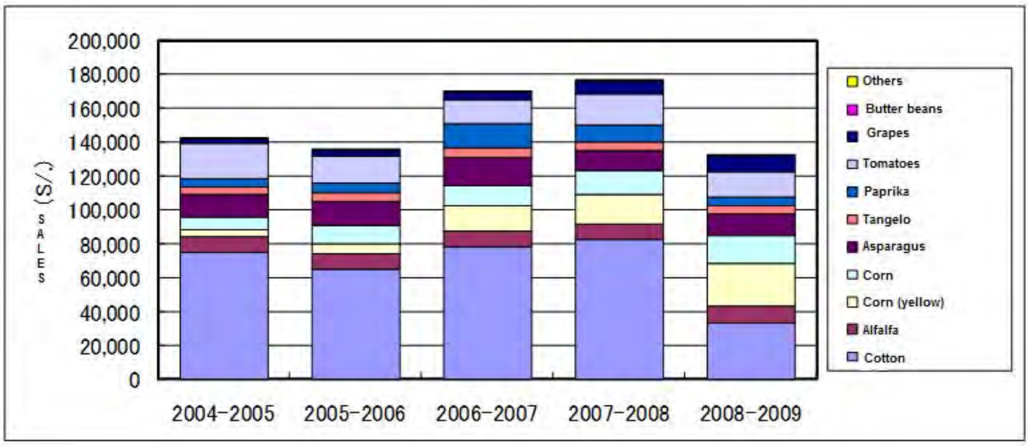


Figure 3.1.3-9 Sales

(4) Majes-Camana river

1) Irrigation sectors

Table 3.1.3-8 and 3.1.3-9 shows basic data on the irrigation commissions of the Majes River and the Camana River, respectively. In the first one there are 45 irrigation sectors, 17 irrigation commissions with 2,519 beneficiaries. The surface managed by these sectors reach a total of 7,505 hectares.

In the watershed of the Camana River there are 38 irrigation sectors, 17 irrigation commissions with 3,388 beneficiaries. The surface managed by these sectors amounts 6,796 hectares.

Table 3.1.3-8 Basic data of the irrigation commissions in the Majes river

Irrigation Commissions	Irrigation sectors	Irrigated areas		Nº de Beneficiaries	River
		ha	%	(Person)	
Ongoro	Las Joyitas Las Palmas	8.08	0.11%	4	Majes
	Andamayo	94.35	1.26%	25	
	Luchea	35.26	0.47%	24	
	Ongoro	368.13	4.91%	65	
	Huatiapilla	367.26	4.89%	75	
	La Central	406.57	5.42%	66	
	El Castillo	623.05	8.30%	73	
	La Banda	4.15	0.06%	3	
	Jaran	3.52	0.05%	6	
Ongoro Bajo	Huanco Iquiapaza	4.46	0.06%	11	
	Huatiapilla Baja	103.62	1.38%	23	
	Alto Huatiapa	44.47	0.59%	20	
	Bajo Huatiapa	19.11	0.25%	8	
	Quiscay	17.84	0.24%	1	
Beringa	San Isidro	10.53	0.14%	3	
	Beringa	109.07	1.45%	80	
Huancarqui	La Collpa	14.93	0.20%	14	
	Huancarqui	342.56	4.56%	211	
Cosos	Cosos	125.43	1.67%	92	
Aplao	Aplao	232.26	3.09%	145	
	Bajos Aplao	11.50	0.15%	5	
La Real	Caspani	20.54	0.27%	18	
	La Real	172.07	2.29%	125	
Monte los Apuros	Monte los Apuros	370.86	4.94%	160	
Querulpa	Alto Maran Trapiche	131.78	1.76%	53	
	La Revilla Valcarcel	151.01	2.01%	50	
Tomaca	Tomaca	296.32	3.95%	54	
	El Rescate	92.34	1.23%	41	
Uraca	Uraca	688.81	9.18%	239	
Cantas Pedregal	Alto Cantas	162.87	2.17%	74	
	Bajo Cantas	147.09	1.96%	47	
Sogiata	Sogiata	522.66	6.96%	154	
San Vicente	San Vicente	230.68	3.07%	100	
	Caceres	57.31	0.76%	12	
Pitis	Pitis	93.10	1.24%	53	
	Escalerillas	155.61	2.07%	74	
Sarcas Toran	Sarcas Toran	777.69	10.36%	195	
	Hinojosa Pacheco	1.00	0.01%	2	
	Medrano	12.29	0.16%	7	
	La Cueva	6.24	0.08%	6	
	Callan Jaraba	37.91	0.51%	10	
	Sahuani	58.47	0.78%	17	
	Paycan	24.44	0.33%	6	
	Vertiente	2.29	0.03%	3	
El Granado	El Granado	345.45	4.60%	65	
Total		**7,504.98**	**100%**	**2,519**	

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

Table 3.1.3-9 Basic data of irrigation commissions in the Camana river

Irrigation Commission	Irrigation Sectors	Irrigated areas		Nº de Beneficiaries	River
		ha	%	(Person)	
Socso-Sillan	Huamboy	28.23	0.42%	8	Camana
	Puccor	13.30	0.20%	2	
	Pillistay	13.91	0.20%	6	
	Nueva Esperanza	27.31	0.40%	19	
	Socso	52.97	0.78%	15	
	Socso Medio	21.27	0.31%	12	
	Casias-Sillan	45.32	0.67%	20	
Sonay	Sonay	110.48	1.63%	34	
Pisques	Pisques	86.82	1.28%	39	
Characta	Soto	16.29	0.24%	4	
	Characta	174.35	2.57%	54	
Pampata	Naspas-Pampata	130.31	1.92%	21	
	Pampata-Baja	164.77	2.42%	27	
La Bombon	Tirita	15.67	0.23%	12	
	Montes Nuevos	49.41	0.73%	26	
	La Bombon	402.38	5.92%	265	
	Gordillo	8.14	0.12%	9	
	La Era	1.44	0.02%	4	
	La Rama Era I	45.53	0.67%	37	
	Toma Davila	58.20	0.86%	11	
El Alto	El Alto	314.57	4.63%	128	
Los Molinos	Los Molinos	435.97	6.41%	295	
El Medio	El Medio	477.98	7.03%	231	
	Los Castillos	44.36	0.65%	48	
	Flores	4.73	0.07%	5	
La Valdivia	El Desague	45.56	0.67%	55	
	La Lurin	17.35	0.26%	11	
	La Chingana	51.27	0.75%	33	
	La Valdivia	323.86	4.77%	196	
La Deheza	La Deheza	336.71	4.95%	228	
La Gamero	La Gamero	356.04	5.24%	257	
El Molino	El Molino	370.29	5.45%	302	
El Cuzco	El Cuzco	290.02	4.27%	261	
Montes Nuevos	Montes Nuevos	192.46	2.83%	123	
Huacapuy	Huacapuy	23.12	0.34%	21	
Pucchun	Mal Paso-Sta. Elizabeth	1070.90	15.76%	296	
	1er y 2do Canal Aereo	872.79	12.84%	202	
	Jahuay	102.11	1.50%	71	
Total		**6,796.19**	**100%**	**3,388**	

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

2) Main crops

Table 3.1.3-10 shows the variation between 2004 and 2009 of the planted surface and the performance of main crops.

In the Majes – Camana River Watershed, in 2004 the planted area, performance and sales decreased, but later increased so that during the period 2008-2009 profits were of S/.188,596,716. Main crops in this watershed were represented by: rice, beans, onions, corn and pumpkins.

Table 3.1.3-10 Sowing and sales of main crops

	Variables	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009
Paddy Rice	Sown surface (ha)	6,216	6,246	6,211	6,212	6,224
	Unit performance (kg/Ha)	12,041	13,227	12,841	13,370	13,823
	Harvest (Kg)	74,844,450	82,617,571	79,753,422	83,057,334	86,032,532
	Unit price (S/./kg)	0.92	0.65	0.80	1.10	0.70
	Sales (S/.)	68,868,814	53,701,421	63,802,738	91,354,778	60,222,772
Dried beans	Sown surface (ha)	4,458	4,433	3,947	4,045	3,886
	Unit performance (kg/Ha)	1,630	1,660	1,745	1,743	1,920
	Harvest (Kg)	7,264,349	7,359,607	6,888,684	7,051,876	7,460,849
	Unit price (S/./kg)	2.93	2.44	3.03	4.12	3.85
	Sales (S/.)	21,304,797	17,970,689	20,888,054	29,058,175	28,746,981
Onion	Sown surface (ha)	2,063	1,958	2,168	2,331	1,886
	Unit performance (kg/Ha)	40,552	32,073	41,231	46,034	35,840
	Harvest (Kg)	83,659,519	62,798,588	89,388,731	107,304,225	67,594,277
	Unit price (S/./kg)	0.58	0.38	0.71	0.43	1.37
	Sales (S/.)	48,800,305	24,067,447	63,582,270	46,002,256	92,290,918
Corn	Sown surface (ha)	50	30	34	618	558
	Unit performance (kg/Ha)	4,192	3,500	3,680	5,670	4,580
	Harvest (Kg)	209,600	105,000	125,120	3,503,916	2,555,501
	Unit price (S/./kg)	0.85	0.80	1.00	0.90	0.75
	Sales (S/.)	178,160	84,000	125,120	3,153,524	1,918,916
Pumpkin	Sown surface (ha)	193	223	217	129	159
	Unit performance (kg/Ha)	29,341	34,419	32,869	40,346	42,789
	Harvest (Kg)	5,662,900	7,675,350	7,132,607	5,204,624	6,803,456
	Unit price (S/./kg)	0.36	0.30	0.30	0.41	0.26
	Sales (S/.)	2,056,542	2,295,721	2,123,348	2,154,472	1,786,014
Chala Corn	Sown surface (ha)	55	35	38	29	44
	Unit performance (kg/Ha)	60,800	59,435	59,962	60,675	58,332
	Harvest (Kg)	3,344,000	2,080,242	2,278,540	1,759,566	2,566,613
	Unit price (S/./kg)	0.08	0.10	0.10	0.10	0.25
	Sales (S/.)	267,520	208,024	227,854	175,957	633,487
Sweet Corn	Sown surface (ha)	51	40	27	19	51
	Unit performance (kg/Ha)	16,980	17,694	18,053	18,201	18,223
	Harvest (Kg)	865,998	707,742	487,426	345,824	929,377
	Unit price (S/./kg)	0.30	0.40	0.61	0.32	0.58
	Sales (S/.)	259,799	283,097	296,066	111,028	536,123
Potato	Sown surface (ha)	39	38	22	22	65
	Unit performance (kg/Ha)	31,538	26,368	27,866	27,524	32,091
	Harvest (Kg)	1,230,000	1,002,000	613,045	605,531	2,085,916
	Unit price (S/./kg)	0.50	0.50	0.46	0.83	0.63
	Sales (S/.)	615,000	501,000	281,443	500,939	1,310,597
Tomato	Sown surface (ha)	5	45	36	11	48
	Unit performance (kg/Ha)	29,000	38,951	30,584	34,963	36,310
	Harvest (Kg)	145,000	1,752,790	1,101,025	384,597	1,742,875
	Unit price (S/./kg)	0.50	0.38	0.73	0.45	0.41
	Sales (S/.)	72,500	662,165	804,360	173,418	714,942
Watermelon	Sown surface (ha)	29	30	13	14	40
	Unit performance (kg/Ha)	9,862	17,265	12,920	13,087	13,718
	Harvest (Kg)	286,000	517,938	167,960	183,218	548,708
	Unit price (S/./kg)	0.30	0.40	0.40	0.47	0.80
	Sales (S/.)	85,800	207,175	67,184	86,112	438,966
Otros	Sown surface (ha)	95	153	204	190	116
Total	Sown surface (ha)	13,254	13,231	12,917	13,620	13,077
	Harvest (Kg)	177,511,816	166,616,828	187,936,560	209,400,711	178,320,104
	Sales (S/.)	142,509,238	99,980,740	152,198,437	172,770,659	188,599,716

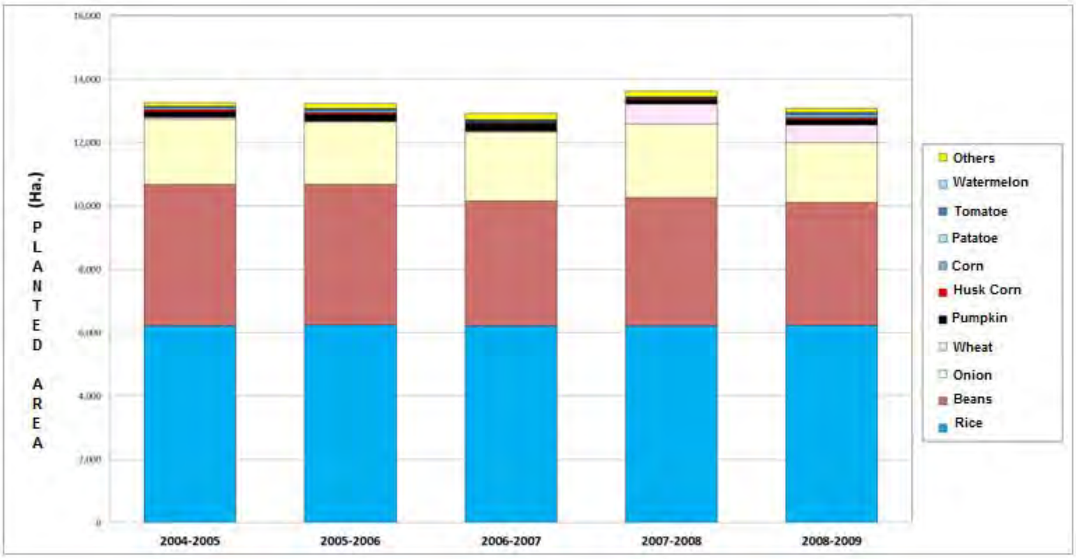


Figure 3.1.3-10 Planted surface

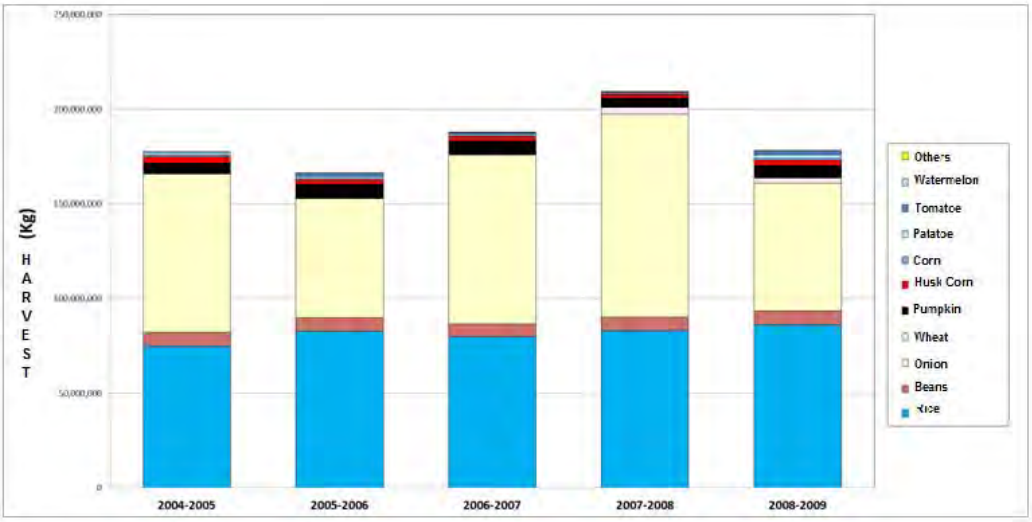


Figure 3.1.3-11 Harvest

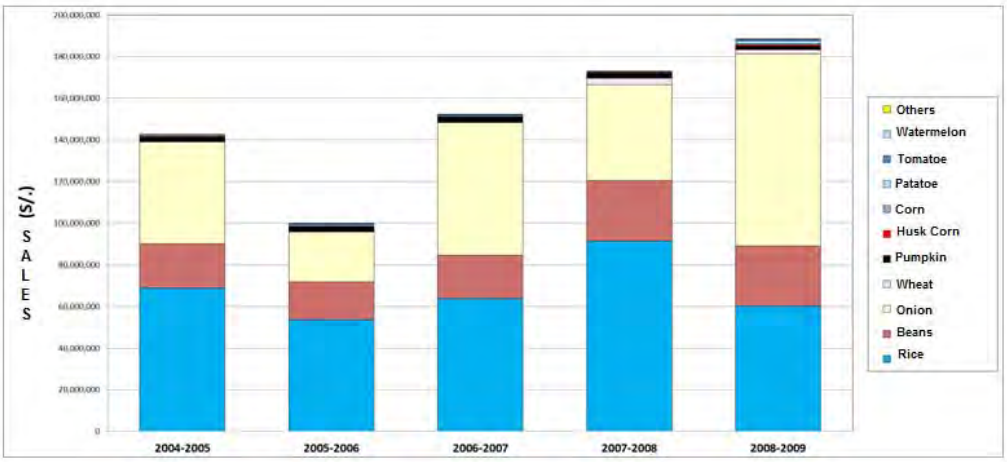


Figure 3.1.3-12 Sales

3.1.4 Infrastructure

(1) Cañete river

1) Road Infrastructures

Table 3.1.4-1 shows road infrastructures in the watershed of the Cañete River. In total there are 822.39km of roads, 265.89km of them (32.3%) are national roads, 59.96km (7.3%) regional roads, and 496.54km (60.4%) municipal roads.

Table 3.1.4-1 Basic data of road infrastructure

（Km）

Roads	Total Length		Paving			
			Asfphalted	Compacted	Non-compacted	Soil
National Roa	265.89	32.3%	205.75	60.14	0.00	0.00
Regional Roa	59.96	7.3%	10.40	49.56		
Municipal Ro	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

a) Intake:

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

b) 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

c) 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 channel

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/.)
			Department	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 infrastgructure 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

(2) Chincha river

1) Road infrastructures

Table 3.1.4-5 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 3.1.4-5 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 3.1.4-6 shows implemented projects by PERPEC between 2006 and 2009.

Table 3.1.4-6 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	First 5 km canal, Huampullo, the 200m tunnel 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	0.477	Km	130,264.00
6	2007	Pampa Baja, Belen and Chochocota channels cleanliness	Ica	Chincha	El Carmen	Pampa Baja, Belen , Chochocota	Channel cleanliness	12.63	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) Pisco river

1) Irrigation systems

Table 3.1.4-7 shows irrigation infrastructures of Pisco River. There are 41 intakes, 41 main channels and 167 secondary channels.

Table 3.1.4-7 Irrigation infrastructure

Nº	STRUCTURE		QUANTITY
1	INTAKE		41
2	CHANNEL	MAIN	41
		SECONDARY	167
3	WATERWORKS		11
4	SEWERS		73
5	SPILLWAY		6
6	DUMP		105
7	FALLS		163
8	CANOES		85
9	COVERED CONDUCT		2
10	BRIDGES	PEDESTRIAN	36
		VEHICLE	381
11	QUICK		10
12	TRAP		3
13	METER		39
14	TUNNELS		32

Source: Jica Study Team

2) PERPEC

Table 3.1.4-8 shows implemented projects by PERPEC between 2006 and 2009.

Table 3.1.4-8 Projects implemented by PERPEC

Nº	Year	Work name	Location				Description			Total cost (S/.)
			Department	Province	District	Town				
1	2006	Pisco River coastal defense - Condor area	Ica	Pisco	Independencia	Cóndor	Channel conformation	0.5	Km.	186,723.00
2	2007	Hydraulic infrastructure protection with coastal defense on right bank of Pisco River, Manrique area, Independece District, Pisco Province - Ica Region	Ica	Pisco	Independencia	Manrique	Dike with gavions and /or cushion	0.84	Km	501,939.72
3	2007	Channel and drains conduction capability restitution on right bank of Pisco River	Ica	Pisco	Independencia	Several	Channel box replacement	17.03	Km	145,810.00
4	2007	Main channel cleanliness Chunchanga-Murga-Pisco Area	Ica	Pisco	Humay	Chunchanga	Channel box replacement	2.824	Km	42,700.00
5	2007	Channel and drains conduction capability restitution on left bank of Pisco River	Ica	Pisco	Independencia	Varias	Channel box replacement	10.91	Km	92,504.00
							Drains Rehabilitation	6.307	Km	
6	2007	Slide rehabilitation of Huaya,Tambo colorado and Miraflores derivation channels - Pisco	Ica	Pisco	Humay	Varias	Intake rockfilling	0.051	Km	52,003.00
7	2007	Main and secondary channels rehabilitation in the Huancano-Pampano High area of Pisco River	Ica	Pisco	Huancano	Varias	Channel sheathing	0.544	Km	71,219.00
8	2007	Rehabilitation in Cabeza de Toro and Storage pools fixing for agricultural supply purposes in Cabeza de Toro - Pisco River	Ica	Pisco	Independencia	Cabeza de Toro	Replacement and fixing of pools	55	und.	106,819.00
9	2008	Coastal defense with short breakwaters with tumbling rocks right bank (several areas) Pirsco river (Contingency)	Ica	Pisco	Independencia	Several Areas	Building of 23 breakwaters of 40 mts.	23	Unid	107,735.00
							Dike conformation	1	Km	
10	2008	Derivation channel protection in Chunchanga (Contingency)	Ica	Pisco	Pisco	Chunchanga	Desilting	400	ml	279,240.00
							Dike with rockfilling	200	ml	
11	2008	Coastal defense with aims of San Ignacio intakes protection on the right bank and Bernales on the left bank of Pisco River, Bernales area, Humay district, Pisco province (Prevention)	Ica	Pisco	Humay	Bernales	Rockfilling dike	260	ml	435,781
							Rock breakwaters	19	und	
							Dike conformation	520	ml	

(4) Majes-Camana river

1) Road infrastructures

Table 3.1.4-9 shows road infrastructures in the watershed of the Majes River. In total there are 981.291 km of roads, 282.904 km of them (28.8 %) are national roads, 208.163 km (21.2 %) regional roads, and 490.223 km (50,0 %) municipal roads.

Table 3.1.4-2 shows road infrastructures in the watershed of the Camana River. In total there are 574.039 km of roads, 143.608 km of them (25.0 %) area national roads, 365.940 km (63.8 %) regional roads, and 64.491 km (11.2 %) municipal roads.

Table 3.1.4-9 Basic data of road infrastructure in the Majes river

Roads	Total Length (Km)		Paving (Km)			
			Asphalted	Trail Road	Gravel Road	Path
National Road	282.904	28.83%	64.400	173.842		44.662
Regional roads	208.164	21.21%			2.727	205.437
Municipal roads	490.223	49.96%		10.321		479.902
Total	981.291	100.00%	64.400	184.163	2.727	685.339

Table 3.1.4-10 Basic data of road infrastructure in the Camana river

Roads	Total Length (Km)		Paving (Km)			
			Asphalted	Trail Road	Gravel Road	Path
National Road	143.608	25.02%	114.748	28.860		
Regional roads	365.940	63.75%	16.100	82.610		267.230
Municipal roads	64.491	11.23%	1.040	6.677		56.774
Total	574.039	100.00%	131.888	118.147		324.004

2) Irrigation systems

Table 3.1.4-11 shows data on existing irrigation systems in watershed of the Majes - Camana River. There are 58 water inlets and 79 water direct inlets. Besides, there are 58 main channels, 128 primary ones, 54 secondary and 5 tertiary. Main channels have an accumulated length of 167.24 km. Lagged channels amount 3,498 km, while 334,019 km have no lagging.

3) PERPEC

Table 3.1.4-12 shows implemented projects by PERPEC between 2006 and 2009.

Table 3.1.4-11 Present conditions of irrigation channels

IRRIGATION COMMISSION	Number of Water Inlets	Number of Direct Water Inlets	N° of Intakes and sluicegates at CD level				Number of channels				Long. de C.D. (Kms.)	Total System Length	
			Housing inlets	N° of sluicegates	Lateral inlets	N° of sluicegates	C.D.	1er.	2do.	3er.		Lagged (Kms.)	Rustic (Kms.)
ONGORO	5	5	63	35	25	25	5	25	6	0	30.064	0.363	69.600
ONGORO BAJO	3	6	49	0	4	0	3	4	1	0	9.841	0.600	11.586
	2	0	29	0	2	0	2	2	0	0	5.530	0.000	7.880
BERINGA	1	2	37	0	4	0	1	4	3	0	3.976	0.000	9.140
COSOS	1	0	47	2	6	2	1	6	1	0	5.933	0.000	9.660
APLAO	2	0	39	1	10	1	2	10	3	0	7.401	0.000	20.483
HUANCARQUI	3	0	36	0	10	0	3	10	12	2	7.653	0.000	29.180
TOMACA	3	0	47	0	1	0	3	1	0	0	6.664	0.000	7.604
LA REAL	2	0	71	0	9	0	2	9	3	1	6.508	0.360	12.884
	0	4	0	0	0	0	0	0	0	0	0.000	0.000	0.000
MONTE LOS PUROS	1	1	66	2	7	1	1	7	5	1	4.941	0.000	16.766
	0	8	0	0	0	0	0	0	0	0	0.000	0.000	0.000
QUERULPA	5	2	78	2	4	0	5	4	0	0	7.439	0.000	10.457
	4	3	71	0	3	0	4	3	0	0	5.225	0.000	6.944
URACA	1	0	34	9	3	1	1	3	7	1	7.930	0.090	20.886
	8	23	48	0	1	0	8	1	1	0	8.011	0.000	8.616
SOGIATA	1	0	42	0	8	0	1	8	2	0	7.650	0.000	16.920
	0	9	0	0	0	0	0	0	0	0	0.000	0.000	0.000
SAN VICENTE	1	0	26	0	7	3	1	7	2	0	3.925	0.000	9.655
	2	2	21	0	0	0	2	0	0	0	3.100	0.000	3.100
CANTAS PEDREGAL	2	0	33	4	6	1	2	6	4	0	4.770	2.085	15.512
PITIS	2	0	97	0	5	0	2	5	1	0	6.252	0.000	11.385
	1	1	8	0	0	0	1	0	0	0	0.160	0.000	0.160
SARCAS - TORAN	6	2	76	2	8	0	6	8	2	0	18.801	0.000	28.412
	1	11	10	0	0	0	1	0	0	0	0.940	0.000	0.940
EL GRANADO	1	0	15	0	3	0	1	3	1	0	4.526	0.000	6.249
TOTAL	58	79	1,043	57	126	34	58	126	54	5	167.240	3.498	334.019

Table 3.1.4-12 Projects implemented by PERPEC

Nº	YEAR	Work	Location				Description			Total Cost (S/.)
			Departament	Province	District	Town				
1	2006	Construction of a Rockfill Dike - Huantay Sector	Arequipa	Camana	Ocoña	Huantay	Conformacion de Dique	0.27	Km	150,000.00
2	2006	Construction of breakwaters and rockfill dikes in the Majes Valley	Arequipa	Castilla	Aplao y Uraca	El Granado	Rockfill Dike	0.2	Km.	607,186.00
3	2006	Construction of Coastal Defense - Quilca Valley Sector	Arequipa	Camana	Quilca	El Platanal	Conformacion de Dique	0.36	Km.	81,305.00
4	2006	Majes River Coastal Defense - Montes Sector	Arequipa	Castilla	Aplao	El Monte	Conformacion de Dique	0.34	Km.	96,000.00
5	2006	Construction of Coastal Defense - Ocoña Valley, Jayhuiche Sector	Arequipa	Camana	Mariano Nicolas Valcarcel	Jayhuiche	Rockfill Dike	0.27	Km.	149,992.00
6	2006	Construction of rockfill dike - Zurita Sector	Arequipa	Camana	Ocoña	Zurita	Conformacion de Dique	0.3	Km.	151,484.00
7	2006	Construction of Coastal Defense - Ocoña Valley, Santa Rita Sector	Arequipa	Camana	Ocoña	Santa Rita	Conformacion de Dique	0.3	Km.	149,487.00
8	2007	Construction of coastal defense - Querulpa Tomaca Sectors	Arequipa	Castilla	Aplao, Huancarqui	Querulpa Tomaca	Breakwater with Rock	0.67	Km	380,233.00
9	2007	Construction of dike with breakwaters - El Platanal Sector, Quilca District, Province of Camana - Arequipa	Arequipa	Camana	Quilca	El Platanal	Breakwater with Rock	0.42	Km	259,174.00
10	2008	Construction of Provisional Coastal Defense Construcción in the Majes River - Los Puros Sector, Aplao District, Province of Castilla - Arequipa (Contingency)	Arequipa	Castilla	Aplao	Los Puros	Construction of Dike and Breakwaters	0.18	Km	117,215.00
11	2008	Construction of Provisional Coastal Defense in the Ocoña River - Santa Rita Sector, Ocoña District, Province of Camana - Arequipa (Contingency)	Arequipa	Camana	Ocoña	Santa Rita	Construction of Dike and Breakwaters	0.23	Km	97,066.00
12	2008	Construction of Provisional Coastal Defense in the Majes River - San Vicente and Sacramento Sectors, Uraca District, Province of Castilla - Arequipa (Contingency)	Arequipa	Castilla	Uraca	San Vicente y Sacramento	Construction of Dike and Breakwaters	0.3	Km	124,952.00
13	2008	Construction of rockfill dike - Sonay Sector (Prevention)	Arequipa	Camana	Nicolas de Pierola	Sonay	Descolmatacion y conformacion de dique	0.4	Km	230,058.00
14	2008	Construction of coastal defense - Anchalo Huacan Sector - Ocoña Valley (Prevention)	Arequipa	Camana	Ocoña	Huancan	Rockfill Dike	0.26	Km	123,352.00
15	2008	Construction of Rockfill Dike - Huantay Sector - Ocoña Valley (Prevention)	Arequipa	Camana	Ocoña	Huantay	Rockfill Dike	0.28	Km	117,348.00

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 region, that the presents study is part of.

Table 3.1.5-3 Disasters in the region

Años	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Media
ALUD	2		1	2	1				3	1		1			1	3	15	
ALUVION	3	2	1	8	3	1		1	2	6	15	4	2	5	5	12	70	
DERRUMBE					1	1	2	3	53	18	61	160	67	68	99	85	618	
DESLIZAMIENTO	9	19	18	38	27	74	75	32	138	100	99	158	126	128	116	99	1256	
HUAYCO	37	17	54	134	57	55	39	28	69	50	48	73	53	50	64	59	887	
TOTAL DESASTRES DE SEDIMENTOS	51	38	74	182	89	131	116	64	265	175	223	396	248	251	285	258	2846	178
TOTAL INUNDACIONES	30	53	224	358	292	208	239	136	470	234	134	348	272	242	219	229	3688	231

Piura 0

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 SEDIMENT DISASTERS	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

Lima

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 SEDIMENT DISASTERS	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

Ica

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 FLOODING	4	4	0	13	14	1	2	0	0	1	1	0	4	6	1	0	51	3

Arequipa

Years	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total	Media
LANDSLIP																1	1	
FLOOD											5						5	
COLLAPSE						1	1	1								1	4	
LANDSLIDE		1		1	1	2	1	1	4	3	4	2			1	2	23	
AVALANCHE	6	1	7	14	3	2	4				2	2	1		9	3	54	
TOTAL SEDIMENT DISASTERS	6	2	7	15	4	5	6	2	4	3	11	4	1	0	10	7	87	5
TOTAL FLOODING	3	1	42	6	44	2	15	3	1	2	2	3	0	1	3	3	131	8

3.1.6 Investigation of 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) Cañete river

1) Hearing

Critical points:

- 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 flooding.

○ 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.

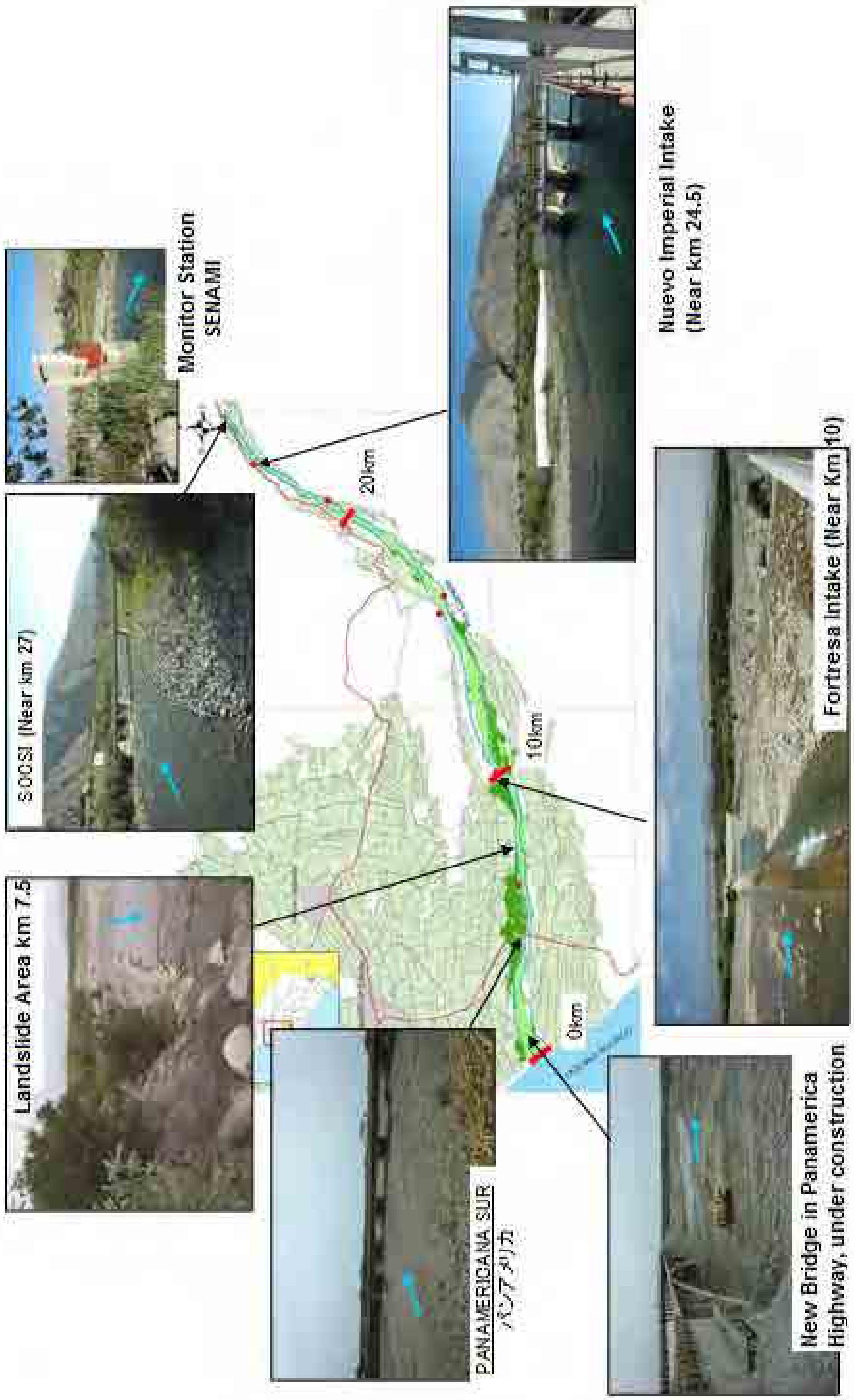


Figure 3.1.6-1 Visit to the study site (Cañete river)

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.

i) 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 eroded 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)

ii) 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)

iii) Challenge 3: Narrow section (km 4.3)

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

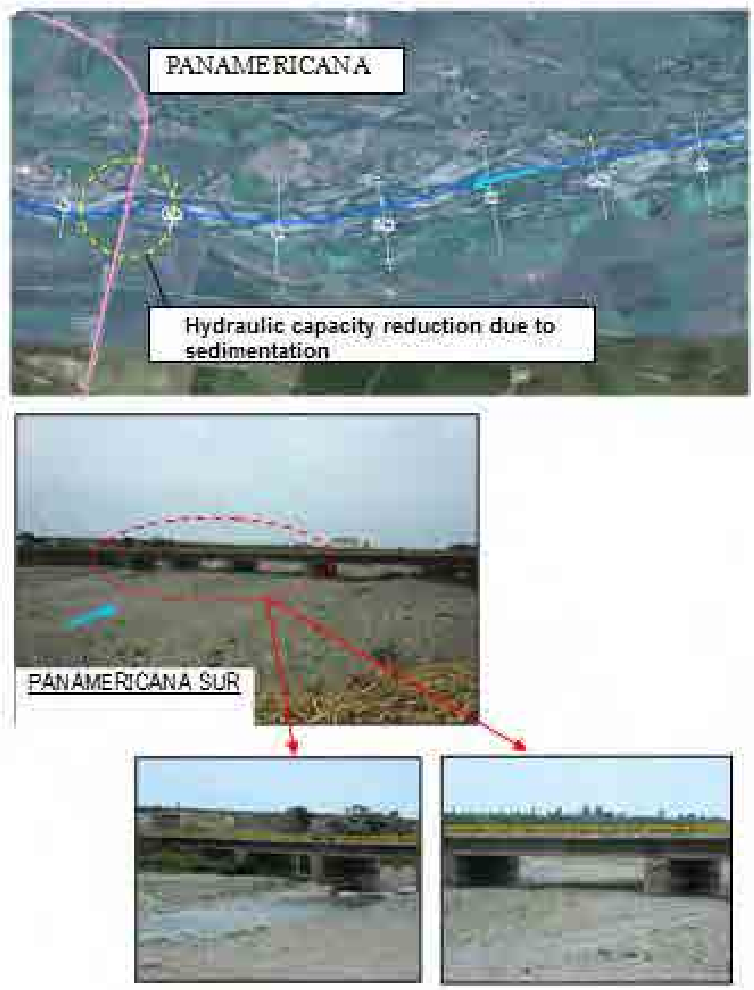


Figure 3.1.6-4 Local conditions related with Challenge 3 (Cañete river)

(2) Chincha river

1) Hearing

(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 $104\times10^6m^3$. 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 3.1.6-5 shows pictures of main sites visited.

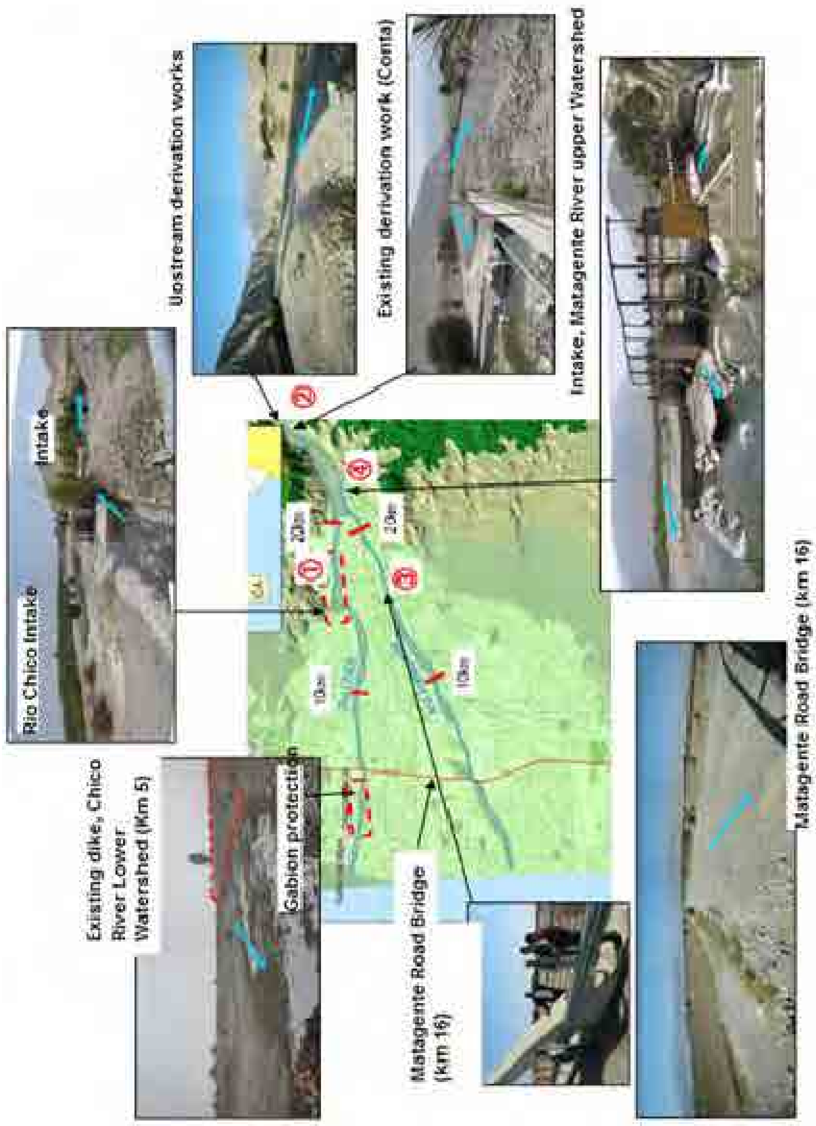


Figure-3.1.6-5 Visit to the study site (Chincha river)

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.

i) Challenge 1: Derivation works (Km 24) （Conta weir：Free diversion type with training dike and free overflow weir, without reference materials such as drawings）

Current situation and challenges	・The problem is from December to March. Approximately, 10 floods of 5 to 12 hours happen. Max flow in El Niño event reached 1.200m^3/s. ・According to design the river water must be derived within a relation 1:1, and this relation dose not happen when frequent overflows take place
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 ・The discharge control method with gate is difficult to be adopted from view point of operation and maintenance work and construction cost.

Figure 3.1.6-6 Local conditions related with Challenge 1 (Chincha river)

ii) Challenge 2: Intake (km 21 of Matagente)

Current situation and challenges	・Water intake is in January through March. This was built in 1936 ・It is one of the most important intakes in the area
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 3.1.6-7 Local conditions related with Challenge 2 (Chincha river)

iii) 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 bank ・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 3.1.6-8 Local conditions related with Challenge 3 (Chincha river)

(3) Pisco river

1) Hearing

(On critical points)

- The 1st critical point is 1.5 km downstream the bridge (km7). Flooded water floods the left bank's community. There is no dike under this point (1,5km from the bridge)
- The 2nd critical point is 11.5km away, where flood to the left bank is produced
- There is an intake on km 14.5. The work itself is not destroyed, but what is destroyed is the protection constructed on the right bank. There is a water channel connected to the urban area and an irrigation channel that covers all the left bank
- There are cement blocks criss-crossed on the left bank (km 12.5 and 13.5)
- The bed has elevated 3 meters approximately in the last 40 years (between 1970 and 2010)
- 40 years ago the dike existed so that there is no inundation, however due to the insufficient maintenance the dike seems to be washed away by floods so that the inundation frequently occurs nowadays.
- There is purify plant and an intake on km 28
- The 3rd critical point is on km 20.5. Conduction tubes were dragged when the flood occurred on this area

- There are 5 reservoirs upstream, with a total capacity of 54 x 106m^3.
- When El Niño occurred in Quitasol, 50km upstream, always produces floods

(Others: visited sites by the Study Team)

○ Intake, km 27.5

- Currently 7m3/s of water are taken (to supply 620 ha of agricultural lands)
- A bank against overflowing was built on the right bank
- Flood season: December through March

○Flood point, km 5,5

- Bank protection works were executed using track type tractors, hydraulic shovels and trailers. The stones were brought from upstream the intake
- With this section 500m3/s of water will flow (during El Niño a 700m3/s flow was reduced and we adopted the minimum value of such event)
- The left bank's area is private property, but it was decided to adopt this width considering that is not necessary to buy the land
- There are cement blocks criss-crossed up to the bed's height + 2meters
- There is no other disaster prevention plan in this area
- We are planning to build a new bridge 100meters downstream the existing bridge in km7 (Panamericana Highway)
- The project's building cost of the dike + cement blocks installation (L=800mts on both banks) is estimated in S/. 960.000 (equivalent to 30 million Japanese yens)

○Km 13.5 (Floodable area)

- A new dike on the exterior of the former dike is being built on the left bank. However, the work was stopped without being finished. The soil of the area was originally crop soil and then passed to be State land, 2 years was this area abandoned
- The construction cost of the dike of 600 meters is $850.000

○Casaya Intake

- The intake was not destroyed by floods, but the right bank protection did

○Murga Bridge

- Left bank protection was not destroyed during 1998 floods, but was destroyed during the February 1999 event. The penetration depth was approx. 1meter

○Montalbán Intake

- The intake was destroyed due to 1998 floods. Previously, the upstream bed was elevated and the high waters entered into the right bank (where the intake is) destroying the floodgate
- Water level reaches chest height
- Right bank's channel was buried
- The river's width at the intakes area is 90m approx., which is narrower than the upstream and downstream sections. The land of the left bank is private property
- The value of agricultural lands is approx. $5,000 per hectare (10,000 m^2).

○Francia Intake (between km 19.5 and km 20)

- Because this area is not protected, both banks flooded
- The bed has risen in the last years
- Limit demarking of private properties has been investigates by MINAG in 1998. Originally, this work was done by INRENA and then passed to MINAG. It is probable that there is similar information in another watershed

2) Description of the visit to the study sites

Figure 3.1.6-9 shows pictures of main sites visited.

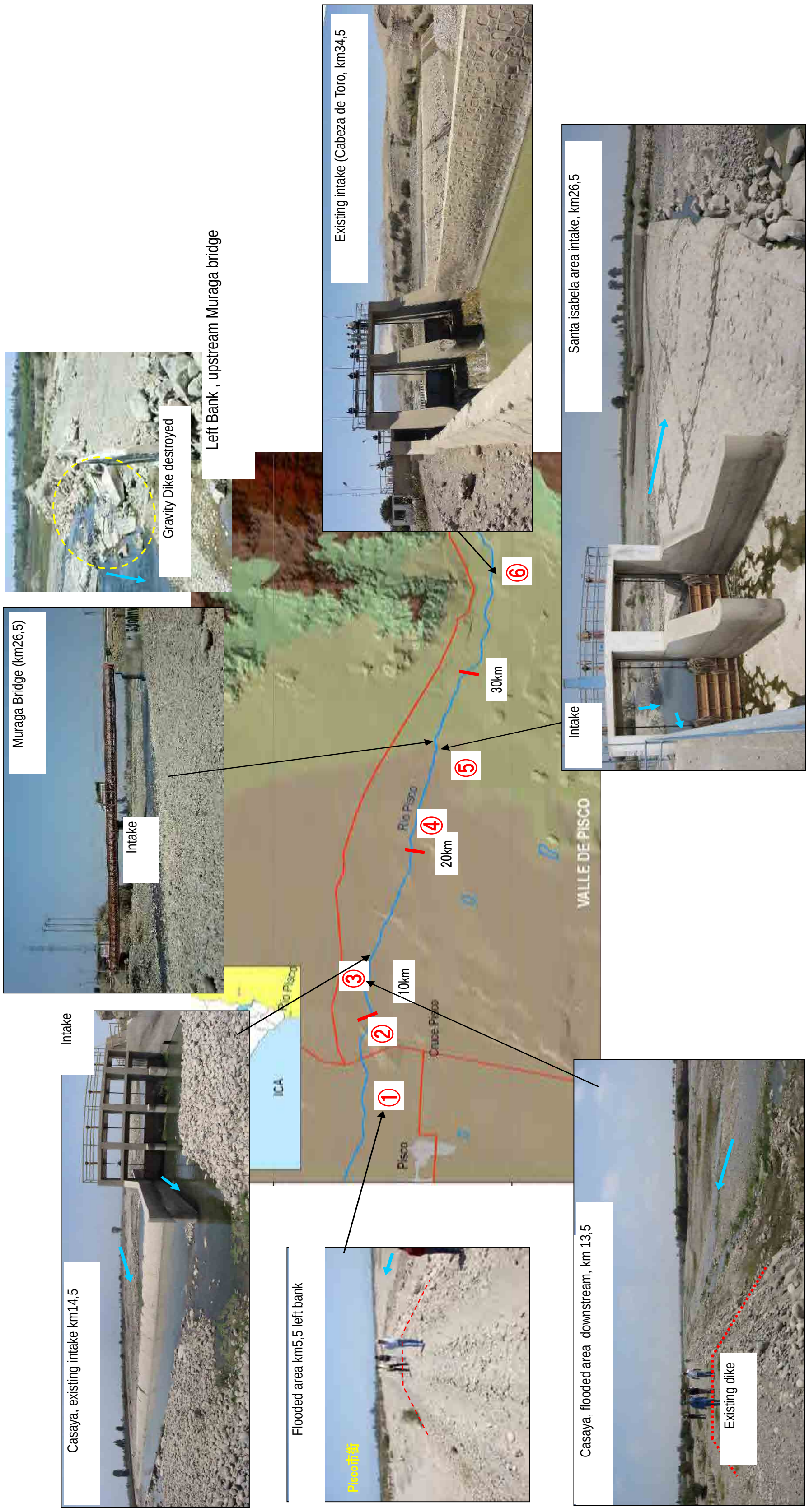


Figure 3.1.6-9 Visit to the study site (Pisco river)) challenges and measures

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

i) Challenge 1: Flood area (km 5.5)

Current situation and challenges	・A flood of 700 m^3/s was registered during El Niño ・Pisco Municipality was flooded by the overflow of the left bank in km 5.5 ・The bed has been rising up approx 3meters in the past 40 years ・The dike needs to be extended to the lower region, but there is no actual concrete plan
Main elements to be conserved	・Agricultural lands ・Pisco urban area
Basic measures	・Construct a dike on the non-protected section ・Bank protection works

Figure 3.1.6-10 Local conditions related with Challenge 1 (Pisco river)

ii) Challenge 2: Intake (km 26.5)

Current situation and challenges	・During El Niño in 1998, the overflow waters gathered on the intake and destroyed it. Also, the channels were buried ・Currently, the intake and the channel have been repaired ・The river's width to the intake's height is 90meters and is narrower Downstream than upstream (between 250 and 500meters)
Main elements to be conserved	・Agricultural lands (main products are not known currently)
Basic measures	・Rehabilitate destroyed installations and reinforce the existing dike ・Stable water flow throughout widening and rehabilitation of channels, buying the necessary lands

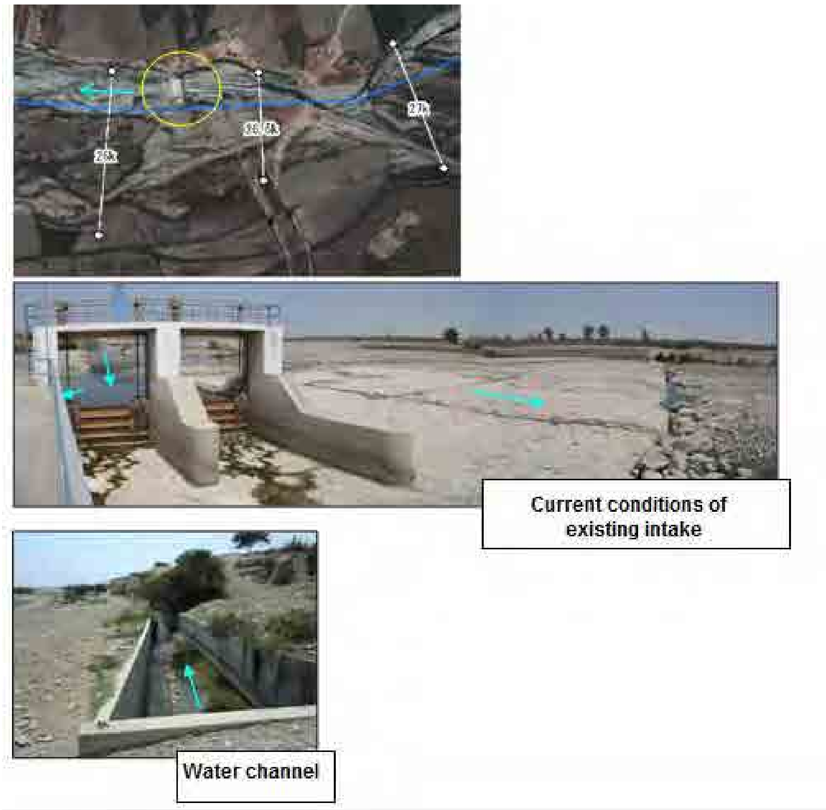


Figure 3.1.6-11 Local conditions related with Challenge 2 (Pisco river)

iii) Challenge 3: Flooding area (km 34.5)

Current situation and challenges	・One time the water has overflow from the right bank, upstream the intake, and this event left several sediments amounts gathered ・A dike upstream the intake was built alter the floods
Main elements to be conserved	・Agricultural lands (main product: corn)
Basic measures	・Rehabilitate the intake ・Build sediment retarding reservoir upstream the intake (at the upstream of the narrow section, fixing the deposited sediment and for sediment reservation in future)

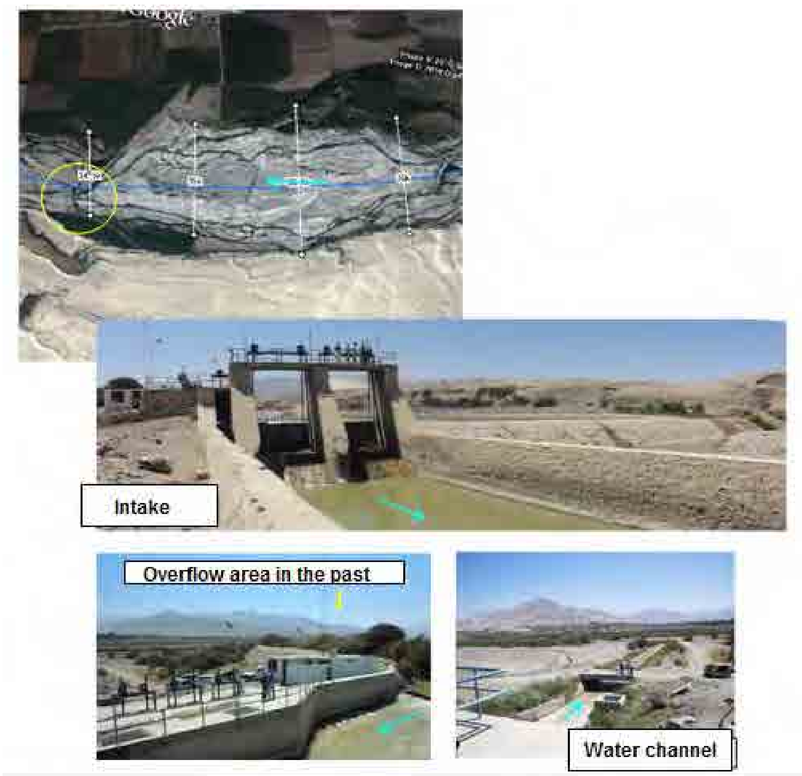


Figure 3.1.6-12 Local conditions related with Challenge 3 (Pisco river)

(4) Majes-Camana river

1) Hearing

i) Camana river

(General conditions of the watershed)

- The jurisdiction area of Camana covers from the river mouth to 39 km upstream
- The dike was constructed thirty years ago by the irrigation commission, but there are various eroded parts
- 99% of rice crops are commercialized in Lima's market
- Flow is measured once a day. The maximum historical flow was form 1,200 to 1,500 m^3/s. Floods last almost a week
- There are some colonial ruins in the upper area at the left riverbank between km 2 and 6 (On critical points)

○ Obstruction of the river mouth

- The formation of the gravel bank in the river mouth caused by beach waves obstructs water flow in the river mouth (obstruction in the river mouth). The construction of a longitudinal dike along the sea side has been considered in order to control this situation. The gravel bank disappeared with floods and reappeared between June and December
- The path km 2.5 – km 4.5 burst its banks the same year El Niño Phenomenon hit, 1998. The right bank also did burst in the past
- Riverbed elevation

○ Path with lower dike (left bank between km 6 and km 7.5).

- The dike at the left bank is particularly low between km 6 – 7.5 (LA BOMBOM)
- There are arable lands between the dike at the left bank and the river downstream in the Camana Bridge that can eventually be removed for being illegal. As to the arable lands outside the dike, the negotiation might be complicated
- The riverbed has elevated more than a meter

○Erosion in the riverbank around the channel (left bank between km 12– 13)

- There is an arm water inlet for Camana's drinking water by km 13
- There is a channel that goes from the water inlet along the river. The river's left bank is seriously eroded at km12, endangering the adjacent channel

○ Scour of bridge piers (by km 26)

- There is a local community at the right bank of the river, by km 26 (SONAI) with 40 households. There is a suspension bridge constructed a year ago with semi-eroded piers because of floods, presenting collapse risks with following floods

○ Other parts presenting problems

- The left bank dike at km 3 is eroded and has been provisionally repaired
- There is an unprotected part at km 14.2
- There is a path whose left bank is being eroded at km 19 (CHARACTA)

- The left bank dike at km 26.5 is eroded
- A left bank dike at km 28 needs to be constructed
- Arable lands at km 29 of the left bank are eroded (CULATA DE SIYAN)
- The left bank at km 30 is being eroded and needs protection (FUNDO CASIAS)
- A dike at km 33.5 needs to be constructed given that annually the water inlet and the irrigation channels get flooded
- A 1km dike needs to be constructed at the right bank of km 34
- A 2km dike needs to be constructed at km 37.5 downstream in order to protect the water inlet and adjacent arable lands (80 ha) of the left bank (HUAMBOY)
- A 1km dike needs to be constructed at km 39 downstream in order to protect the water inlet and adjacent arable lands (80 ha) of the right bank (HUAMBOY)

ii) Majes river

(Critical points)

○ Areas overflowing (right bank at km 104)

- A 500m dike needs to be constructed at the right bank
- Elements to be protected: arable lands (ONGORO BAJO)
- Landslide occurred on 1977 left arable lands buried at river banks. Accumulated sediment in the river course was dragged downstream by river level rise

○ Fluvial erosion (right river bank, km 101)

- Arable lands were eroded by 1997 floods
- The elements to be conserved are arable lands (HUATIAPILLA BAJA)
- The current dike (600 m) at the right river bank needs to be extended between 500 and 800 m

○ Fluvial erosion (right river bank, km 88.5)

- River banks have been eroded by the floods in February 2011 dragging also part of a house (which is still being occupied)
- The elements to be conserved are arable lands and houses (BERINGA)
- The existing dike (1 km) as well as protection works at the right river bank need to be prolonged 600 m

○ Dike erosion (right river bank, km 84.5)

- The dike at the right river bank is being progressively eroded year by year, and if measures are not taken, this could affect the adjacent bridge (Huancarqui Bridge)
- The dike has been repaired in an improvised way, but it needs a pertinent measure as river bank protection, etc
- The elements to be conserved are arable lands and the bridge (APLAO)
- The town of Aplao, the biggest city hall in Majes, has 18 thousand inhabitants, and Huancarqui at the other side of the river, crossing the bridge, has 5 thousand inhabitants

○ Unprotected stretch (right river bank, between km 70.5 and km 71)

- ➢ Currently an 800m dike is being constructed financed by the regional government. However, other 1,3 km are considered to be built in order to protect approximately 30 houses located in lower lands of the lower watershed
- ➢ Last August 2010, the area was flooded after eight years
- ➢ The elements to be conserved are arable lands and private houses (EL DEQUE)
- ➢ There is an irrigation channel upstream, conducting water to arable lands (700 ha) downstream. The water inlet is being eventually repaired, to be finished in 15 days
- ➢ Big rocks for river bank protection are extracted and transported from a quarry in Aplao

○ Overflowed stretch (both river banks, between km 60 and km 62)

- ➢ It is necessary to construct 2km dikes at the left river bank and 1.5 dikes at the right river bank
- ➢ Elements to be conserved are arable lands (Pitis at the left river bank and San Vicente at the right river bank)

○ Overflowed stretch (left river bank, between km 58 and km 58.5k)

- ➢ A dike needs to be constructed at the left river bank
- ➢ The elements to be conserved are arable lands (ESCALERILLAS)

○ Fluvial erosion (left river bank between km 55 and km 56.5k)

- ➢ Agriculture lands are being progressively eroded year by year by floods
- ➢ Elements to be conserved are arable lands (SARCAS)
- ➢ Part of the area has been flooded in 1998 by 1,500 m^3/s floods, forcing three small communities to move from lower lands to upper ones
- ➢ The river overflowed in February 2011 by floods of 800 m^3/s

○Other parts presenting problems

- ➢ A dike is looked to be built at the left river bank, between km 81.5 and km 82 (HUANCARUQUI)
- ➢ A dike is looked to be built at the right river bank, between km 81.5 and km 82 (CASPANI)
- ➢ Parts between km 75–km 75.5k and km 71–km 71.5 are unprotected at the left river bank (TOMACA)
- ➢ The stretch km 73.5 – km 74 is unprotected at the right river bank (QUERULPA)
- ➢ A dike is looked to be built at the left river bank, between km 49 and km 51.5 (PAMPA BLANCA)

2) Description of the visit to the study sites

Figure 3.1.6-13and Figure 3.1.6-14 show pictures of main sites visited, which figures are colored to represent the topography schematic.

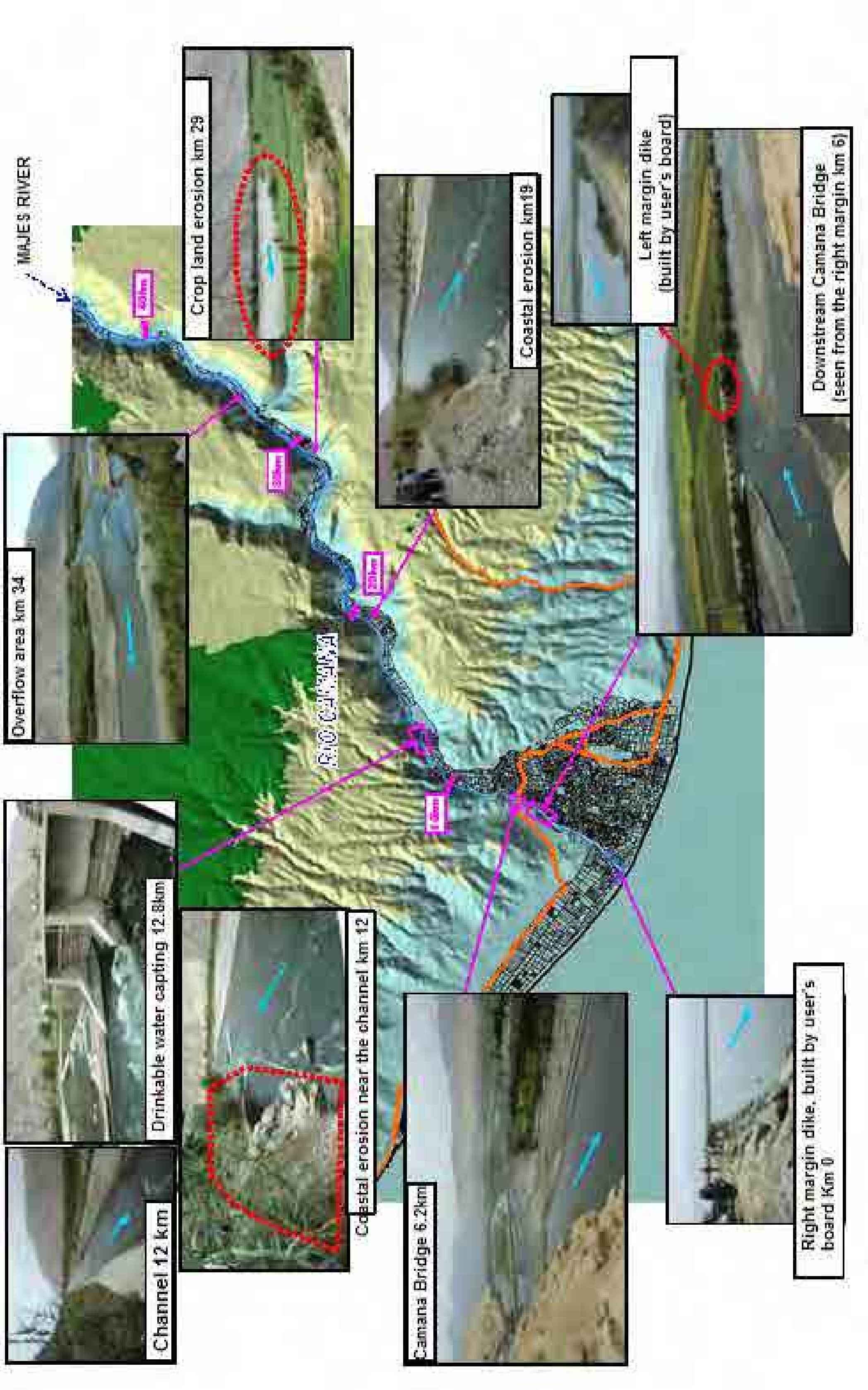


Figure -3.1.6-13 Visit to the study site (Camana river)

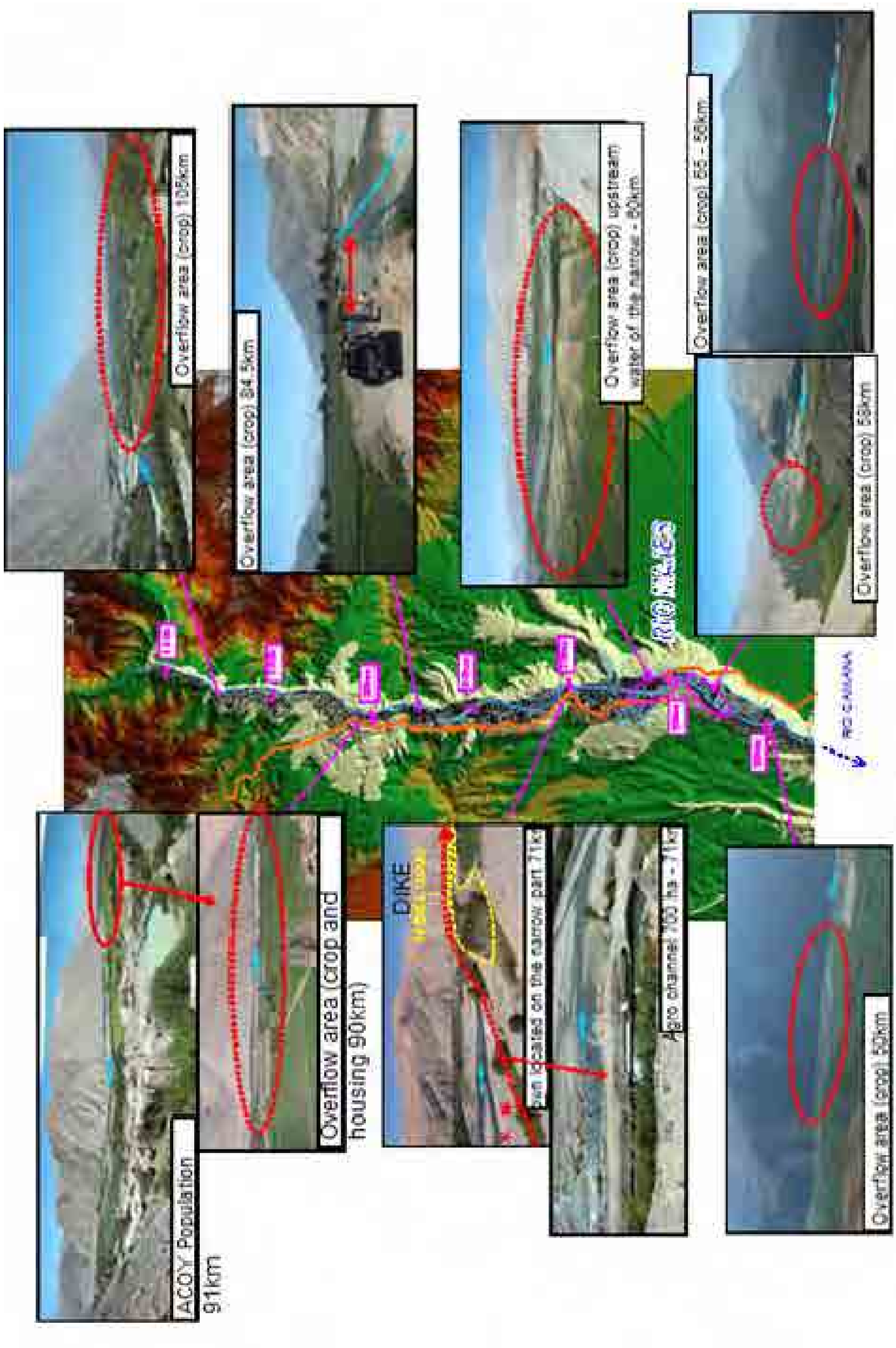


Figure 3.1.6-14 Visit to the study site (Majes river)

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.

i) Challenge 1: Deterioration of the existing dike caused by fluvial erosion (km 0 - 5 of the Camana River)

Current situation and challenges	・The existing dike which control corresponds to the Irrigation Commission of Camana has been constructed about 30 years ago with their own resources. There are several eroded parts ・ The dike is low upstream and downstream of Camana Bridge at km 6, putting at flood risk arable lands and urban area
Main elements to be conserved	・Urban area of Camana ・Arable lands (main crop: rice)
Basic measures	・Construction of dikes and riverbank protection

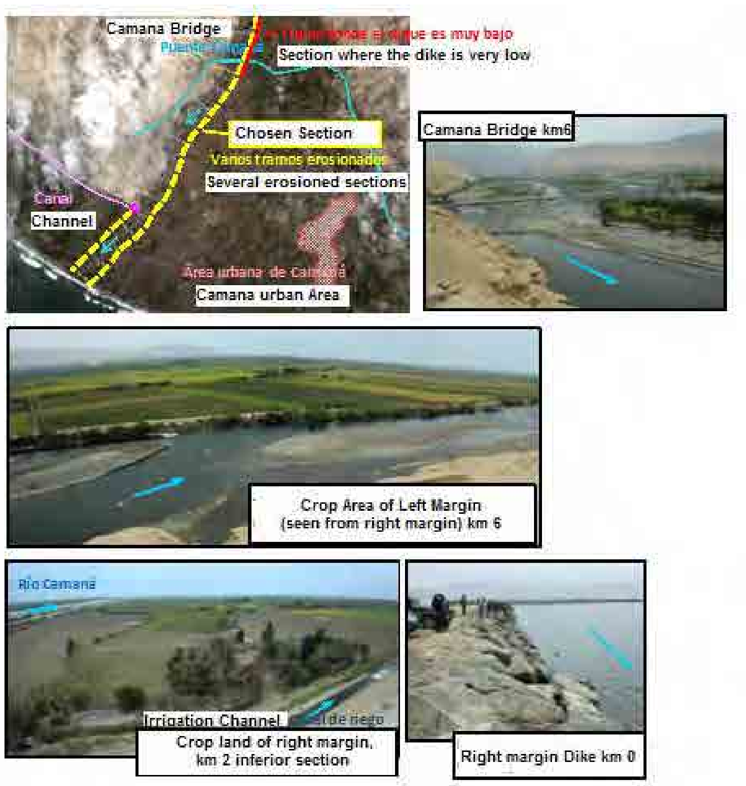


Figure 3.1.6-15 Local conditions related with Challenge 1 (Camana river)

ii) Challenge 2: Fluvial erosion impact on the drinking water inlet (Camana river, km 12)

Current situation and challenges	・There is an inlet for the drinking water service to Camana at km 13, as well as a channel along the river ・Currently the left bank at km 12 is eroded and if not taking correct measures, this could affect the adjacent channel
Main elements to be conserved	・Channel for drinking water
Basic measures	・Reinforcement of the existing dike and riverbank protection

Figure 3.1.6-16 Local conditions related with Challenge 2 (Camana river)

iii) Challenge 3: Overflow of the narrow upper stretch (Majes river, km 60-km 62)

Current situation and challenges	・The hydraulic capacity is reduced given the narrowing of the river, causing flood damages on arable lands of the upper areas ・There is a new bridge at the narrow area of the river. Parts are unprotected at both banks presenting high overflow risks
Main elements to be conserved	・Arable lands (main crop: rice)
Basic measures	・Construction of dikes and river bank protection (construction of retarding basin is difficult due to good agricultural land spreads in the upstream)

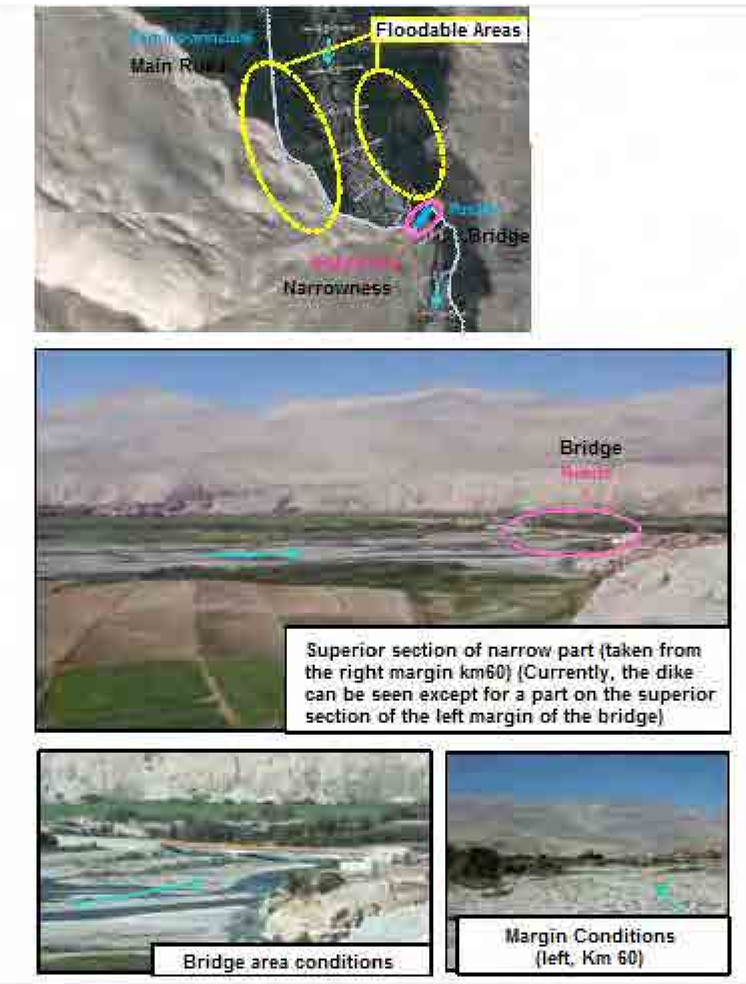


Figure 3.1.6-17 Local conditions related with Challenge 3 (Majes river)

iv) Challenge 4: Overflowing towards rural zone (Majes river km 70.5–km 71)

Current situation and challenges	・There is a community, dike, along the riverside, in the narrow section, 30 houses in the low lands ・Even though it is true that the higher section of this community is protected by a dike, there is a section downstream which is unprotected, with higher risk of overflowing ・There is a water intake to supply irrigation water to 700ha of crop land, which is also exposed to flood risk
Main elements to be conserved	・Houses, water intake for irrigation ・Croplands (main crop: rice)
Basic measures	・Construction of dikes and protection of banks （the extension of dike to the downstream non-dike section using existing small dike at river side of housing settlement is better compared with removal of 30 households in the cost and implementation of the project.）

Figure 3.1.6-18 Local conditions related to Challenge 4 (Majes river)

v) Challenge 5: Impact of fluvial erosion to the bridge (Majes river km 84.5)

Current situation and challenges	・The dike of the right bank is progressively eroded year by year, and if no measure is taken, it could affect the next bridge downstream (Huancariqui bridge) ・This bridge is an important path which connects Aplao, the larger town of Majes (with a population of 18 thousand inhabitants), and Huancarqui (with a population of 5 thousand inhabitants)
Main elements to be conserved	・Bridge (Huancarqui) ・Croplands (main crop: rice)
Basic measures	・Construction of dikes and protection to the banks

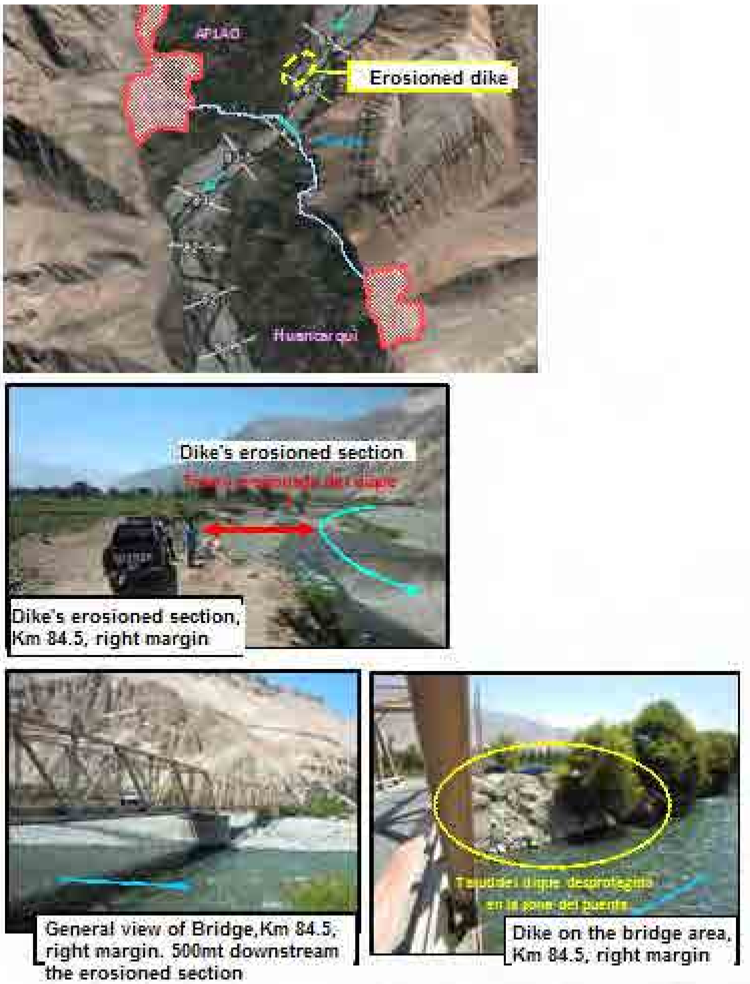


Figure 3.1.6-19 Local Conditions related to Challenge 5 (Majes river)

vi) Challenge 6: Damages from fluvial erosion to the community (Majes river km 88-km 88,5)

Current situation and challenges	・The river banks are progressively eroded per year due to the risings and floods of February 2011, which dragged a house ・Currently, the banks are unprotected and if the appropriate measures are not taken, it may worsen the damages, so taking measures is urgently needed
Main elements to be conserved	・Houses ・Croplands (main crop: rice)
Basic measures	・Construction of dikes and protection to the banks

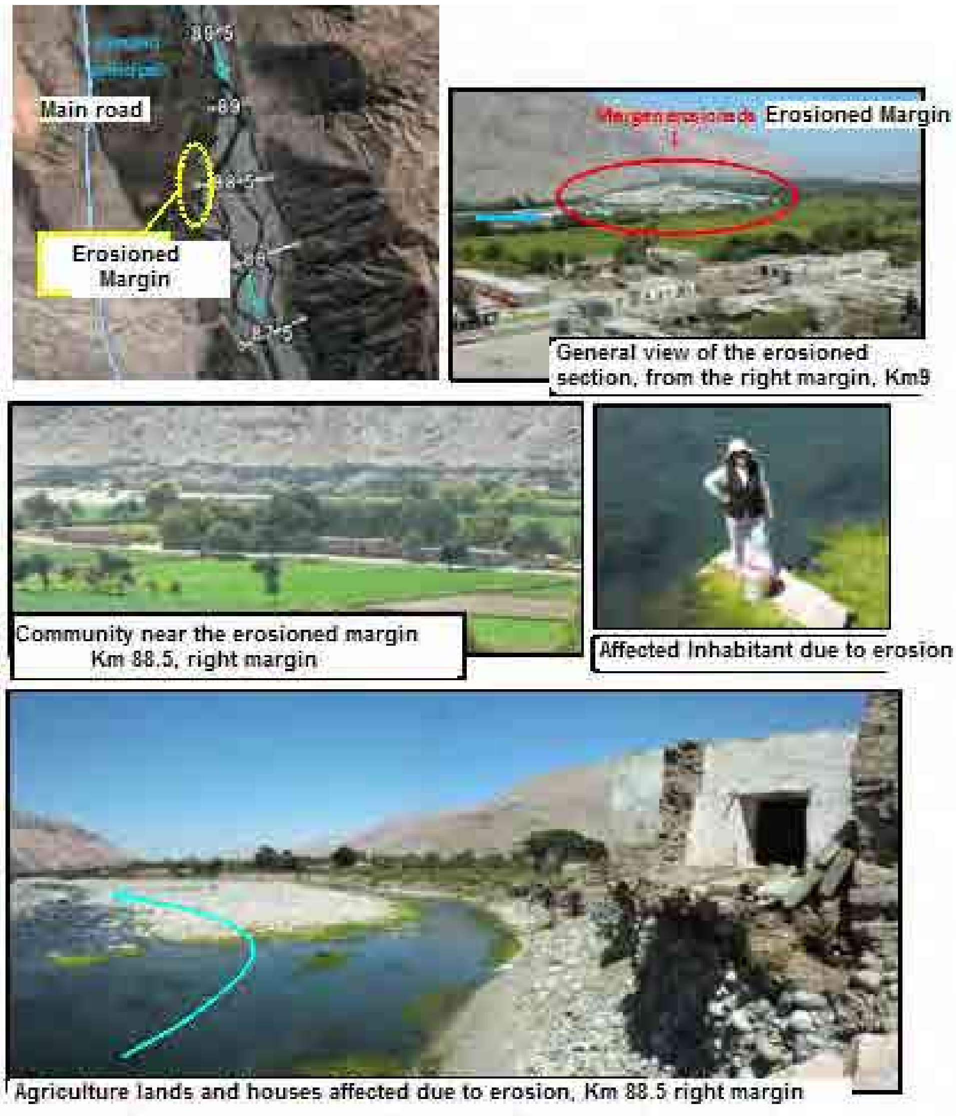


Figure 3.1.6-20 Local conditions related to Challenge 6 (Majes river)

3.1.7 Current Situation of Vegetation and Reforestation

(1) Current vegetation

1) Cañete, Chincha and Pisco watershed

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

Table 3.1.7-1 List of representative vegetable forming in Cañete, Chincha, Pisco watersheds

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) Majes-Camana watershed

According to vegetation formation map of 1995, the vegetation distribution in this watershed is similar to the 3 watersheds described in number 1). The difference among this watershed with the rest is: i) absence of Cu (arid and semiarid zones), ii) existence of hills "Lo" and iii) existence of Bf (wetlands).

The explanations that are only for this watershed, and not the rest, are the following. In Figure 3.1.7-4 a vegetation formation map is show of the Majes-Camana River.

[1] Subsequently, INRENA was dissolved and its functions were assumed by the Wild Forest and Fauna General Direction.

i) Lo: Hills

It goes from 0 to 1000m.a.s.l, from coastal desert of Peru to Chile. In winter (May to September) the hazel from the sea allows the development of plants communities. It is characterized for *Tillandsia spp,* tara (*Caesalpinea spinosa*), amancaes fower (*Ismene amancae*), cactus (*Haageocereus spp.),* clover (*Oxalis spp*.), wild potatoe (*Solanum spp*) among others. On the other hand, the coastal desert area is 11% of Peruvian territory, 2,000 km along the coast; also the area has 14,000km2. The coastal hills area couldn't be found in this study.

ii) Bf: Wetlands

From 3,900 to 4,800 m.a.s.l , its topography is basically flat lands, with mils slopes and slight depressions. They are in areas where there are springs and have permanent water the whole year. It's characterized for species such as champa (*Distichia muscoides*), sillu - sillu (*Alchemilla pinnata*), libro-libro (*Alchemilla diplophylla*), chillihua (*Festuca dolichophylla*), crespillos (*Calamagrostis curvula*), tajlla (*Lilecopsis andina*), sora (*Calamagrostis eminens*), ojho pilli (*Hipochoeris stenocephala*) among others. These plants are short and the fauna, American camelids (llama, alpaca, vicuña and guanaco) feed from them.

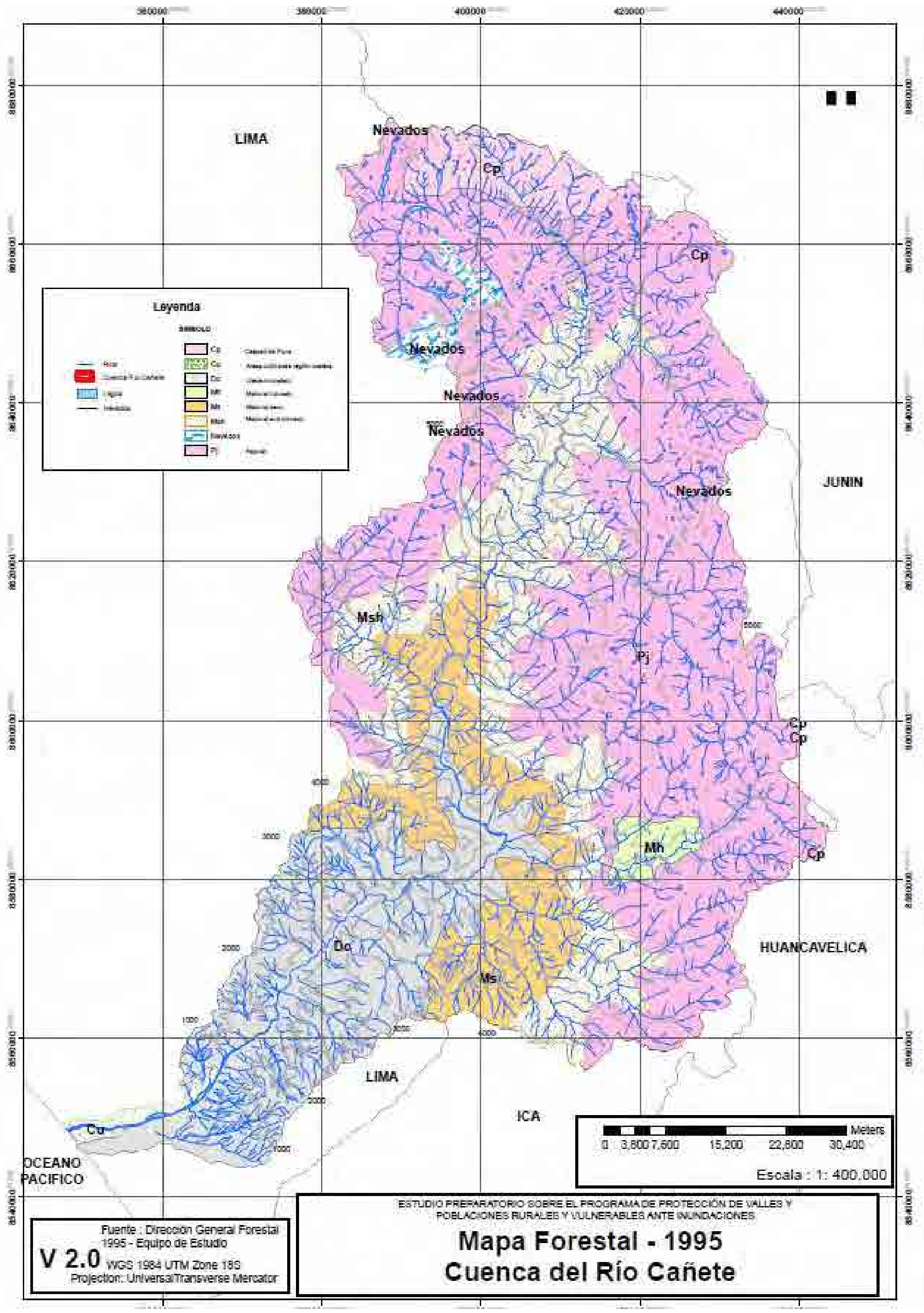


Figure 3.1.7-1 Cañete river watershed forestry map

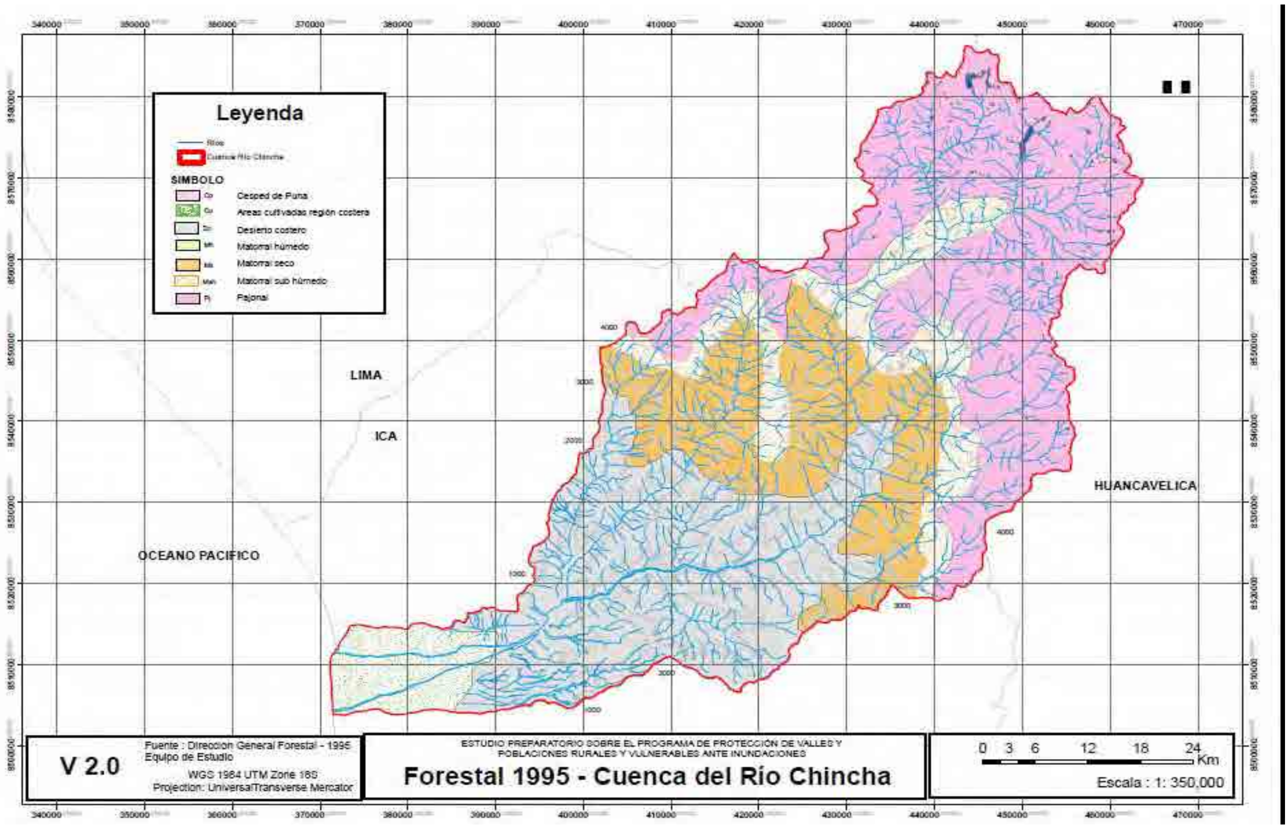


Figure 3.1.7-2 Chincha river watershed forestry map

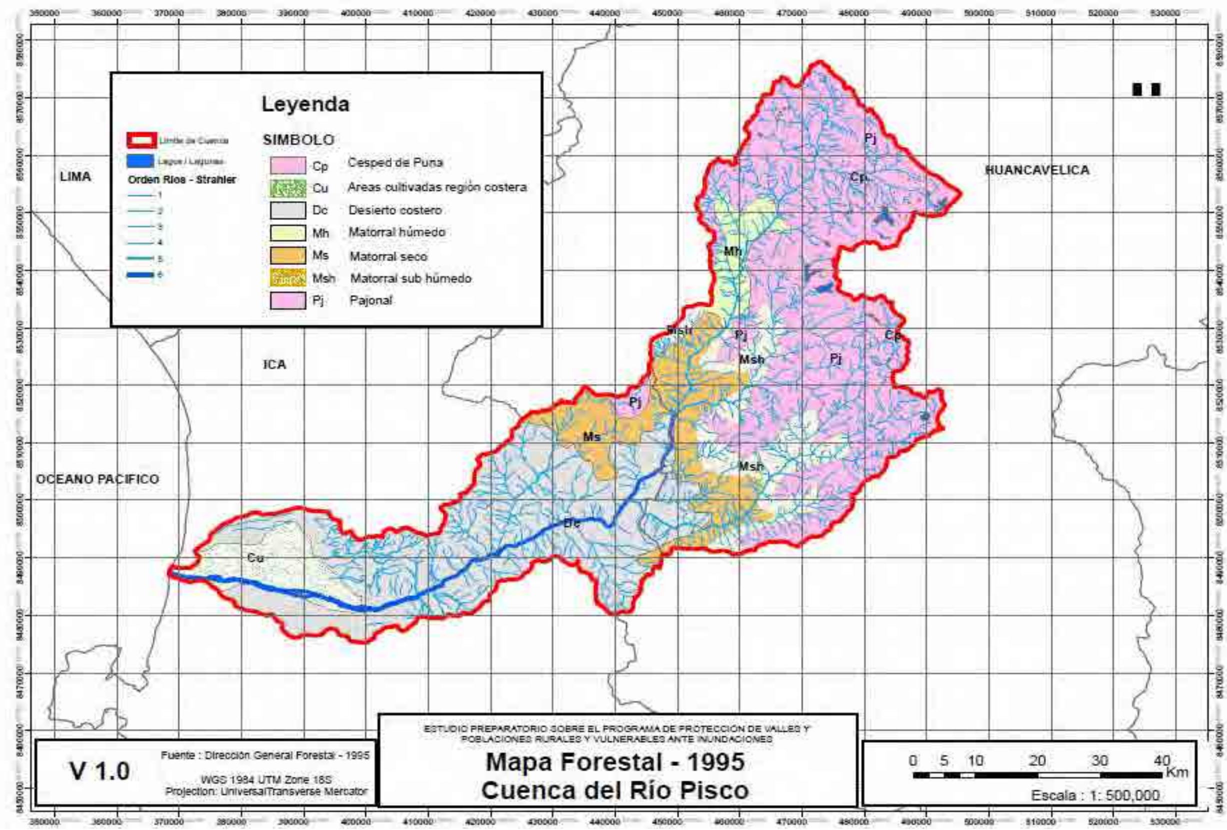


Figure 3.1.7-3 Pisco river watershed forestry map

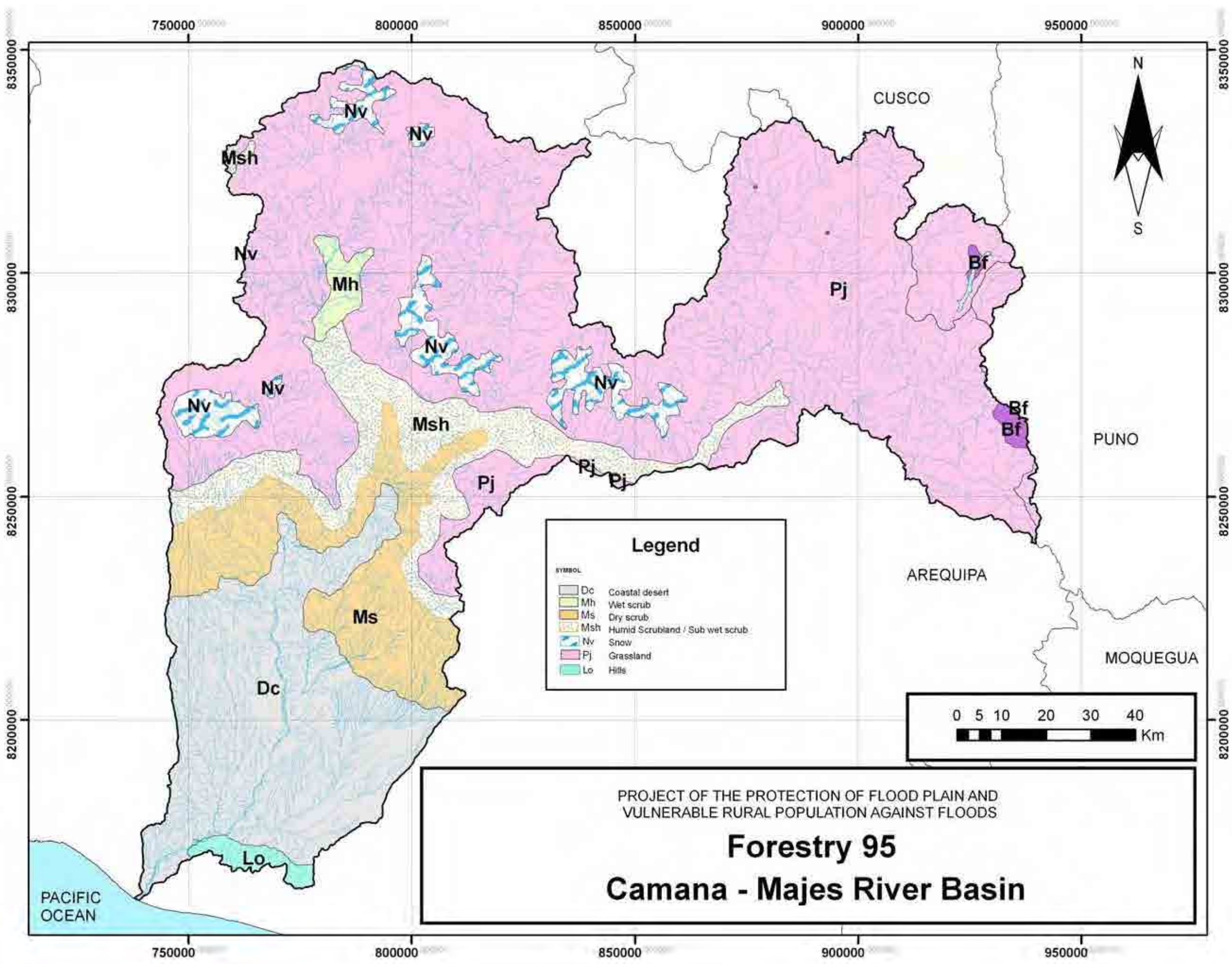


Figure 3.1.7-4 Majes-Camana river watershed forestry map

(2) Area and distribution of vegetation

1) Cañete, Chincha and Pisco watersheds

The present study was determined by the surface percentage that each vegetation formation occupies on the total watershed's surface, overcoming the INRENA study results of 1995 to the GIS (see Tables 3.1.7-2 and Figures 3.1.7-1 to 4). 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, due to which the surface of these bushes is not wide. So, natural conditions of the 3 watersheds of Cañete, Chincha and Pisco 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 (Cañete, Chincha and Pisco watersheds)

Watershed	Vegetation								
	Cu	Dc	Ms	Msh	Mh	Cp	Pj	N	Total
（Vegetation Area：ha）									
Pisco	217.88	1,354.39	469.99	381.55	140.01	672.59	1,035.68	0.00	4,272.09
Chincha	169.98	1,010.29	642.53	365.18	0.00	854.74	261.17	0.00	3,303.89
Cañete	61.35	1,072.18	626.23	1,024.77	70.39	187.39	2,956.65	66.78	6,065.74
Total	449.21	3,436.86	1,738.75	1,771.50	210.40	1,714.72	4,253.50	66.78	13,641.72
（Ratio to Watershed Area：%）									
Pisco	5.1	31.7	11.0	8.9	3.3	15.7	24.2	0.0	99.9
Chincha	5.1	30.6	19.4	11.1	0.0	25.9	7.9	0.0	100.0
Cañete	1.0	17.7	10.3	16.9	1.2	3.1	48.7	1.1	100.0
Total	3.3	25.2	12.7	13.0	1.5	12.6	31.2	0.5	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 (Cañete, Chincha, Pisco watershed)

Watershed	Vegetation					
	Desert etc. (Cu, Dc)	Grass・Cactus（Ms）	Shrub（Msh, Mh)	Gassland（Cp, Pj）	Snow Mountain（N)	Total
（Ratio to Watershed Area：%）						
Pisco	36.8	11.0	12.2	40.0	0.0	100.0
Chincha	35.7	19.4	11.1	33.8	0.0	100.0
Cañete	18.7	10.3	18.1	51.8	1.1	100.0
Total	28.5	12.7	14.5	43.7	0.5	100.0

2) Majes-Camana river watershed

This watershed, as the Cañete watershed, has the same results in INRENA study since 1995 and these were put on GIS. So, the area percentage of each vegetation classification in the watershed was obtained. (Table 3.1.7-4)

Table 3.1.7-4 Area of each classification of vegetation (Majes-Camana watershed)

Distribution	Classification of vegetation								
	Lo	Dc	Ms	Msh	Mh	Bf	Nv	Pj	Total
Area of distribution of vegetation (km^2)	104,54	3108,12	1570,08	1334,76	155,20	66,16	641,44	10069,21	17.049,51
Watershed area percentage (%)	0,6	18,2	9,2	7,8	0,9	0,4	3,8	59,1	100,0

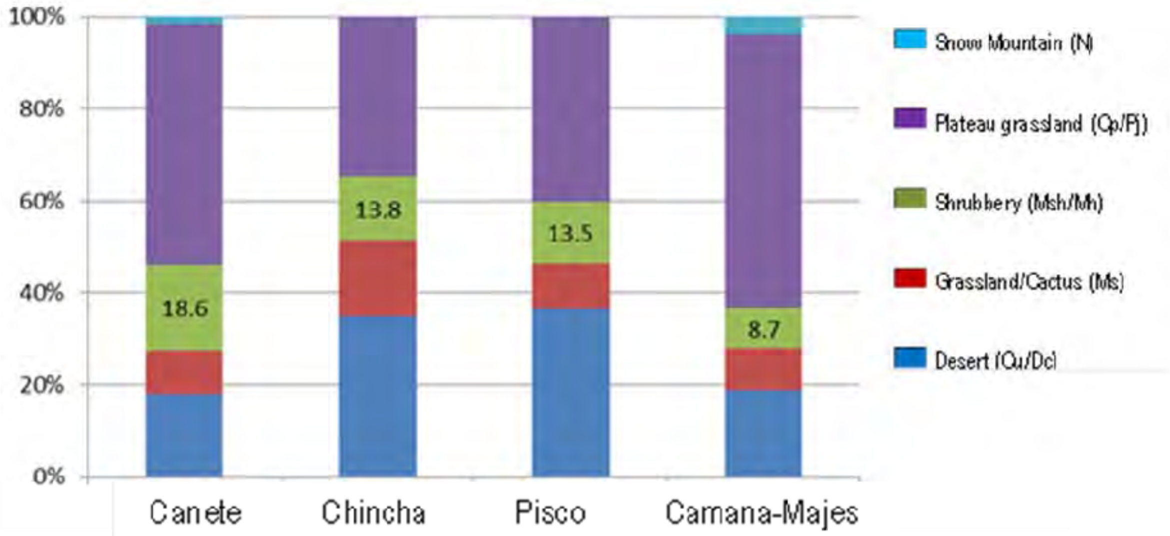
Source: Prepared by the JICA Team based on the INRENA1995 Forest Map

If the classification is added to this result, Table 3.1.7-5 is obtained. The characteristic of the vegetation classification of the Majes-Camana River watershed consists of low percentages of thicket areas (less than 9%); on the other hand, there are high percentages of scrublands (less than 60%). The altitude of high watershed of Rio Majes consists of more than 4,000 m.a.s.l, which cover most of the scrublands.

Table 3.1.7-5 Area and percentages of each classification of vegetation (Majes-Camana river watershed)

EE	Desserts and others (Lo,Dc)	Dry thicket (Ms)	Scrublands (Msh, Mh)	High elevation hills (Cp/Pj)	Ice-capped mountain (N)	Total
Vegetation area (km^2)	3.212,66	1.570,08	1.489,96	10.135,37	641,44	17.049,51
Watershed area percentage (%)	18,8	9,2	8,7	59,4	3,8	99,9

In Figure 3.1.7-5 the percentage distribution of vegetation formations in the 4 watersheds is shown (Cañete, Chincha, Pisco and Majes-Camana). In the 1st 3 watersheds, shrubs represent only 11 to 18%, while in Majes-Camana is even more reduced (less than 9%).



(Source: Arrangement by JICA Study Team based on Survey of INRENA 1995)

Figure 3.1.7-5 Watershed comparison (percentage among vegetal formations)

(3) Forest area variation

1) Forestry surface variation according to region

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. In Table 3.1.7-6 the accumulated forestry surface is shown of the regions of Arequipa, Ayacucho, Huancavelica, Ica, Lima and Piura. However, the information only covers a part. In Ayacucho, Huancavelica and Piura approximately 100,000ha, 10,000 and 10,000 of forests disappeared respectively.

Table 3.1.7-6 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)
Arequipa	6.286.456	-	-	-
Ayacucho	4.326.169	97.992 (2,3 %)	73.554	24.438
Huancavelica	2.190.402	11.112 (0,5 %)	11.112	-
Ica	2.093.457	-	-	-
Junín	4.428.375	628.495 (14,2 %)	289.504	338.991
Lima	3.487.311	-	-	-
Piura	3.580.750	9.958 (0,3 %)	5.223	4.735

Source: National Reforestation Plan, INRENA, 2005

2) Forestry surface variation according to watershed

a) Cañete, Chincha and Pisco watersheds

The variation of the distribution of vegetation was analyzed, comparing the FAO data from the 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 3.1.7-7).

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) and Ice-capped (N) increased.

Table 3.1.7-7 Changes in the areas of distribution of vegetation from 1995 to 2000 (Cañete and other 2 watersheds)

Watersheds	Vegetation Formations								
	Cu	Dc	Ms	Msh	Mh	Cp	Pj	N	Area of watershed
(Vegetation Area：ha)									
Pisco	-3.59	-3.44	-50.99	46.88	7.01	-9.52	13.65	—	4,272.09
Chincha	-5.09	-19.37	-95.91	86.85	3.55	-5.54	35.51	—	3,303.89
Cañete	-13.46	-28.34	-50.22	7.24	23.70	34.89	-2.18	28.37	6,065.74
Total(a)	-22.14	-51.15	-197.12	146.97	34.26	19.63	46.98	28.37	13,641.72
Current Area(b)	449.21	3,436.86	1,738.75	1,771.50	210.40	1,714.72	4,253.50	66.78	13,641.72
Percentage (a/b) %	-4.9	-1.5	-11.3	+8.3	+16.3	1.2	+1.1	+42.5	

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

b) Majes-Camana river watershed

See Table 3.1.7-8 for the vegetation distribution surface variation of Majes-Camana River. Since 1995 to 2000, semi-humid and humid bushes decreased in 30km2 (2.3%) and 5km2 (3.2%) respectively; grasslands (Pj), ice-capped (Nv) have decreased significantly in 364km2 (3.6%) and 60km2 (9.4%) respectively. Wetlands (Bf) are increasing in 12km2 (18.2%). The area with the most increase is the coastal desert (Dc) with approx 40km2 (13%).

Table 3.1.7-8 Changes in the areas of distribution of vegetation from 1995 to 2000 (Majes- Camana watershed)

Area	Vegetation							
	Lo	Dc	Ms	Msh	Mh	Bf	Pj	Nv
Year 1995 (km2) (a)	104,54	3.108,12	1.570,08	1.334,76	155,20	66,16	10.069,21	641,44
Year 2000 (km2) (b)	131,55	3.512,24	1.586,48	1.304,54	150,25	78,18	9.705,02	581,25
Changes (b-a) (km2) (c)	27,01	404,12	16,40	-30,22	-4,95	12,02	-364,19	-60,19
Change Percentage (%) (c/a)	25,8	13,0	1,0	-2,3	-3,2	18,2	-3,6	-9,4

(4) Current situation of forestation

1) Cañete, Chincha and Pisco Watersheds

As indicated before, the climate conditions of 3 watersheds (Cañete, Chincha and Pisco watersheds) do not improve high trees species development, so natural vegetation is not distributed; this only happens in the banks where the ground 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 3.1.7-9). 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. On the other hand, Ayacucho, Huancavelica and Junin that are located in the Mountains, and there is a lot of demand of timber and agriculture lands and livestock protection; also, rain is very abundant. However, for the above mentioned reasons, the reforested surface is reduced in these areas too.

Table 3.1.7-9 History registry of forestation 1994-2003

(Units: ha)

Departaments	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Arequipa	3.758	435	528	1.018	560	632	nr	37	282	158	7.408
Ayacucho	14.294	9.850	3.997	8.201	2.177	6.371	4.706	268	2.563	220	52.647
Huancavelica	12.320	1.210	2.587	2.061	294	7.962	6.001	545	1.035	0	34.015
Ica	2.213	20	159	159	89	29	61	15	4	1	2.750
Junín	38.064	921	3.781	8.860	2.597	4.412	718	995	556	752	61.656
Lima	6.692	490	643	1.724	717	1.157	nr	232	557	169	12.381
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

2) Majes-Camana river watershed

According to the obtained information throughout Agrorural interviews, the forestry experiences are shown in Table 3.1.7-10. Forestry has been done in 4 places, in much reduced areas and mostly experimental forestry. On the other hand, Conservancy Nature NGO currently performs vegetation recovery activities in Hills of the Peruvian Coastal Areas.

Table 3.1.7-10 Forestry experiences (Arequipa Department)

Year	Plantation Site	Executor Unit	Planted Species	Area (ha)	Observations
1992	Arequipa	Univ. Nac. San Agustín	Native Species	2	Forestry Diagnosis and Possibilities
2004	Usuña, Bellavista Polobaya district, Prov. Arequipa	AGRORURAL	Eucalyptus, pine, cypress	3	
2005	Arequipa	Tesis de Universidad	molle	0,5	

3.1.8 Current Situation of 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 map
- - Geological and Hydrographic watershed Map
- - 2000 Vegetation formation map
- - 1995 Vegetation formation map
- - Geological and slopes map
- - Hydrographic and slopes watershed map
- - Soil and watersheds map

- Isohyets map
- Population distribution 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 each watershed's altitudes. In Cañete and Majes-Camana watersheds there is high percentage of areas with more than 4,000 m.a.s.l. Slopes in this area are light and are distributed on ice-capped and reservoirs areas. This part of Cañete and Majes-Camana rivers is big and has plenty water in comparison to other watersheds. In Majes-Camana watershed, elevations between 4,500 and 5,000m.a.s.l are 53% of the total.

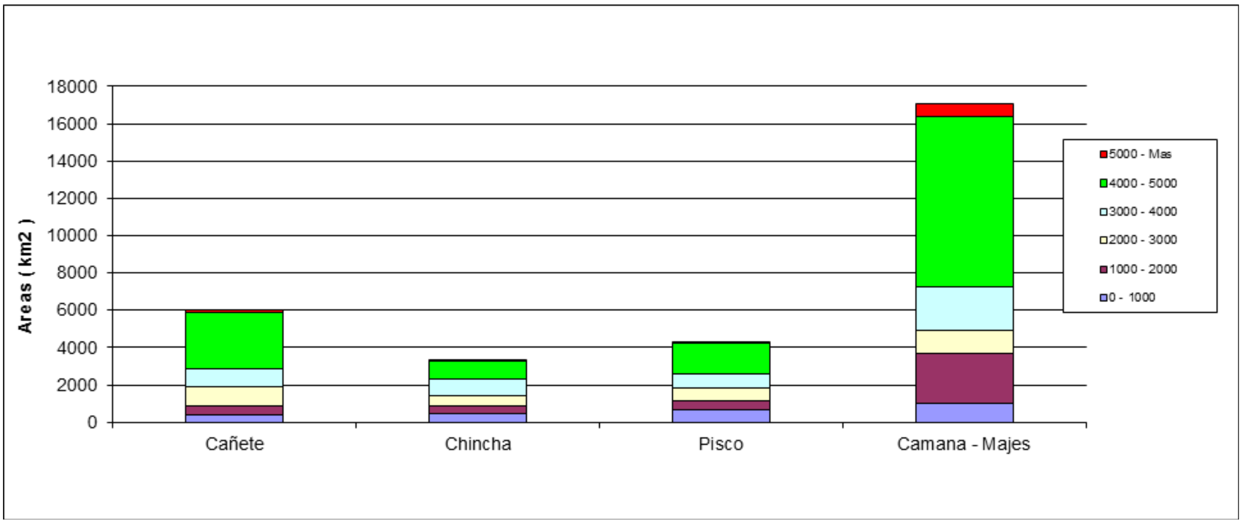


Figure 3.1.8-1 Area according to altitude

Table 3.1.8-2 Area according to altitudes

Elevation (m.a.s.l.)	Area (Km^2)			
	Cañete	Chincha	Pisco	Majes-Camana
0 - 1000	381.95	435.6	694.58	1040.56
1000 - 2000	478.2	431.33	476.7	2618.77
2000 - 3000	1015.44	534.28	684.78	1277.54
3000 - 4000	1012.58	882.39	760.47	2305.64
4000 - 5000	3026.85	1019.62	1647.8	9171.56
5000 以上	108.95	0.67	6.19	635.44
Total	6023.97	3303.89	4270.52	17049.51
Max. El (m.a.s.l.)	5355	5005	5110	5821

ii) Zoning according to slopes

Slope zoning maps were prepared for each watershed. Figure 3.1.8-2 and Table 3.1.8-3 show the percentage distribution according to each watershed's slope. The accentuated topography of Cañete, Chincha, Pisco and Majes-Camana can be seen following this order. In Cañete and 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.

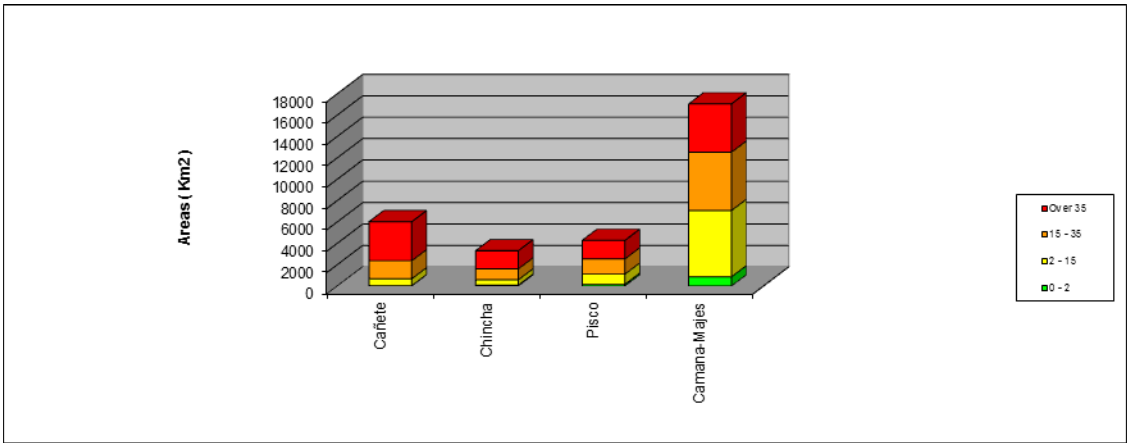


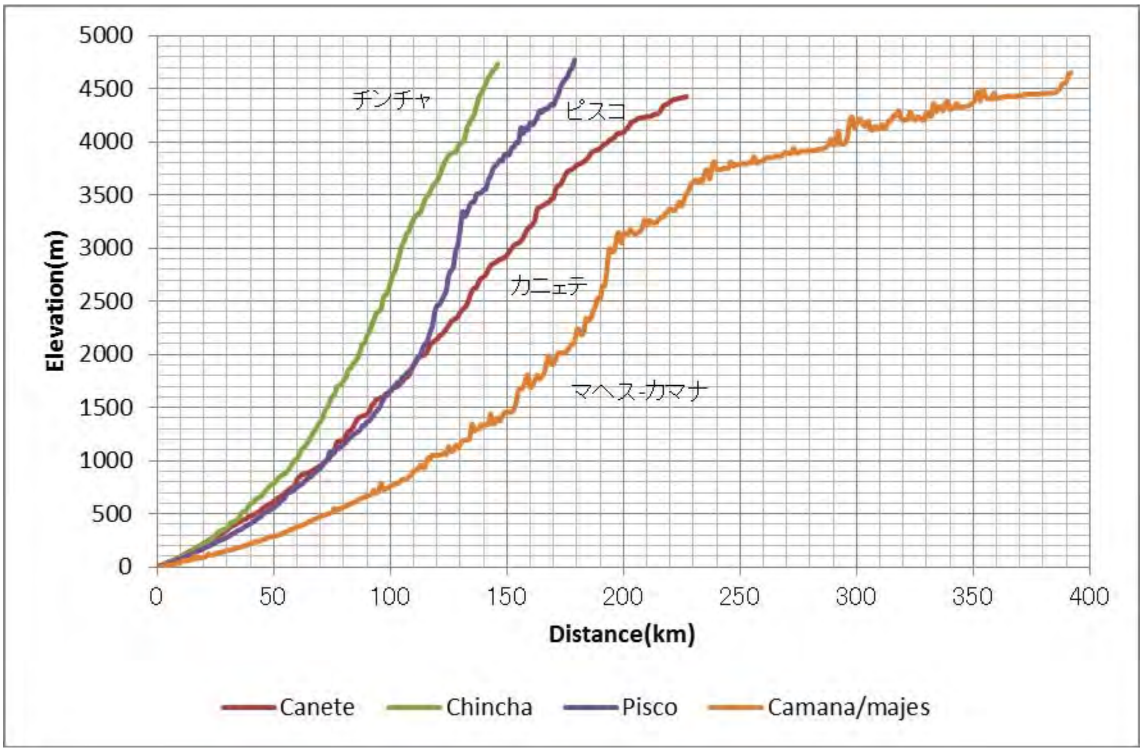
Figure 3.1.8-2 Percentage distribution according to slopes and area

Table 3.1.8-3 Percentage distribution according to slopes and area

Slope of	Cañete		Chincha	
Basin (%)	Area(km2)	Ratio	Area(km2)	Ratio
0 - 2	36.37	1%	90.62	3%
2 - 15	650.53	11%	499.68	15%
15 - 35	1689.81	28%	1019.77	31%
Over 35	3647.26	61%	1693.82	51%
TOTAL	6023.97	100%	3303.89	100%
Slope of	Pisco		Majes-Camana	
Basin (%)	Area(km2)	Ratio	Area(km2)	Ratio
0 - 2	168.57	4%	869.75	5%
2 - 15	947.86	22%	6210.54	36%
15 - 35	1426.18	33%	5452.97	32%
Over 35	1727.91	40%	4516.25	26%
TOTAL	4270.52	100%	17049.51	100%

iii) River longitudinal profile

Figure 3.1.8-3 shows the longitudinal profile of the rivers. Cañete, Chincha and Pisco have a similar profile. In case of Majes-Camana, the slope is steep from the mouth to km200, but from this point until km400, the slope is gentle.



Source: Elaborated by JICA Study Team based on 30m mesh

Figure 3.1.8-3 Longitudinal profile of 4 rivers

iii) River-bed slope

As seen in Figure 3.1.8-5, ravines are divided into bed load and debris flow sections. Table 3.1.8-4 and Figure 3.1.8-4 show the percentage bed slope. It is said that the sections where debris flow is produced have a bed-slope between 1/30 and 1/6. It is seen that the entire watersheds have a high regulation capacity of sedimentation.

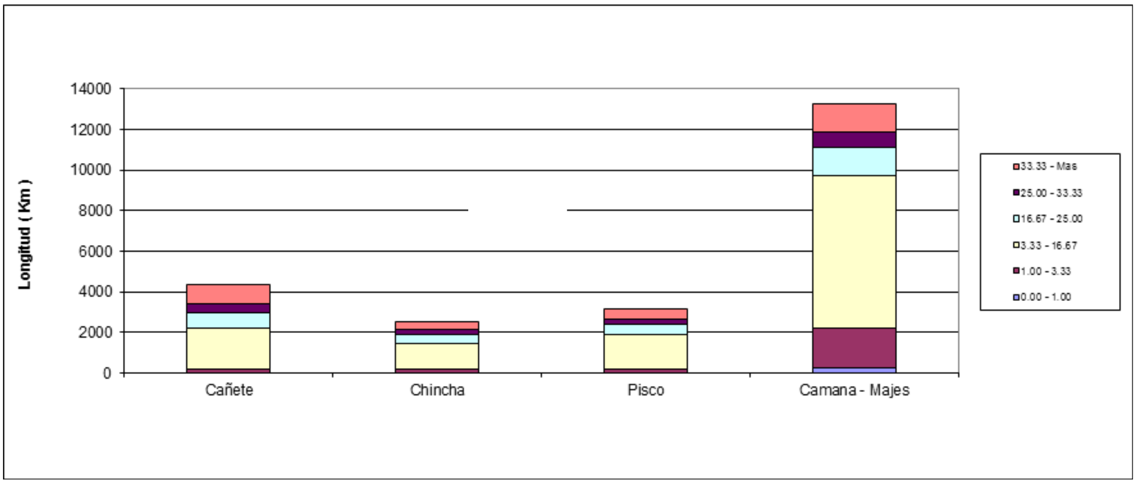


Figure 3.1.8-4 River-bed Slope and total length of streams

Table 3.1.8-4 River-bed Slope and total length of streams (km)

Slope River (%)	Cañete	Chincha	Pisco	Majes-Camana
0.00 - 1.00	12.82	5.08	12.15	263.45
1.00 - 3.33	173.88	177.78	165.05	1953.19
3.33 - 16.67	1998.6	1250.82	1683.15	7511.73
16.67 - 25.00	753.89	458.76	519.64	1383.17
25.00 - 33.33	467.78	255.98	291.84	761.15
33.33 - Mas	975.48	371.8	511.76	1425.65
TOTAL	4382.45	2520.22	3183.59	13298.34

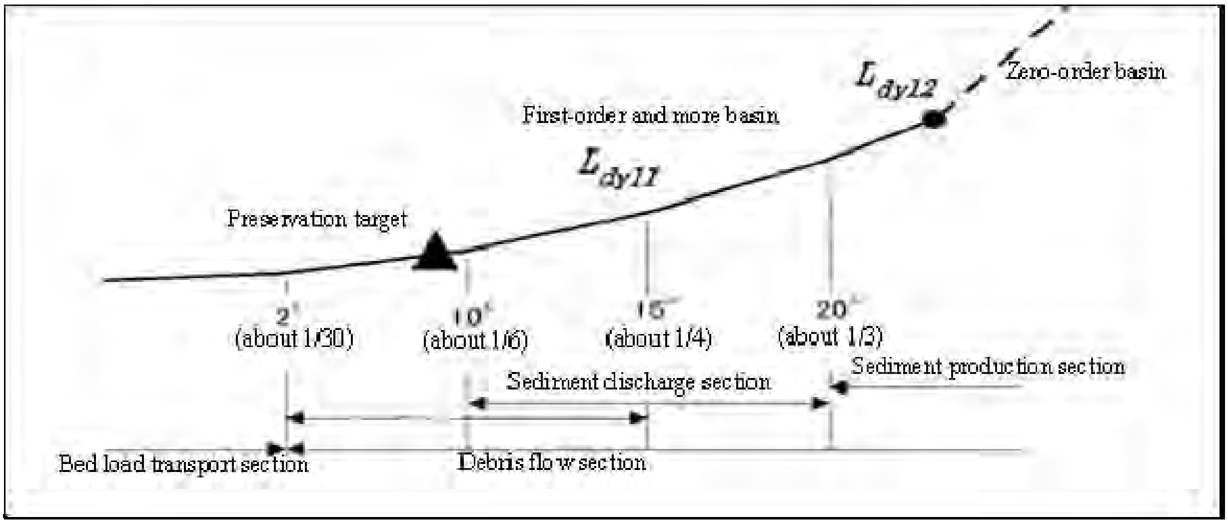


Figure 3.1.8-5 River-bed slope and sediment movement pattern

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 2,500 and 3,000 m.a.s.l. belong to the Quechua zone, where annual precipitation exist between 200 and 300mm. On altitudes from 3,500 and 4500m.a.s.l there is another region, called Suni, characterized by its sterility. Precipitations in this region occur annually with 700mm .

Figures 3.1.8-6 and 3.1.8-9 show the isohyets map (annual rainfall) of each watershed, of which characteristics are as follows:

- Cañete; The annual rainfall is 0~25mm in the inundation study area of the Project, and 750~1,000mm in the northern area with elevation more than 4,000 m.a.s.l
- Chincha; The annual rainfall is 0~25mm in the inundation study area of the Project, and 500~750mm in the eastern area with elevation more than 4,000 m.a.s.l
- Pisco; The annual rainfall is 0~25mm in the inundation study area of the Project, and 500~750mm in the eastern area with elevation of more than 4,000 m.a.s.l

- Majes-Camana; The annual rainfall is 0~50mm in the inundation study area of the Project, and 500~750mm in the south-eastern area with elevation from 4,000~5,000 m.a.s.l

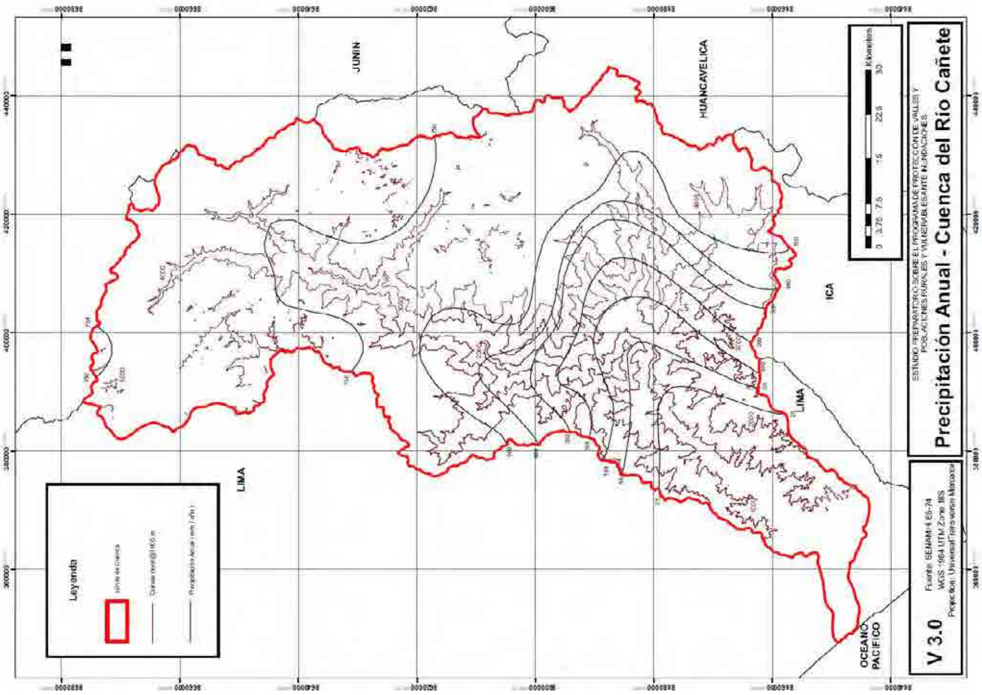


Figure 3.1.8-6 Isohyet map of the Cañete river watershed

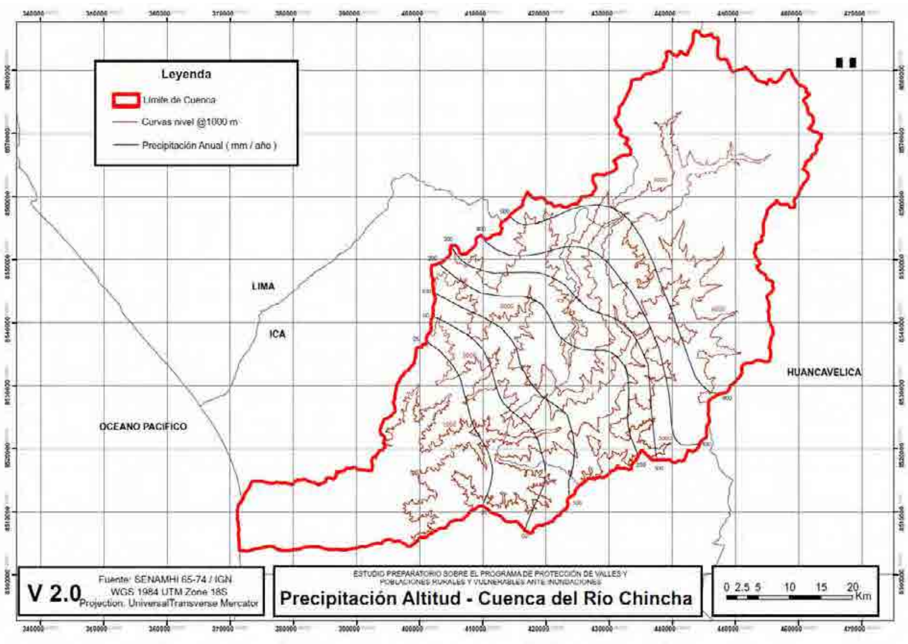


Figure 3.1.8-7 Isohyet map of the Chincha river watershed

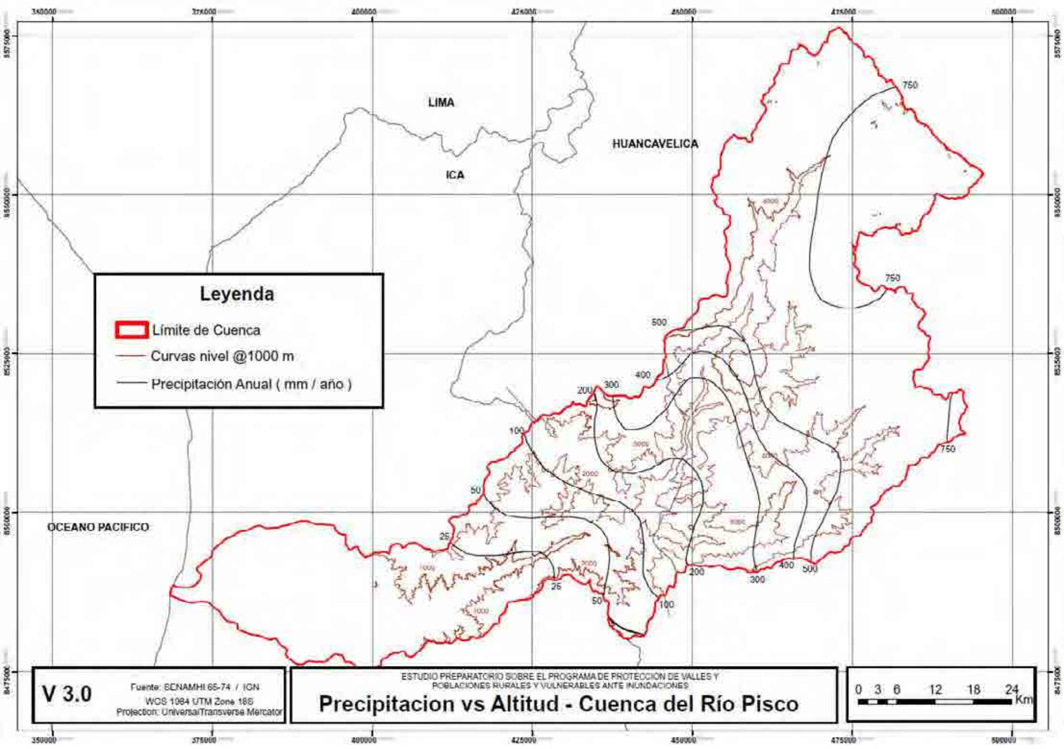


Figure 3.1.8-8 Isohyet map of the Pisco river watershed

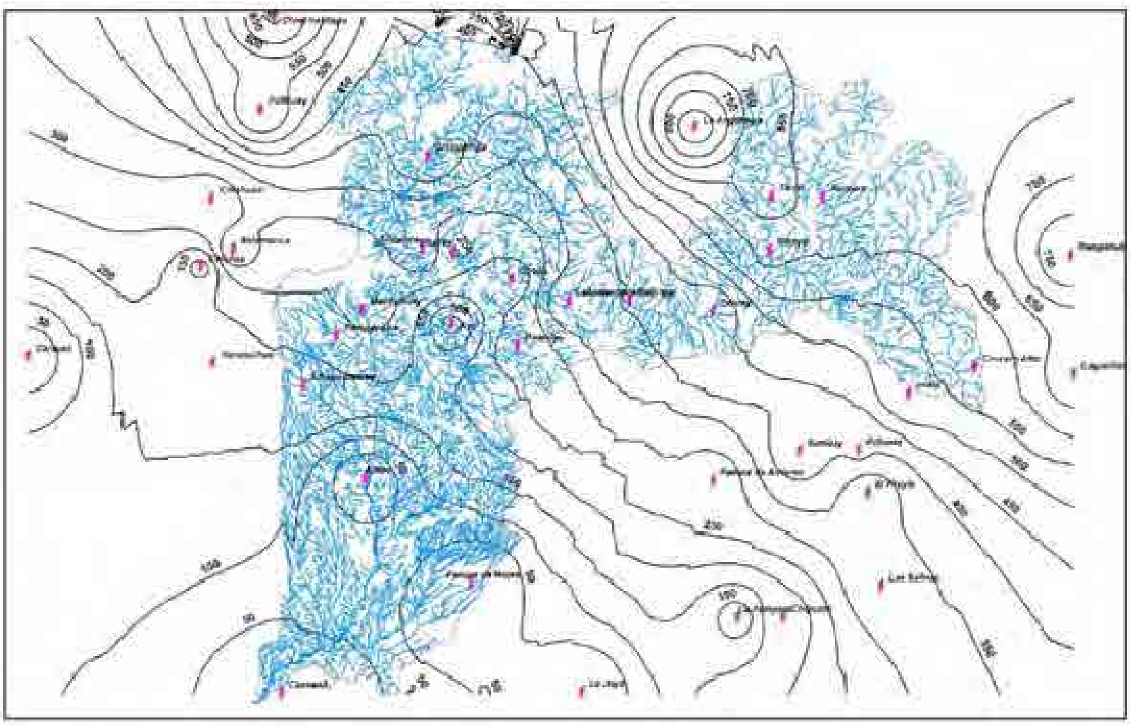


Figure 3.1.8-9 Isohyet map of the Majes-Camana river watershed

3) Slope and altitude

In Figure 3.1.8-10 and Table 3.1.8-5 the relation of the slope and the altitude is shown.

In Cañete river watershed, slopes with more than 35% represent 60% of slopes. Slopes with more than 35% are found mainly in heights between 4,000 and 6,000m.a.s.l.

In Chincha river watershed, slopes with more than 35% are between 2,000 and 4,000m.a.s.l.

In Pisco river watershed, slopes with more than 35% are between 1,000 and 4,000m.a.s.l. Over 4,000m.a.s.l, gebtle slopes with less than 35% are distributed.

In Majes-Camana river watershed, the topography is very variable between 1,000 and 4,000m.a.s.l. Colca Canyon, considered as one of the deepest in the world is located in this area.

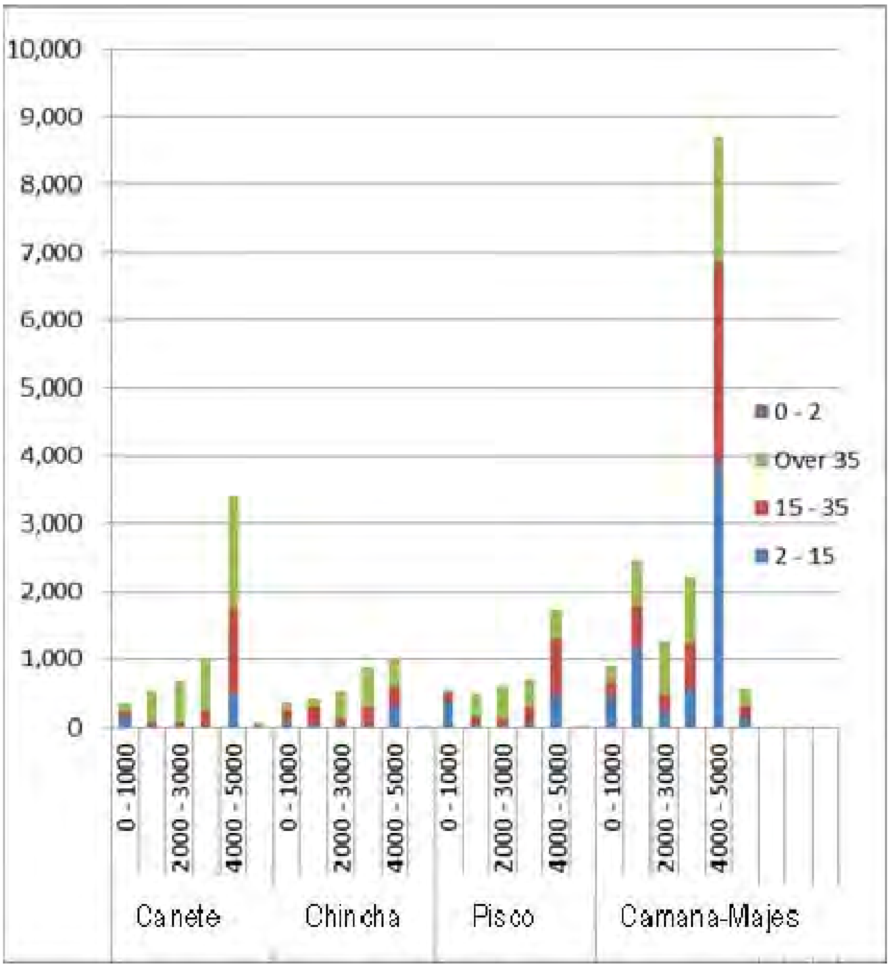


Figure 3.1.8-10 Relation between slopes and altitude in each watershed

Table-3.1.8-5 Relation between slopes and altitude in each watershed

Watershed	Slope	Altitude (m.a.s.l)												Total
		0 - 1000		1000 - 2000		2000 - 3000		3000 - 4000		4000 - 5000		5000 - More		
Cañete	0 - 2	15,51	60%	0,56	2%	0,15	1%	0,52	2%	8,88	35%	0,05	0%	25,67
	2 - 15	111,54	17%	18,13	3%	11,10	2%	35,27	5%	490,68	73%	3,26	0%	669,98
	15 - 35	101,99	6%	75,00	4%	64,27	4%	193,48	11%	1252,70	73%	21,88	1%	1709,32
	35 or more	141,11	4%	435,02	12%	604,91	17%	751,43	21%	1668,31	46%	59,99	2%	3660,77
Chincha	0 - 2	78,15	86%	0,00	0%	0,00	0%	0,00	0%	12,47	14%	0,00	0%	90,62
	2 - 15	80,09	16%	50,00	10%	47,83	10%	32,12	6%	289,52	58%	0,12	0%	499,68
	15 - 35	148,11	15%	234,91	23%	64,87	6%	256,02	25%	315,65	31%	0,21	0%	1019,77
	35 or more	129,25	8%	146,42	9%	421,58	25%	594,25	35%	401,98	24%	0,34	0%	1693,82
Pisco	0 - 2	132,09	76%	1,79	1%	2,08	1%	3,58	2%	33,74	19%	0,02	0%	173,30
	2 - 15	371,35	39%	25,01	3%	23,33	2%	67,75	7%	459,43	48%	1,51	0%	948,38
	15 - 35	118,98	8%	107,69	8%	101,38	7%	230,25	16%	856,43	60%	4,06	0%	1418,79
	35 or more	60,92	4%	373,82	22%	479,29	28%	415,34	24%	398,45	23%	3,8	0%	1731,62
Majes-Camana	0 - 2	140,95	15%	158,22	17%	14,72	2%	78,54	8%	480,22	51%	61,23	7%	140,95
	2 - 15	446,73	7%	1164,54	18%	350,89	5%	560,22	9%	3850,12	59%	128,91	2%	446,73
	15 - 35	222,03	4%	622,51	12%	399,92	8%	673,63	13%	3014,22	59%	154,69	3%	222,03
	35 or more	230,75	5%	677,32	15%	537,05	12%	993,25	22%	1823,81	40%	290,08	6%	230,75

4) Erosion characteristics

In Figure 3.1.8-11 the characteristics of the watersheds are summarized. Characteristics lower than 500m.a.s.l with scarce vegetation and rainfall correspond to “Area A.” Here, little erosion is made. Areas between 1,000 and 4,000m.a.s.l with accentuated slope, scarce vegetation and no vegetation in some others correspond to “Area B.” Here, more erosion happens despite the almost lack of rain. These areas are called Chala,Quechua and Suni. Chala(mountain area) occupies 28% of Peru, Quechua is warm area with elevation from 2,300m～3,500m, Suni is cool area with elevation from 3,000m~4,000m, and there is much rainfall and low temperature, which is covered by low trees adaptable for low temperature and with a little erosion due to gentle slope correspond to “Area C”.

Table 3.1.8-5 shows the corresponding relation between area and altitudes.

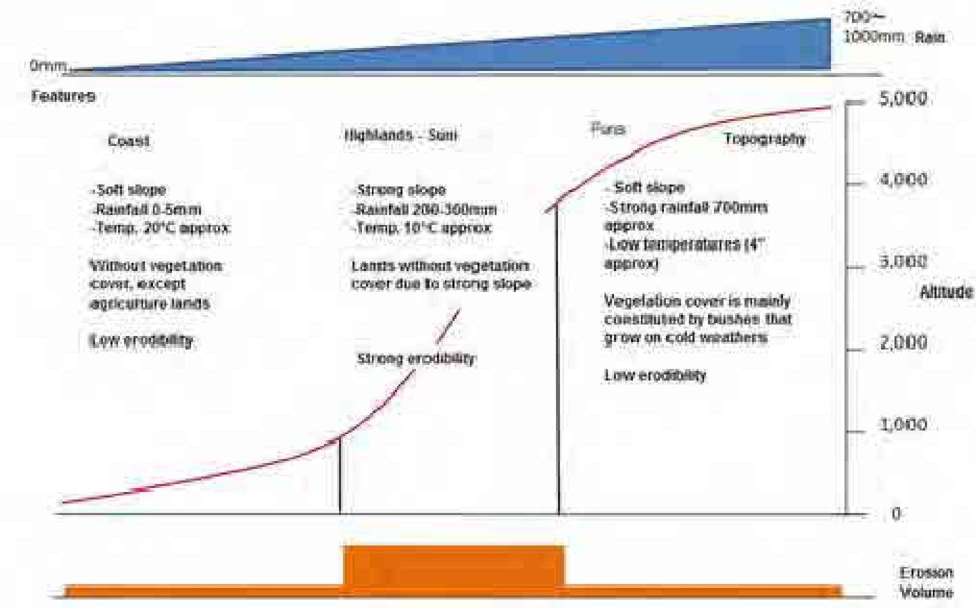


Figure 3.1.8-11 Relation between the altitudes and area

Table 3.1.8-6 Relation between the areas and altitude

Area	Cañete	Chincha	Pisco	Majes-Camana
A	0-1.000	0-1.000	0-1.000	0-1.000
B	1.000-3.500	1.000-3.500	1.000-3.500	1.000-3.000
C	3.500-5.000	3.500-5.000	3.500-5.000	3.000-5.000

(3) Production of sediments

1) Results of the field survey

It is considered that in the 3 watersheds except for Majes-Camana, similar conditions are presented because they are geographically near. Next, the results of the filed survey on Pisco, Cañete and Majes-Camana are shown.

a) Pisco and Cañete watersheds

Next, the study results are described:

- 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 3.1.8-12 and 3.1.8-13)
- There is no rooted vegetation (Figure 3.1.8-14) 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 3.1.8-15)

- 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
- In ravines, terraces are developed (of more than 10m height in Cañete and Pisco watersheds). The base of these terraces has direct contact with channels and from this spot sediments are dragged again and carried-out in ordinary flows (including small and medium overflows in rainy season)

Figure 3.1.8-12 Andesitic and balsitic soil collapsed

Figure 3.1.8-13 Sediment production of sedimentary rocks

Figura 3.1.8-14 Invasion of cactus

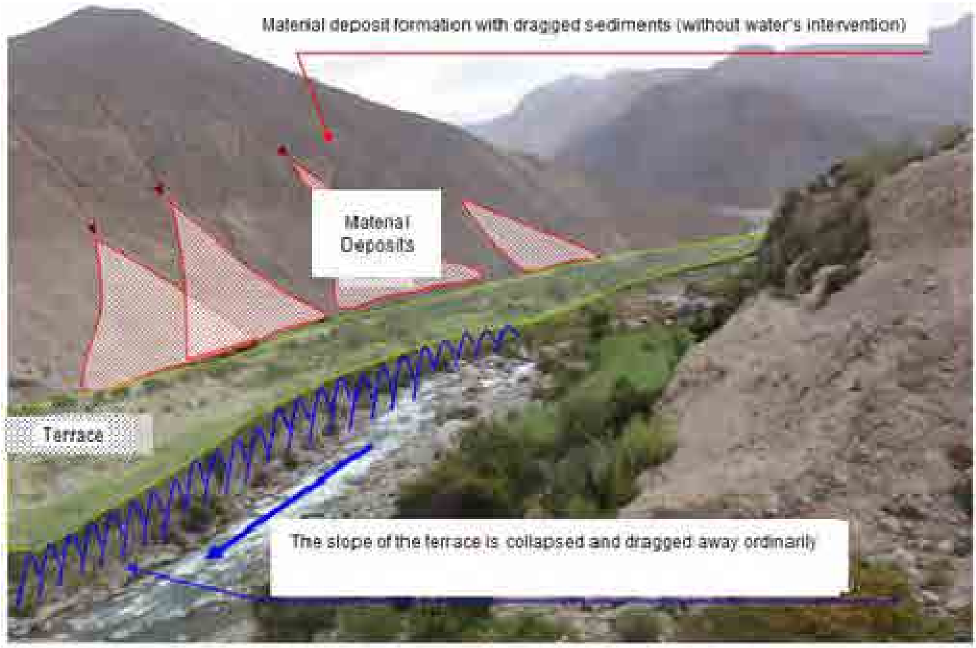


Figure 3.1.8-15 Stream sediment movement

b) Majes-Camana watershed

- The study results are described below.

  - A canyon of approximately 800 m from the soil has been formed, the river flows in the middle. The valley width is 4.2km, the river width is 400m (see Figure 3.1.8-18). It has the characteristics of a terrain setting similar that of Yauca Watershed; however, the depth and the width of Camana-Majes Watershed is larger
  - In the mountain surface there is no vegetation, the formation of clastic material deposits is observed, which are detached due to collapse or eolic erosion (See Figure 3.1.8-24)
  - The Mesozoic sedimentary rock is the main one in the production patterns, mainly due to the mechanism of fall of large amounts of gravel and eolic fracture and erosion. (see Figure 3.1.8-24)
  - In the case of the section subject of this study, the valley base width is broad (111km from the river mouth, in the intersection of Andamayo), the formation of low lands were observed in the beds. IN these places, the sediments dragged from the hillsides do not enter directly to the stream, but are deposited on the terrace. Thus, the most of sediments entering the river are probably produced by the eroded terraces deposits or accumulated sediments due to the alteration of bed (see Figure 3.1.8-24)
  - In the higher watershed, fewer terraces were observed and dragged sediments to the hillsides directly enter to the river, although in a reduced amount (see Figure 3.1.8-24)
  - According to the interviews, the situation of the sediment generation of the study section sub-watersheds is showed below. On the other hand, it was said that there was sediment entrainment from upstream silting to the flow, however, this fact was not observed

・ In the canyon, terraces have been developed; terrace bottoms are in contact with the flow channel in several points. It may be considered that the ordinary water current (including small and medium floods during rainy season) brings sediments

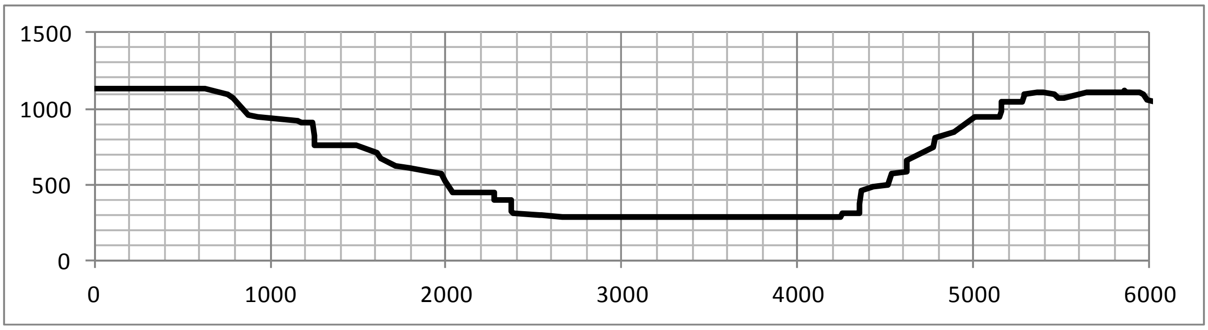


Figure 3.1.8-16 Cross-section of Majes watershed (50km approx. from the mouth)

Table 3.1.8-7 Generation of the water alluvium upstream Majes river

No	River name	Distance	Situation
1	Cosos Figure 3.1.8-11 Figure 3.1.8-12	88km approx.	In rainy season, once per month, alluvium are generated which, due to the sediment entrainment, obstruct rural (=local) highways. The situation may be restored in a day. Sometimes it affects the water pipelines.
2	Ongoro Figure 3.1.8-13	103km approx.	In 1998, an alluvium was generated, 2 persons died due to the sediment entrainment. It took one month to recover the damages in the irrigation channels. 30 minutes before, approximately 8 families listened from the mountain a sound anticipating the alluvium, which helped them to evacuate. These 8 families currently live in the same place of the disaster. The main river of the Majes river is very large and the bed has not been silted. An NGO supported the restoration of the irrigation channels.
3	San Francisco Figure 3.1.8-14	106km approx.	In 1998, an alluvium was generated, producing damages in the irrigation channels. It took one month to temporary restore it and 4 years for restoration. The amount of the alluvium with sand sediment has been 10m. high approximately.
4	Jorón Figure 3.1.8-15	106km approx.	The alluvium was generated and the sediments were entrained to the main river. The sand sediment alluvium was 10m high. It is thought it entrained 100.000 to 1.000.000 m^3 of sediments.

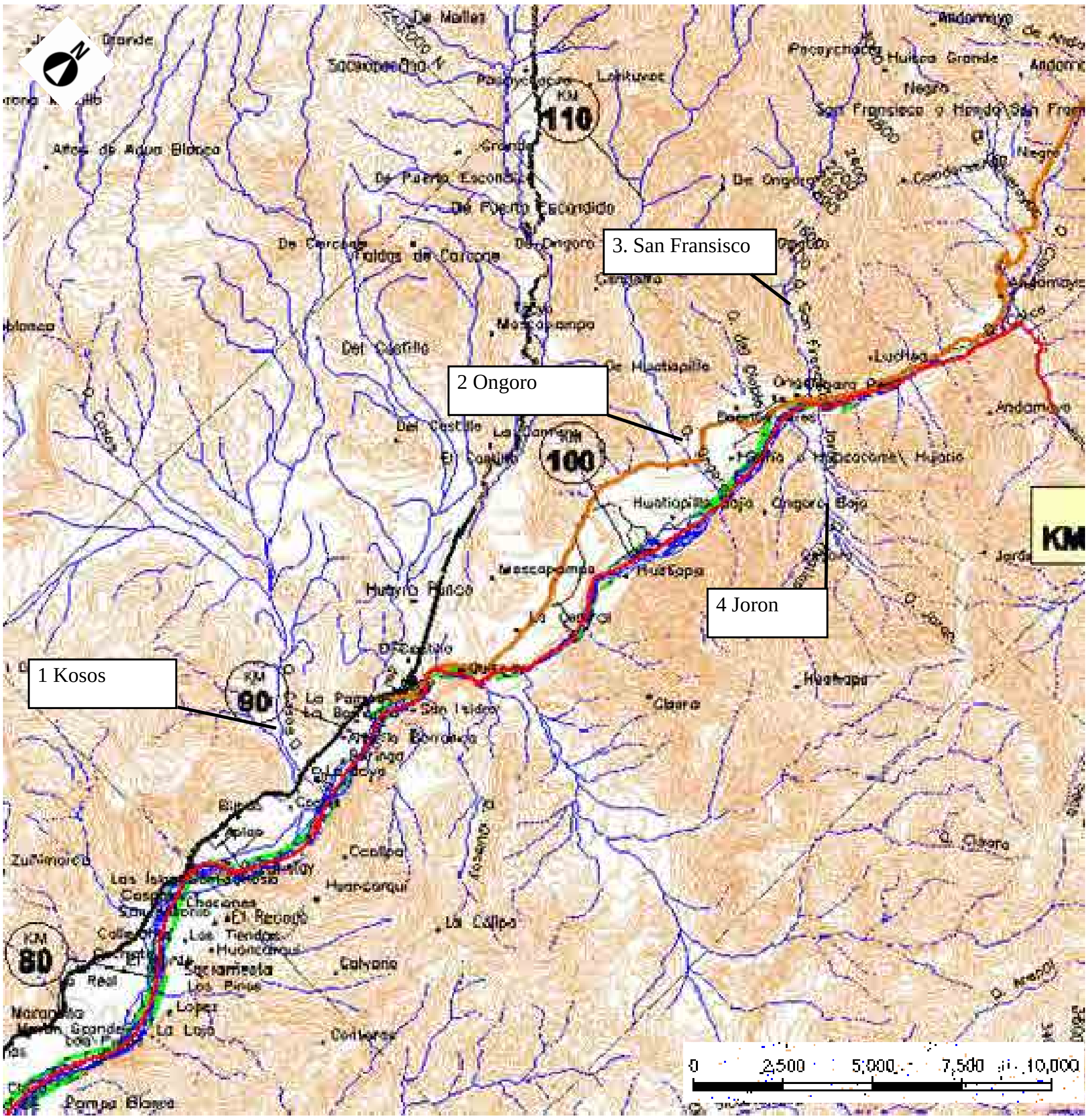


Figure 3.1.8-17 Location of the alluvium generation

Figure 3.1.8-18 Situation around Km 60 (formation of the valley approximately 5km width)

Figure 3.1.8-19 Situation of the sediment silting in Cosos river(Approx. 900m width)

Figure 3.1.8-20 Rural (=local) highway crossing the Cosos river (in rainy season the sediments cover the rural highway, however, it is restored in a day)

Figure 3.1.8-21 Situation of Ongoro (in 1998, 2 persons died due to the alluvium)

Figure 3.1.8-22 Situation of the sediment deposition in the San Francisco river (obstruction of irrigation channels due to the disaster. The walls of the highway are the soil and sand sediments at that time)

Figure 3.1.8-23 Situation of Jorón river (alluvium sediments arrived up to the main river in 1998)

Figure 3.1.8-24 Situation around the Km110 mouth (It may be deduced that there is low affluence of sediments from hillsides to the river channel)

Figure 3.1.8-25 Intersection of the Camana river and Andamayo river (Andamayo river is an overflow channel)

2） Relation of the damages by sediment and rainfall

In 1998, several damages were produced due to sediments in the Camana-Majes watershed. Due to that, a rainfall study was made on 1998. The rainfall data is obtained by the hydrographic analysis of Annex 1 of the Support Report. The pluviometric stations closest to the where the sediments were identified were verified (Table 3.1.8-8), thus obtaining the information of years with probability of higher rainfall and the larger amount of rain days on 1998, as shown in Table 3.1.8-9. In Chuquibamba 15 year rainfall precipitation data have been observed, in Pampacola, 25 years, in Aplao and Huambo only 2 years.

In general, during the powerful El Niño Phenomenon of 1982-1983 and 1998, has occurred almost every 50 years[2], it considered 50 year rainfall; therefore, it was determined that the sediment damages were due to these rainfall.

Table 3.1.8-8 List of pluviometric station to check rainfall

	Coordinates		
Station	**Latitude**	**Length**	**Altitude (m.a.s.l)**
Aplao	16%l 04'10	72%l 29'26	625
Chuquibamba	15%l 50'17	72%l 38'55	2839
Huambo	15%l 44'1	72%l 06'1	3500
Pampacolca	15%l 42'51	72%l 34'3	2895

Table 3.1.8-9 Probability of rainfall in every pluviometric station and the larger amount of rainfall per day in 1998

Station	Rainfall for T (years)							Rainfall in
	2	**5**	**10**	**25**	**50**	**100**	**200**	**1998**
Aplao	1,71	5,03	7,26	9,51	10,71	11,56	12,14	1,20
Chuquibamba	21,65	36,96	47,09	59,89	69,39	78,82	88,21	82,00
Huambo	22,87	30,14	34,96	41,05	45,57	50,05	54,52	25,30
Pampacolca	21,13	29,11	34,40	41,08	46,04	50,95	55,86	42,40

[2] (Source) Lorenzo Huertas DILUVIOS ANDINOS A TRAVÉS DE LAS FUENTES DOCUMENTALES - COLECCIÓN CLÁSICOS PERUANOS 05/2003

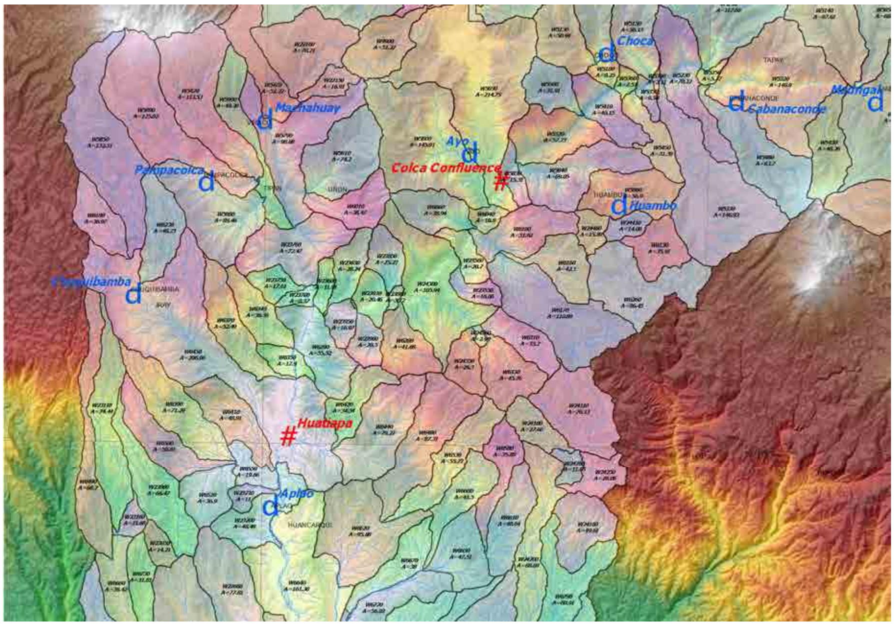


Figure 3.1.8-26 Location of the pluviometric station

(4) 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.

1) An ordinary year

Figure 3.1.8-27 presents production and discharge sediment data in ordinary time:

- 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

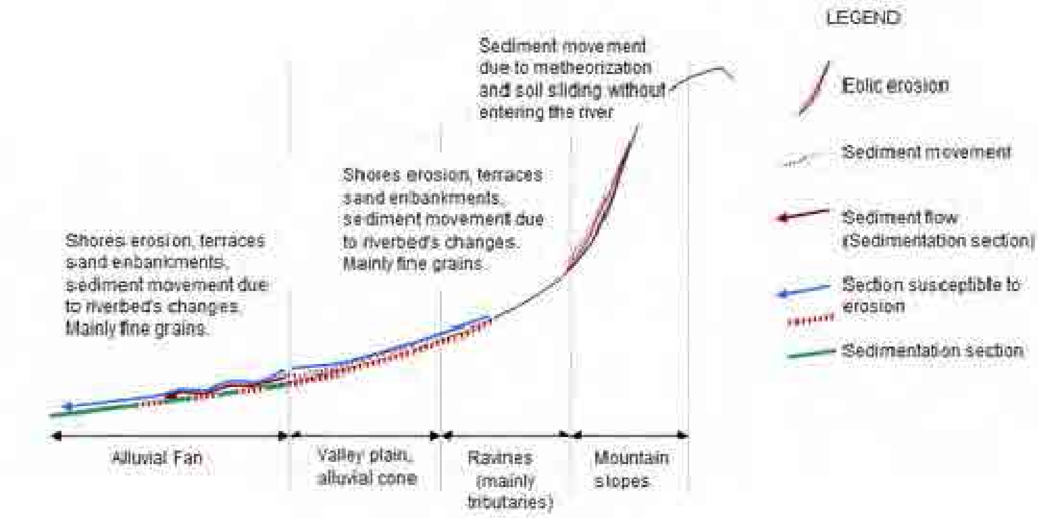


Figure 3.1.8-27 Production and entrainment of sediments in an ordinary year

2) When torrential rains with a 50 year return period occur

Pursuant to the interviews performed in the locality, every time El Niño phenomenon occurs the tributary debris flow occurs. However, since the bed has enough capacity to regulate sediments, the influence on the lower watershed is reduced. The production of sediment in El Niño phenomenon is as shown in the Figure-3.1.8-28. 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

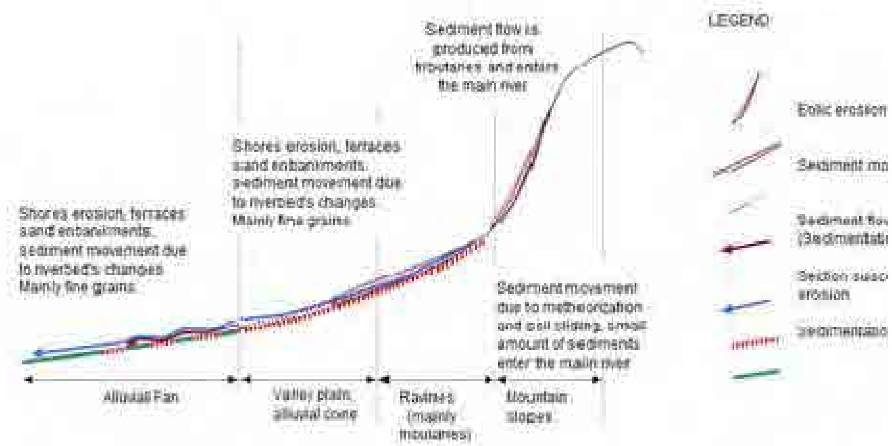


Figure 3.1.8-28 Production and entrainment of sediments during torrential rainfall with a 50 year return period

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

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

If we suppose that rainfall occurs with extremely low possibilities, for example, once a few thousands year we estimate that the following situation would happen (see Figure 3.1.8-29).

- 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.

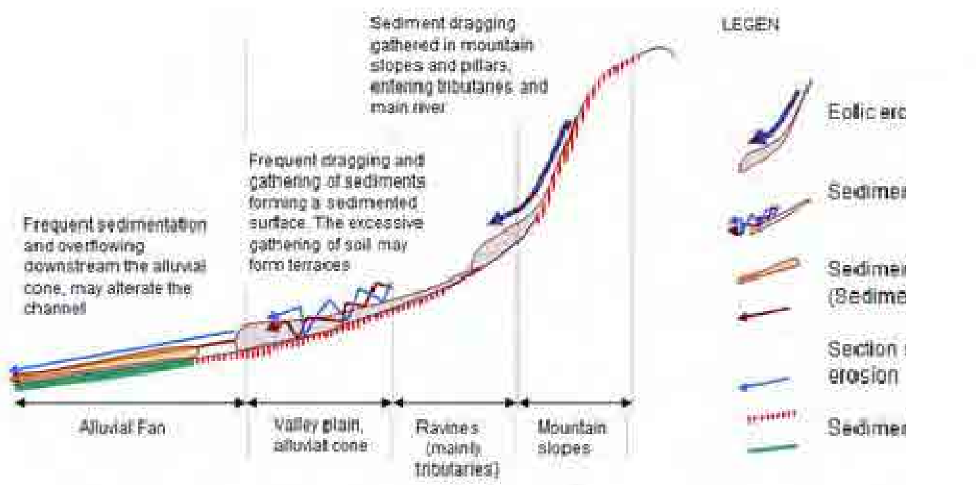


Figure 3.1.8-29 Production of sediments in large overflowing (geologic scale)

(5) Approach of this study

The approach of this Study is focused in rain with 50 year return periods, as indicated in the next Figure, which is equivalent to the precipitations that produce sediment flow from tributaries.

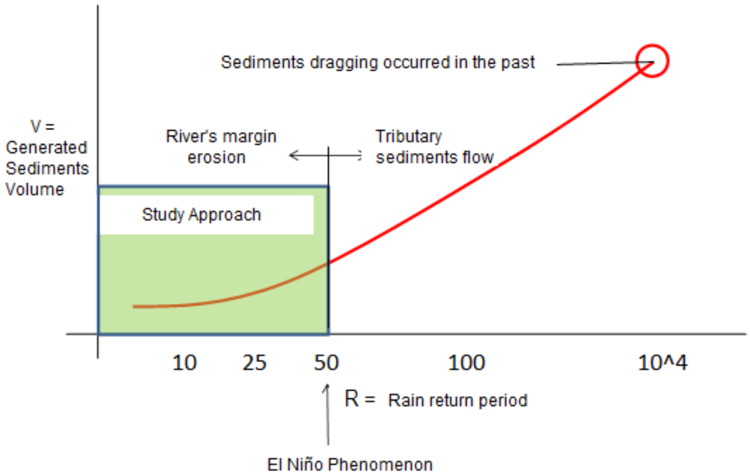


Figure 3.1.8-30 Relation between sediments production and return period of rain

3.1.9 Run-off Analysis

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

3.1.9.1 Rainfall

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

(1) Cañete river

1) Conditions of rainfall observation

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

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

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

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

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

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

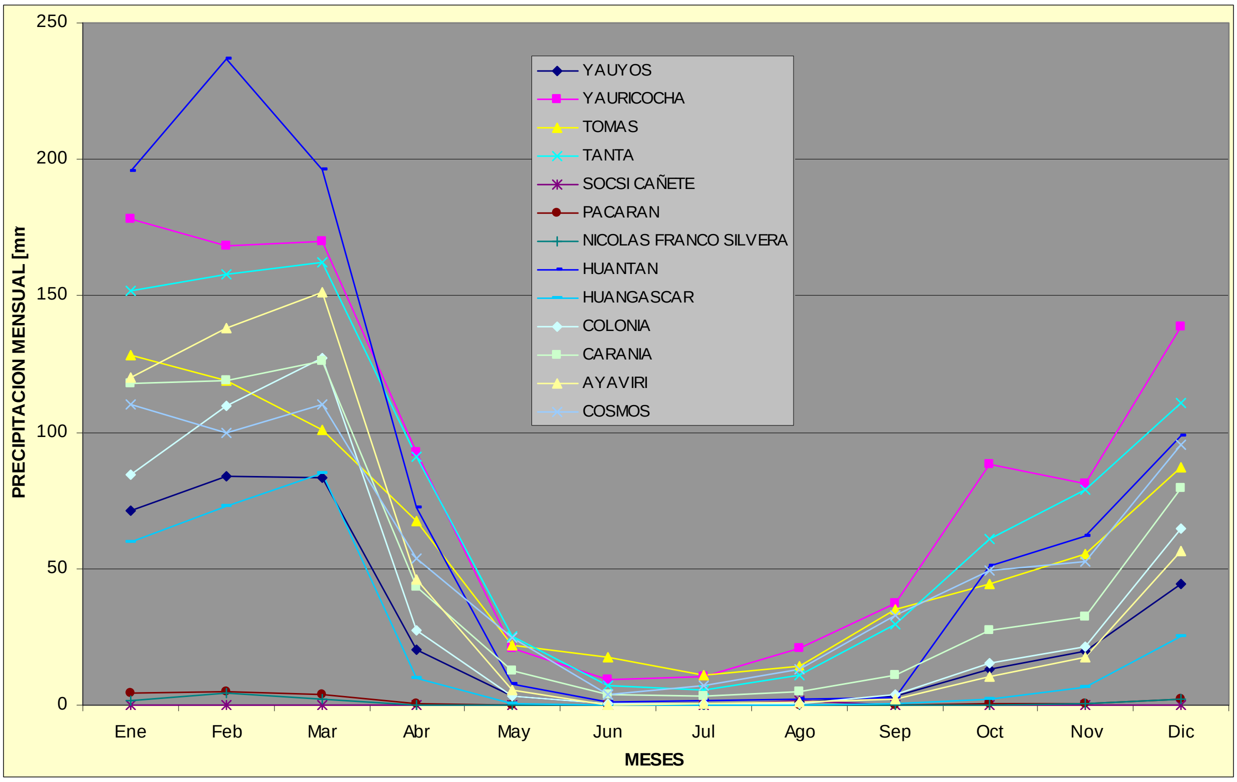
2) Monthly rainfall

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

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

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

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



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

3) Yearly Maximum of 24-hour Rainfall

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

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

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

4) Isohyetal map of yearly average rainfall

The isohyetal map of yearly average rainfall in Cañete basin is as shown in the Figure-3.1.9.1-3.

There is big difference in the yearly rainfall data by areas in Cañete basin, for instance yearly rainfall is less than 25mm in the minimum , on the other hand 750mm in the maximum, and the amount is small in the downstream area and becomes large toward the upstream with higher elevation.

In the objective section for flood protection, the yearly rainfall is not so much from 25～50mm.

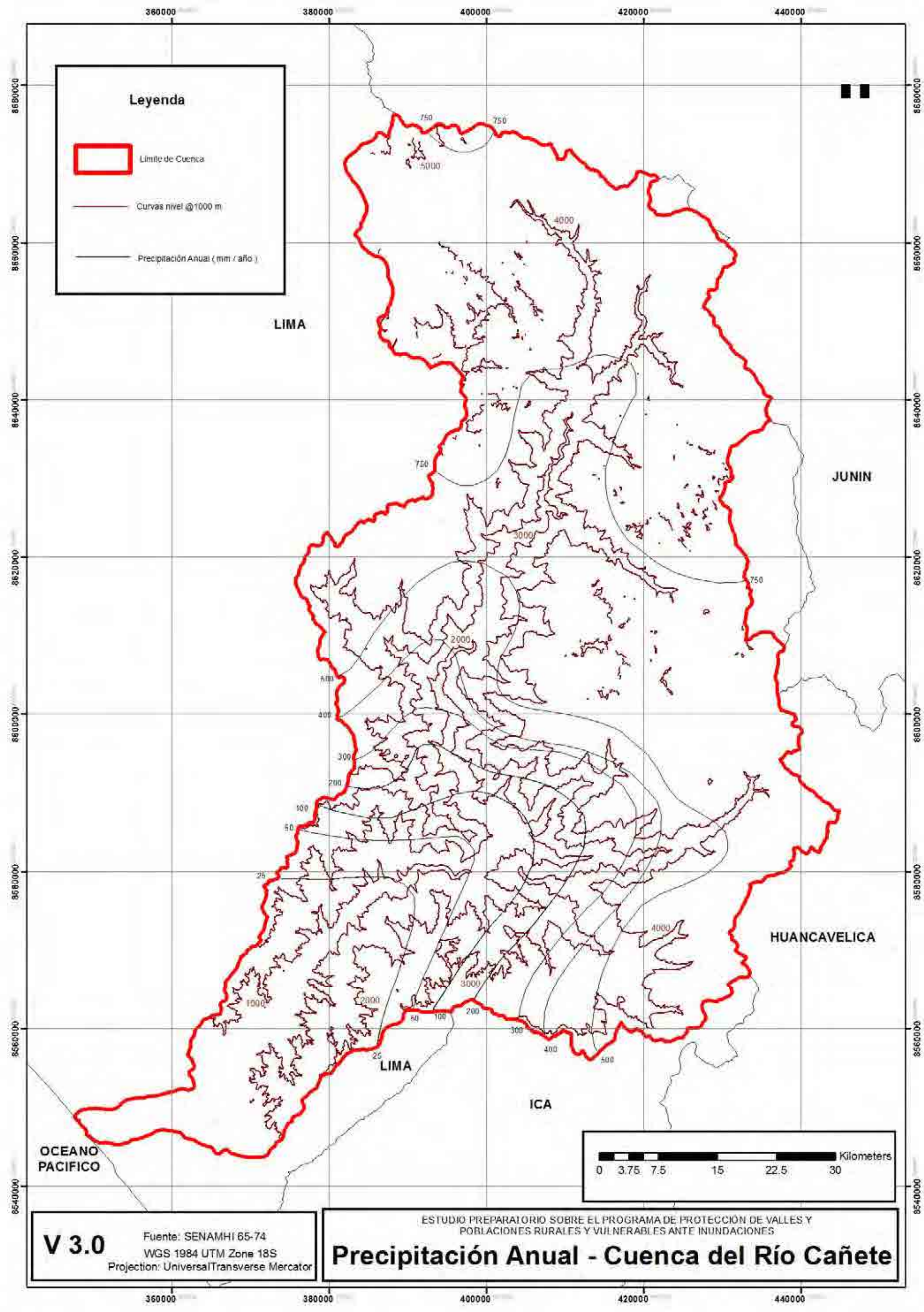


Figure-3.1.9.1-3 Isohyetal map of yearly rainfall (Cañete basin)

(2) Chincha river

1) Conditions of rainfall observation

The rainfall observation stations and their observation period in Chincha basin are as shown in the Table-3.1.9.1-5～ Table-3.1.9.1-6 and the Figure-3.1.9.1-4.

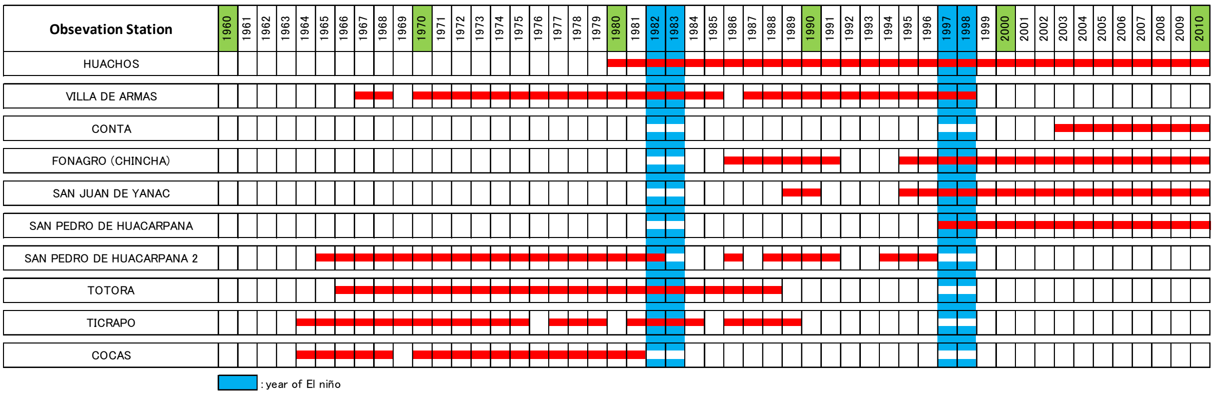
In Chincha basin, the rainfall has been observed in 14 stations, and the longest observation period is

31 years from 1980 to 2010.

Table-3.1.9.1-5 Rainfall observation station (Chincha river)

Code No.	Observation Station	Region	Londitude	Latitude	Responsible Agency
203501	CONTA	Ica	75°58′	13°27′	Water Users committee
130791	FONAGRO	Ica	76°08′	13°28′	
156114	SAN JUAN DE CASTROVIRREYNA	Huancavelica	75°38′	13°12′	
156113	SAN JUAN DE YANAC	Ica	75°47′	13°13′	
151503	HUACHOS	Huancavelica	75°32′	13°14′	SENAMHI
110641	VILLA DE ARMAS	Huancavelica	75°22′	13°08′	
156115	SAN PEDRO DE HUACARPANA	Ica	75°39′	13°03′	
156129	LAGUNA HUICHIN	Huancavelica	75°34′	13°02′	
110633	TANTARA	Huancavelica	75°37′	13°14′	
110631	CHUNCHO	Lima	75°57′	12°45′	Water Users committee
110650	BERNALES	Ica	75°57′	13°45′	
110639	HUANCANO	Ica	76°37′	13°36′	SENAMHI
110643	TICRAPO	Huancavelica	75°26′	13°23′	
110644	TOTORA	Huancavelica	75°19′	13°08′	

Table-3.1.9.1-6 Observation period of rainfall data (Chincha river)



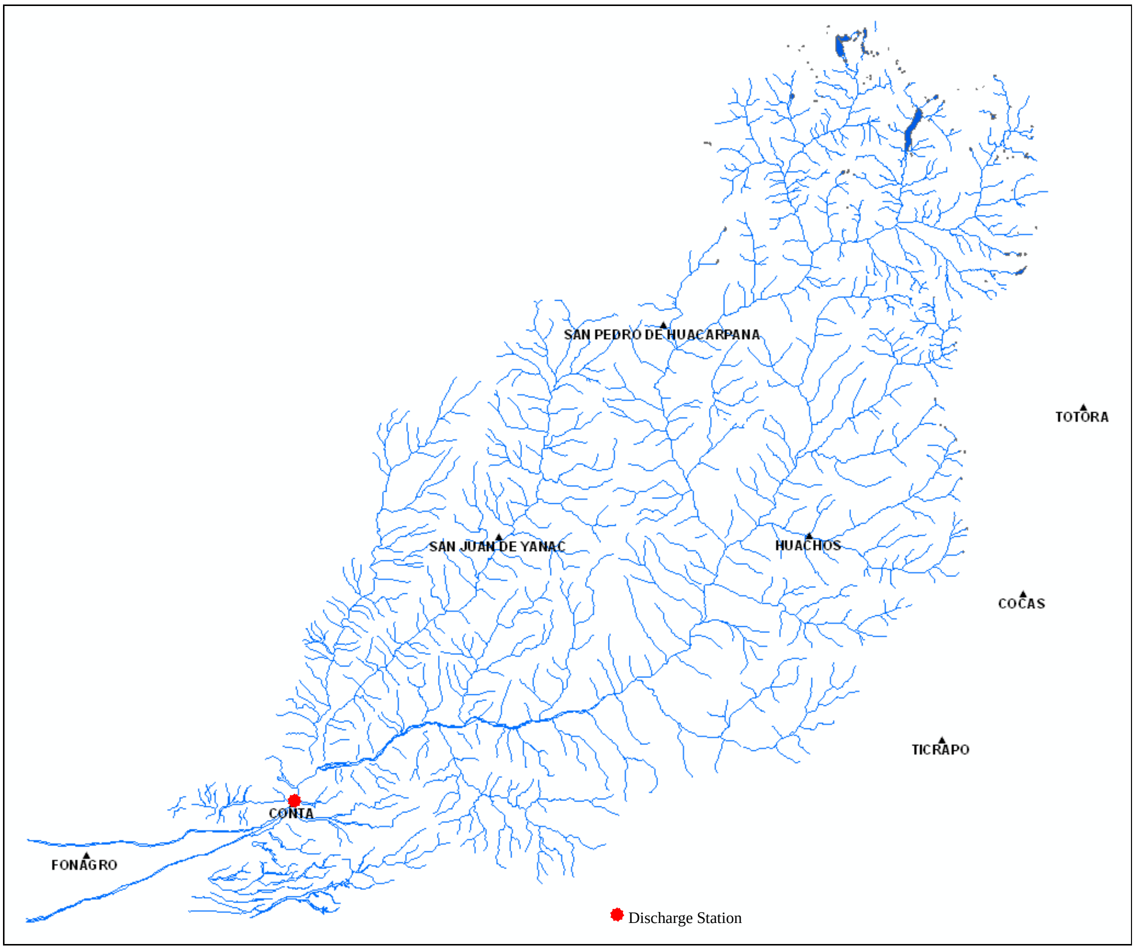


Figure-3.1.9.1-4 Location of rainfall and discharge observation station (Chincha river)

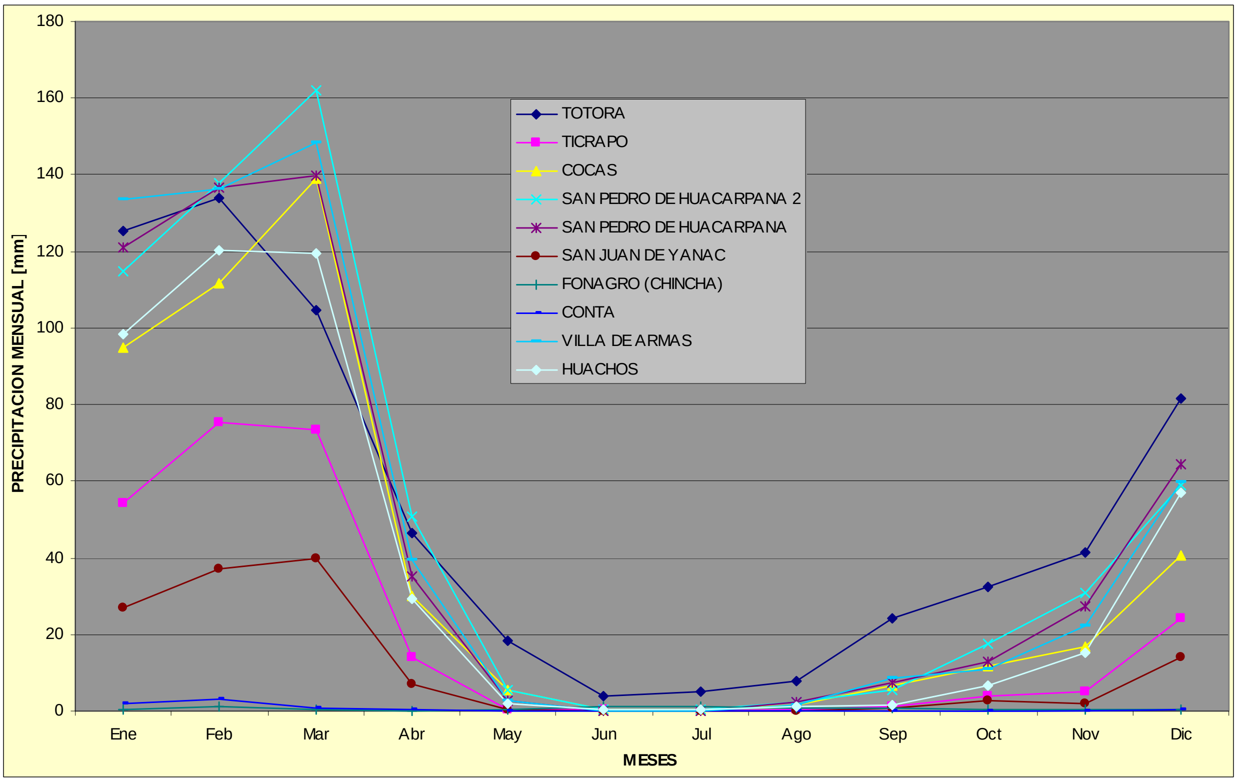
2) Monthly rainfall

The average monthly rainfall and its distribution of each station in Chincha basin are as shown in Table-3.1.9.1-6 and the Figure-3.1.9.1-5.

According to the Table and the Figure, the monthly rainfall is large from October to April and extremely small from May to September. And the yearly rainfall varies from 6.95mm in Conta to 625.95mm in Totora .

Table－3.1.9.1-6 Average monthly rainfall in Chincha basin and adjacent basin (mm)

Observation Station	Month												Total
	Jan.	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	
TOTORA	125.39	133.76	104.56	46.33	18.20	4.07	4.90	7.76	24.24	32.59	41.47	81.67	624.95
TICRAPO	54.24	75.45	73.35	14.10	0.44	0.20	0.03	0.45	0.98	3.99	5.05	24.32	252.60
COCAS	94.93	111.50	138.93	29.87	5.31	0.26	0.36	1.54	6.70	11.83	16.61	40.73	458.57
SAN PEDRO DE HUACARPANA 2	114.93	137.80	161.96	50.64	5.30	0.38	0.23	2.25	5.51	17.68	30.93	58.94	586.56
SAN PEDRO DE HUACARPANA	121.19	136.68	139.80	34.99	2.64	0.00	0.04	2.53	7.24	12.94	27.45	64.52	550.02
CHINCHA DE YANAC	27.03	37.28	39.98	6.97	0.27	0.00	0.10	0.02	0.76	2.81	2.11	14.08	131.41
FONAGRO (CHINCHA)	0.42	1.08	0.34	0.07	0.48	1.23	1.34	0.83	0.68	0.38	0.21	0.56	7.60
CONTA	1.84	3.24	0.81	0.31	0.01	0.03	0.06	0.04	0.05	0.18	0.14	0.24	6.95
VILLA DE ARMAS	133.69	136.26	148.26	39.55	2.82	0.00	0.01	1.57	8.52	10.84	22.17	59.92	563.61
HUACHOS	98.45	120.27	119.57	29.42	1.90	0.23	0.25	1.01	1.73	6.74	15.33	57.08	451.98



Figure－3.1.9.1-5 Distribution of average monthly rainfall in Chincha basin and adjacent basin (mm)

3) Yearly maximum of 24-hour rainfall

The yearly maximum of 24-hour rainfall (daily rainfall) of each observation station in Chincha basin is as shown in the Table-3.1.9.1-7.

Table-3.1.9.1-7 Yearly maximum of 24-hour rainfall (daily rainfall) in chincha basin (mm)

Year	TOTORA	TICRAPO	COCAS	SAN PEDRO DE HUACARPANA 2	SAN PEDRO DE HUACARPANA	SAN JUAN DE YANAC	FONAGRO (CHINCHA)	CONTA	VILLA DE ARMAS	HUACHOS
1964		21.5	19.8							
1965	24.0	20.7	21.6	15.0						
1966	15.0	12.6	20.2	5.2						
1967	24.0	24.4	36.0	31.0					59.6	
1968	20.0	10.0		16.0						
1969	22.0	35.8		24.5						
1970	23.0	40.2	22.1	24.5					24.9	
1971	21.0	28.4	29.4	20.0					31.0	
1972	27.0	32.0	30.8	26.0		12.8			29.6	
1973	25.0	44.3	36.8	21.1					42.4	
1974	22.0	14.0	20.6	14.5		8.2			36.0	
1975	19.0	19.5	22.4	22.5		10.3			35.8	
1976	20.0	25.5	21.4	17.0					38.0	
1977	25.0	24.0	20.6	15.0					36.2	
1978	20.0	5.4	14.4	26.0					61.8	
1979	25.0	18.0	27.4	32.0					27.4	
1980	35.0	24.1		19.5					43.0	33.2
1981	29.0	33.0	0.0	32.0					35.2	20.8
1982	29.0	10.9		18.0					30.0	25.8
1983	24.0	30.0							11.8	19.9
1984	37.0	20.8							11.8	29.2
1985	30.0	18.0							20.8	25.5
1986	27.0	26.8		24.0			0.3		20.0	28.5
1987	13.0						0.2		19.0	20.1
1988	25.0			32.0			0.7		20.0	33.5
1989				27.0		6.8	3.0		10.8	19.8
1990				24.0		5.5	2.0		20.0	23.2
1991				33.0					28.0	24.3
1992										
1993				23.0					26.0	
1994				30.0					21.4	26.1
1995				25.0		10.3	2.3		28.4	23.1
1996						0.4	0.9		48.6	25.4
1997					23.6	2.5	0.8		30.4	16.2
1998					25.0	11.3	1.5			38.5
1999					28.0	15.9	6.0			41.6
2000					24.2	14.0	1.5			20.5
2001					24.2	9.7	1.1			23.8
2002					30.0	14.6	1.1			37.0
2003					20.6	9.5	0.5	0.6		15.2
2004					28.7	7.2	1.2	0.4		44.2
2005					16.0	16.5	0.9	1.0		28.6
2006					27.8	37.4	3.2	6.0		25.6
2007					16.0	14.2	1.0	4.0		20.5
2008					22.6	14.7	1.9	0.8		23.8
2009					16.4	15.9	2.2	0.3		
2010						23.8				

4) Isohyetal map of yearly average rainfall

The isohyetal map of yearly average rainfall in Chincha basin is as shown in the Figure-3.1.9.1-6.

There is big difference in the yearly rainfall data by areas in Chincha basin, for instance yearly rainfall is less than 25mm in the minimum , on the other hand 900mm in the maximum, and the amount is small in the downstream area and becomes large toward the upstream with higher elevation.

In the objective section for flood protection, the yearly rainfall is almost nil, only 25mm.

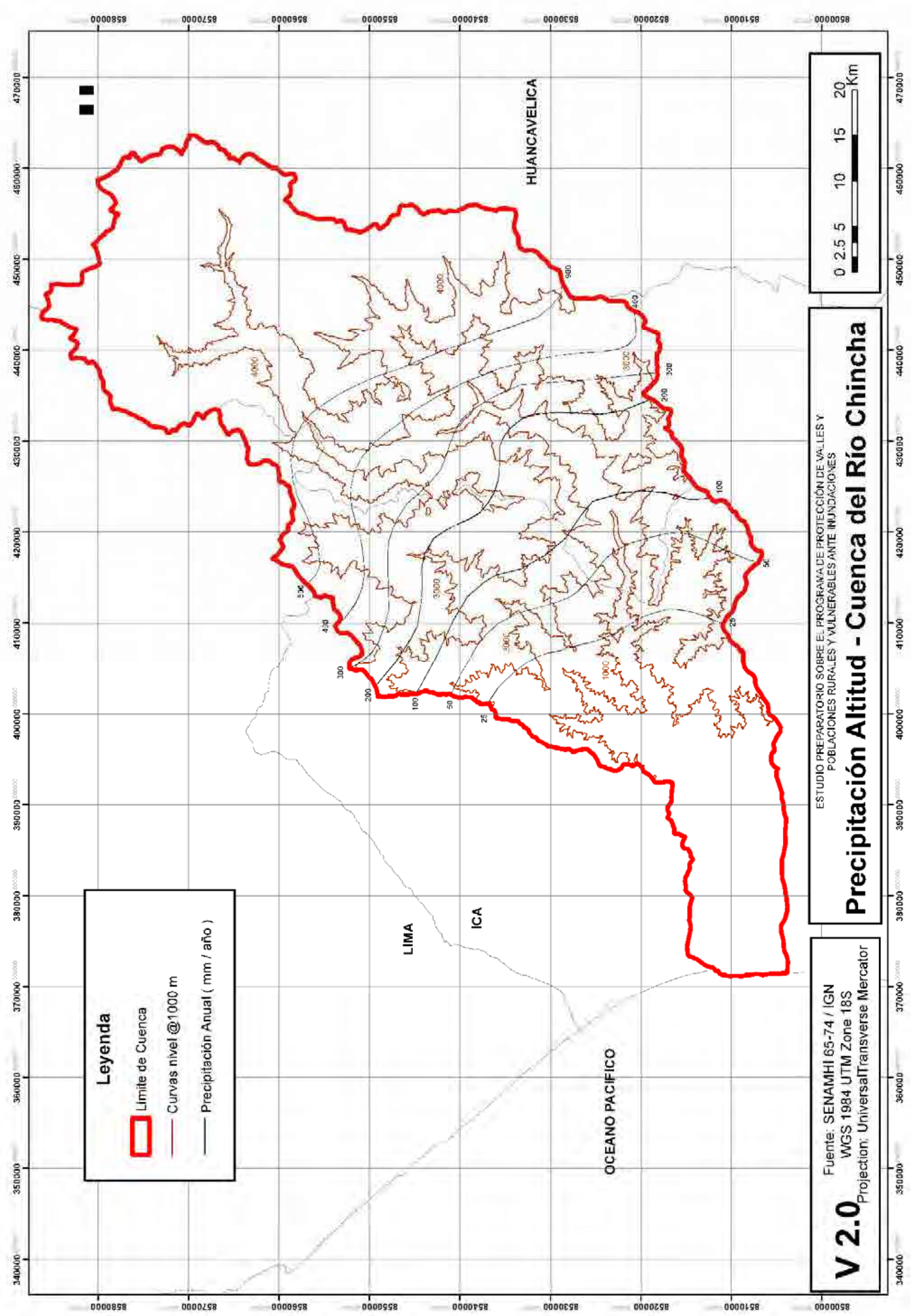


Figure-3.1.9.1-6 Isohyetal map of yearly rainfall(Chincha basin)

(3) Pisco river

1) Conditions of rainfall observation

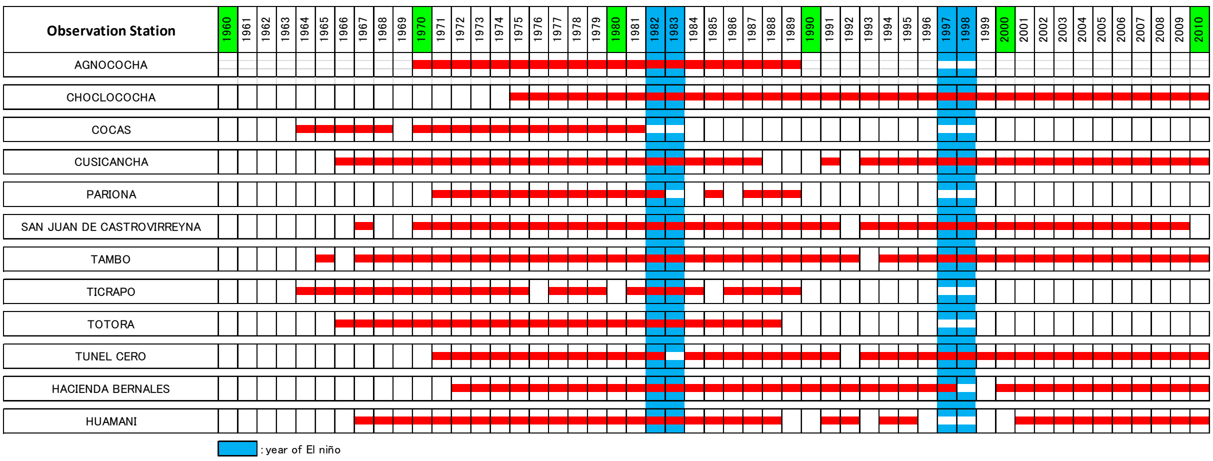
The rainfall observation stations and their observation period in Pisco basin are as shown in the Table-3.1.9.1-8～ Table-3.1.9.1-9 and the Figure-3.1.9.1-7.

In Pisco basin, the rainfall has been observed in 20 stations, and the longest observation period is 39 years from 1964 to 2002.

Table-3.1.9.1-8 Rainfall observation station (Pisco river)

Code No.	Observation Station	Region	Londitude	Latitude	Responsible Agency
646	ACNOCOCHA	HUANCAVELICA	75° 05'1	13° 13'1	
156130	CHOCLOCOCHA	HUANCAVELICA	75° 02'1	13° 06'1	
643	COCAS	HUANCAVELICA	75° 22'1	13° 16'1	
156121	CUSICANCHA	HUANCAVELICA	75° 18'18	13° 29'29	
156131	PARIONA	HUANCAVELICA	75° 04'1	13° 32'1	
156114	SAN JUAN DE CASTROVIRREYNA	HUANCAVELICA	75° 38'38	13° 12'12	SENAMHI
156122	TAMBO	HUANCAVELICA	75° 16'16	13° 41'41	
156117	TICRAPO	HUANCAVELICA	75° 26'1	13° 23'1	
156119	TOTORA	HUANCAVELICA	75° 19'1	13° 07'1	
647	TUNEL CERO	HUANCAVELICA	75° 05'5	13° 15'15	
650	HACIENDA BERNALES	ICA	75° 57'57	13° 45'45	
640	HUAMANI	ICA	75° 35'35	13° 50'50	

Table-3.1.9.1-9 Observation period of rainfall data (Pisco river)



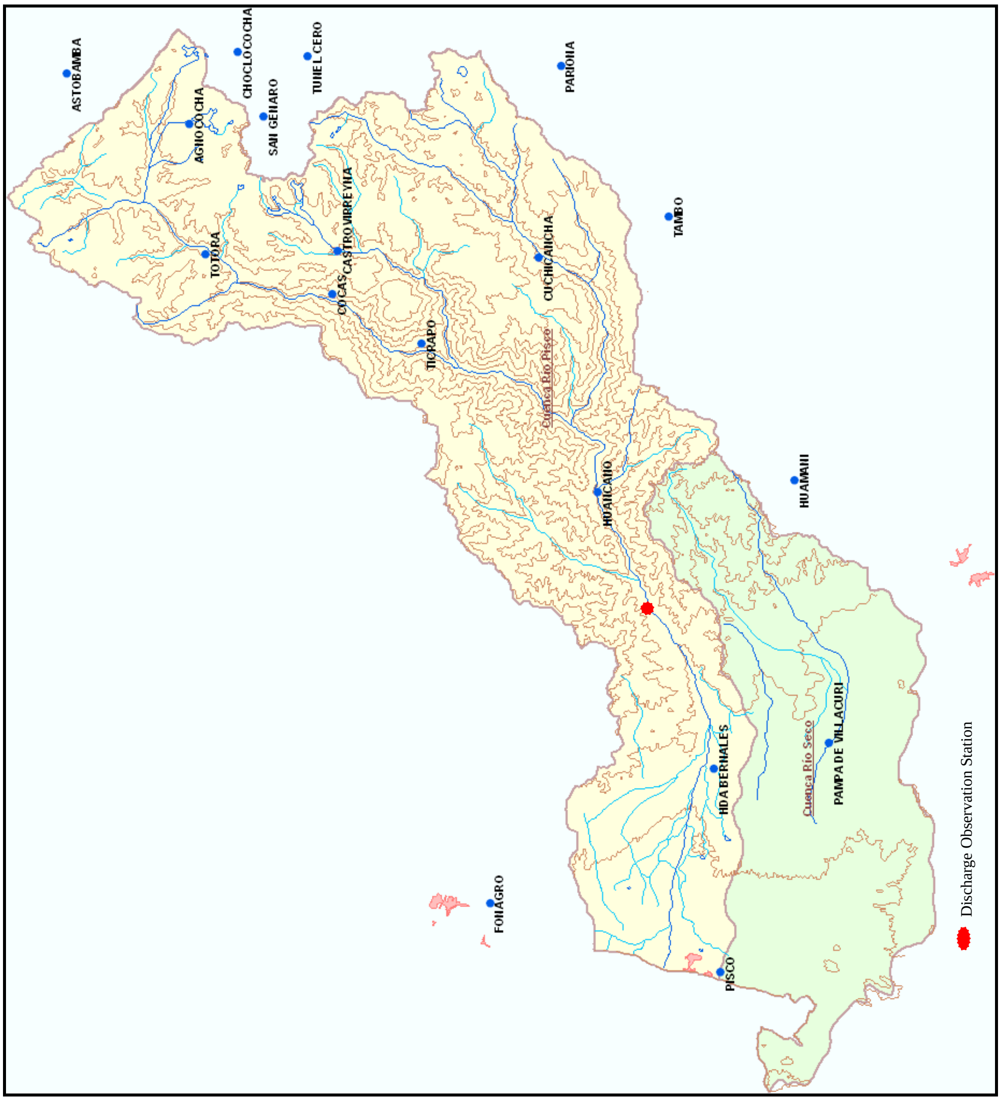


Figure-3.1.9.1-7 Location of rainfall and discharge observation station (Pisco river)

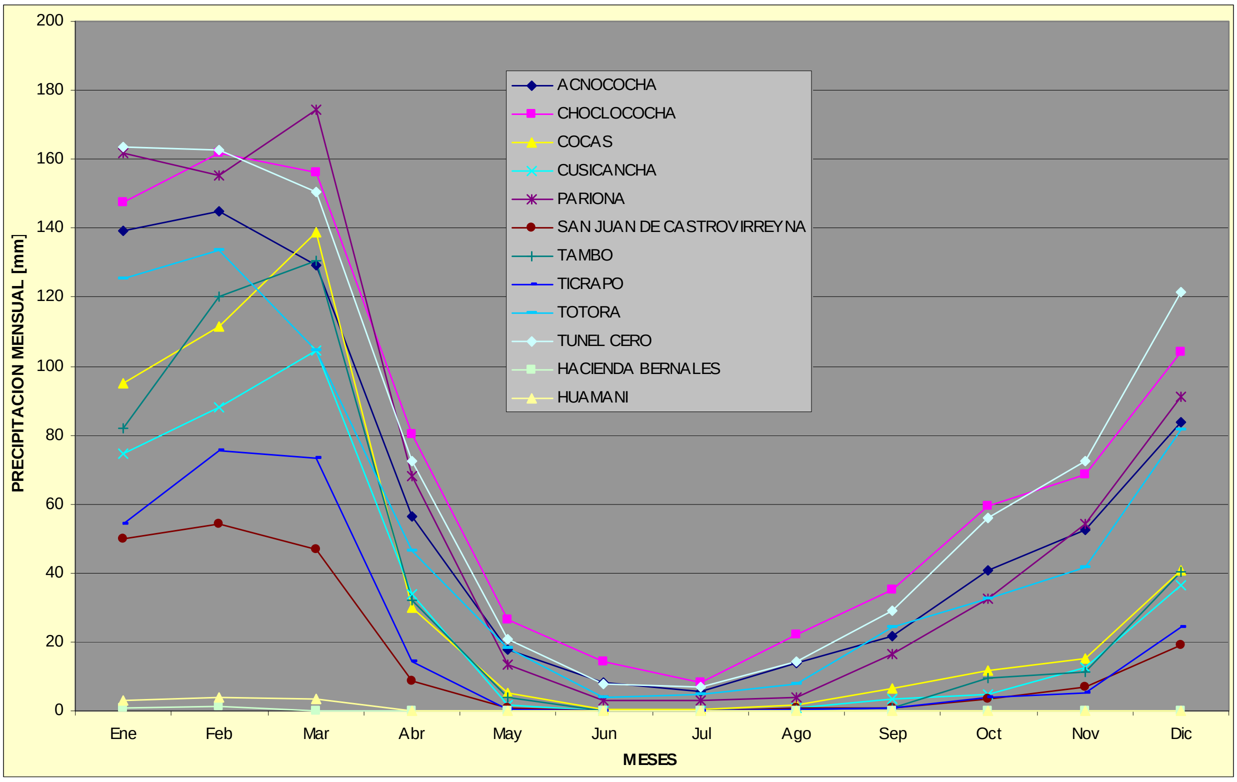
2) Monthly rainfall

The average monthly rainfall and its distribution of each station in Pisco basin are as shown in Table-3.1.9.1-10 and the Figure-3.1.9.1-8.

According to the Table and the Figure, the monthly rainfall is large from October to April and extremely small from May to September. And the yearly rainfall varies from 2.93mm in Hacienda Bernales to 884mm in Choclococha .

Table－3.1.9.1-10 Average monthly rainfall in Chincha basin and adjacent basin (mm)

Observation Station	Month												Total
	Jan.	Feb	Mar	Apr	May	June	Juyl	Aug.	Sep	Oct	Nov	Dec	
ACNOCOCHA	139.08	145.04	129.35	56.57	17.74	8.18	5.65	13.73	21.69	40.59	52.30	83.59	713.51
CHOCLOCOCHA	147.66	161.73	156.09	80.13	26.52	14.25	8.03	22.18	35.24	59.48	68.69	103.97	883.97
COCAS	94.93	111.50	138.93	29.87	5.31	0.26	0.36	1.54	6.70	11.83	15.36	40.73	457.31
CUSICANCHA	74.40	88.26	104.57	33.77	1.74	0.00	0.01	0.71	3.48	4.85	12.38	36.37	360.55
PARIONA	161.82	155.42	174.45	68.15	13.61	3.06	3.12	4.02	16.39	32.52	54.23	90.91	777.70
SAN JUAN DE CASTROVIRREYNA	49.69	54.27	46.95	8.78	0.96	0.09	0.17	0.67	0.95	3.50	7.06	19.24	192.34
TAMBO	82.19	120.28	130.42	32.03	3.95	0.00	0.12	0.51	0.88	9.53	11.48	40.40	431.78
TICRAPO	54.24	75.45	73.35	14.10	0.44	0.20	0.03	0.45	0.98	3.99	5.05	24.32	252.60
TOTORA	125.39	133.76	104.56	46.33	18.20	4.07	4.90	7.76	24.24	32.59	41.47	81.67	624.95
TUNEL CERO	163.61	162.53	150.68	72.29	20.96	7.59	6.98	14.51	29.20	56.12	72.29	121.55	878.32
HACIENDA BERNALES	0.84	1.50	0.05	0.03	0.07	0.14	0.08	0.08	0.02	0.01	0.03	0.09	2.93
HUAMANI	3.08	3.75	3.45	0.05	0.00	0.00	0.01	0.00	0.08	0.00	0.00	0.17	10.60



Figure－3.1.9.1-8 Distribution of average monthly rainfall in Pisco basin and adjacent basin (mm)

3) Yearly maximum of 24-hour rainfall

The yearly maximum of 24-hour rainfall (daily rainfall) of each observation station in Pisco basin is as shown in the Table-3.1.9.1-11.

Table-3.1.9.1-11 Yearly maximum of 24-hour rainfall (daily rainfall) in Pisco basin (mm)

Year	ACNOCOCHA	CHOCLOCOCHA	COCAS	CUSICANCHA	PARIONA	SAN JUAN DE CASTROVIRREYNA	TAMBO	TICRAPO	TOTORA	TUNEL CERO	HACIENDA BERNALES	HUAMANI
1964			19.8					21.5				
1965			21.6				35.0	20.7				
1966			20.2	18.7				12.6	15.0			
1967			36.0	23.5		20.1		24.4	24.0			25.5
1968				12.3			24.0	10.0	20.0			0.0
1969				23.0				35.8	22.0			1.6
1970			22.1	25.3		33.3	13.3	40.2	23.0			33.5
1971	32.3		29.4	28.6		13.7	18.2	28.4	21.0	30.7		1.7
1972	29.2		30.8	26.9	40.0	28.0	30.7	32.0	27.0	28.2	29.5	18.8
1973	24.6		36.8	13.1	37.8	23.0			25.0	34.6	1.6	2.1
1974	31.1		20.6	9.7	36.9	12.1	21.0	14.0	22.0	24.2	0.0	4.1
1975	24.1	27.4	22.4	6.6	39.1	17.0	42.4	19.5	19.0	29.2	0.0	23.0
1976	26.4	36.1	21.4	6.6	34.4	17.2	40.0		20.0	22.8	20.8	12.5
1977	26.9		20.6	24.2	29.7	15.5	20.5	24.0	25.0	31.3	0.0	0.0
1978	28.1	22.9	14.4	20.0	20.6	7.8	32.0	5.4	20.0	19.5	0.6	0.0
1979	22.3	15.4	27.4		25.4	21.6	20.4	18.0	25.0	33.2	0.0	0.2
1980	23.0	14.8		19.0	44.4	40.0	21.2		35.0	27.3	0.0	0.3
1981	22.6	13.5	0.0	20.0	28.5		25.6	33.0	29.0	35.9		0.0
1982	32.1			10.1		17.1	15.7	10.9	29.0	52.2		0.0
1983	30.1	26.5		5.0		28.0	35.0	30.0	24.0		0.0	0.0
1984	28.7			20.0		24.0	40.0	20.8	37.0	38.3	0.0	0.4
1985	26.5	19.0		11.0	26.5	11.5	30.0	18.0	30.0	22.7	0.0	7.5
1986	29.2	36.0				14.7	30.0		27.0	35.3	0.0	
1987	22.4	24.4			14.8	12.3	20.0		13.0	23.1	0.0	0.0
1988	26.9	39.1			28.0	13.5	17.0			27.8	0.0	
1989	20.3					31.8	36.7			31.9	0.0	0.0
1990		39.5				13.1	29.0			54.5	0.0	
1991						11.0	40.0				0.0	0.0
1992												
1993		39.3				13.7				36.5	0.0	
1994		37.3				12.3	22.0			30.5	0.0	
1995		28.1				12.0	43.2			26.2	0.0	
1996		35.9				19.2	42.0			27.3	0.0	
1997		67.5				10.5	30.0			21.6	0.0	
1998		55.5				37.9	40.0			25.1	0.0	
1999		34.4				25.0	23.0			26.1	0.5	
2000		38.0				18.8	26.0				0.3	2.5
2001		29.3				23.2	16.0			29.6	1.3	2.2
2002		30.7				19.5				23.7	0.5	3.1
2003		57.7				10.5	22.0			27.4	0.0	2.7
2004		45.0				10.3	16.0			28.7	0.4	0.0
2005		36.1				16.1	27.0			47.8	4.6	13.0
2006		36.7				21.4	38.0			25.0	3.2	4.2
2007						18.4	16.5			35.8		0.0
2008		24.6				14.5	26.0			28.6	5.1	6.2
2009		58.4				17.2	38.0			36.2	1.3	8.3
2010												

4) Isohyetal map of yearly average rainfall

The isohyetal map of yearly average rainfall in Pisco basin is as shown in the Figure-3.1.9.1-9.

There is big difference in the yearly rainfall data by areas in Pisco basin, for instance yearly rainfall is less than 25mm in the minimum, on the other hand 750mm in the maximum, and the amount is small in the downstream area and becomes large toward the upstream with higher elevation.

In the objective section for flood protection, the yearly rainfall is not so much from 25～50mm.

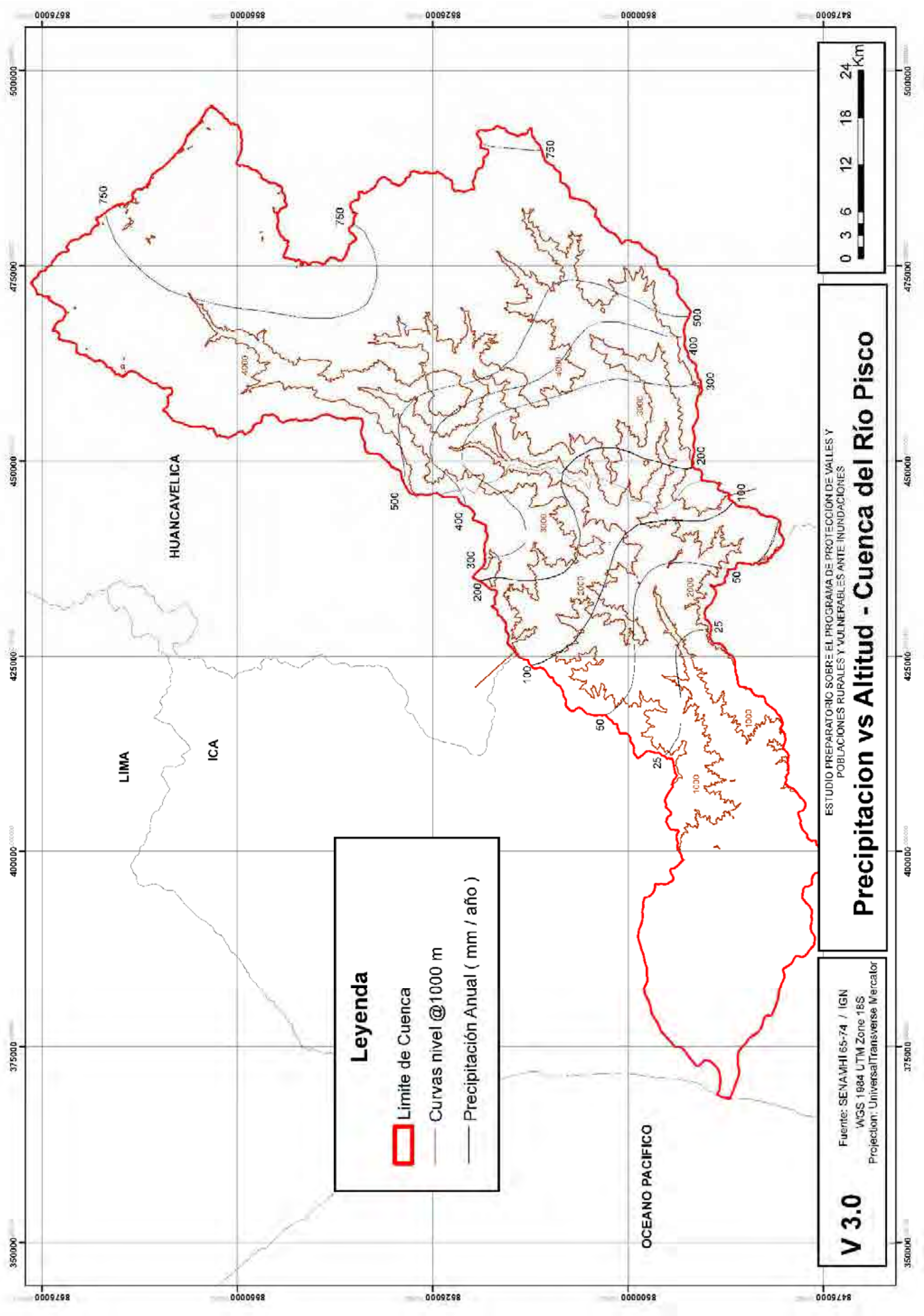


Figure-3.1.9.1-9 Isohyetal map of yearly rainfall (Pisco basin)

(4) Majes-Camana River

1) Conditions of Rainfall Observation

The rainfall observation stations and their observation period in Majes-Camana basin are as shown in the Table-3.1.9.1-12～ Table-3.1.9.1-13 and the Figure-3.1.9.1-10.

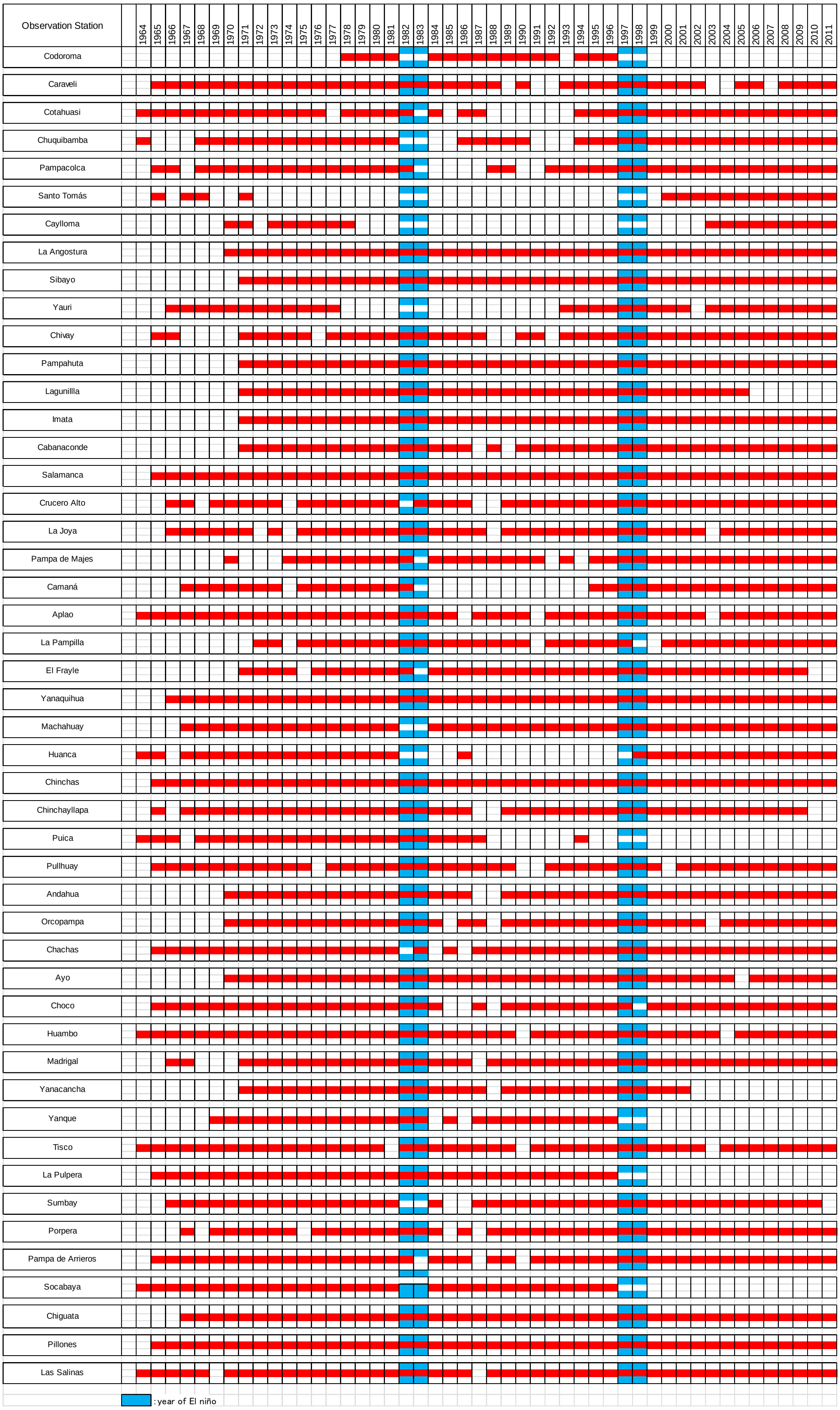
In Majes-Camana basin, the rainfall has been observed in 48 stations, and the longest observation began from 1964. However some of station have no good quality of data such as lack of long period of observation, so that the 38 stations with good quality of data were selected suitable for run-off study as shown in the Table-2.2.6.

In the other hand, from the year 2011 Chivay station, located in the middle basin, began an automatic telemetric monitoring. The Study Team collected information from periods of precipitation in February 2011 and February 2012 (rainy season).

Table-3.1.9.1-12 Rainfall observation station (Majes-Camana river)

Weather station	Coordinates		
	Latitude	Longitude	Altitude (masl)
Andahua	15° 29'37	72° 20'57	3528
Aplao	16° 04'10	72° 29'26	645
Ayo	15° 40'45	72° 16'13	1956
Cabanaconde	15° 37'7	71° 58'7	3379
Camaná	16° 36'24	72° 41'49	15
Caravelí	15° 46'17	73° 21'42	1779
Chachas	15° 29'56	72° 16'2	3130
Chichas	15° 32'41	72° 54'59.7	2120
Chiguata	16° 24'1	71° 24'1	2943
Chinchayllapa	14° 55'1	72° 44'1	4497
Chivay	15° 38'17	71° 35'49	3661
Choco	15° 34'1	72° 07'1	3192
Chuquibamba	15° 50'17	72° 38'55	2832
Cotahuasi	15° 22'29	72° 53'28	5088
Crucero Alto	15° 46'1	70° 55'1	4470
El Frayle	16° 05'5	71° 11'14	4267
Huambo	15° 44'1	72° 06'1	3500
Imata	15° 50'12	71° 05'16	4445
La Angostura	15° 10'47	71° 38'58	4256
La Joya	16°35'33	71°55'9	1292
La Pampilla	16° 24'12.2	71° 31'.6	2400
Lagunillas	15° 46'46	70° 39'38	4250
Las Salinas	16° 19'5	71° 08'54	4322
Machahuay	15° 38'43	72° 30'8	3150
Madrigal	15° 36'59.7	71° 48'42	3262
Orcopampa	15° 15'39	72° 20'20	3801
Pampa de Arrieros	16° 03'48	71° 35'21	3715
Pampa de Majes	16° 19'40	72° 12'39	1434
Pampacolca	15° 42'51	72° 34'3	2950
Pampahuta	15° 29'1	70° 40'33.3	4320
Pillones	15° 58'44	71° 12'49	4455
Porpera	15° 21'1	71° 19'1	4152
Pullhuay	15° 09'1	72° 46'1	3113
Salamanca	15° 30'1	72° 50'1	3303
Sibayo	15° 29'8	71° 27'11	3827
Sumbay	15° 59'1	71° 22'1	4294
Tisco	15° 21'1	71° 27'1	4175
Yanaquihua	15° 46'59.8	72° 52'57	2815

Table-3.1.9.1-13 Observation period of rainfall data (Majes-Camana river)



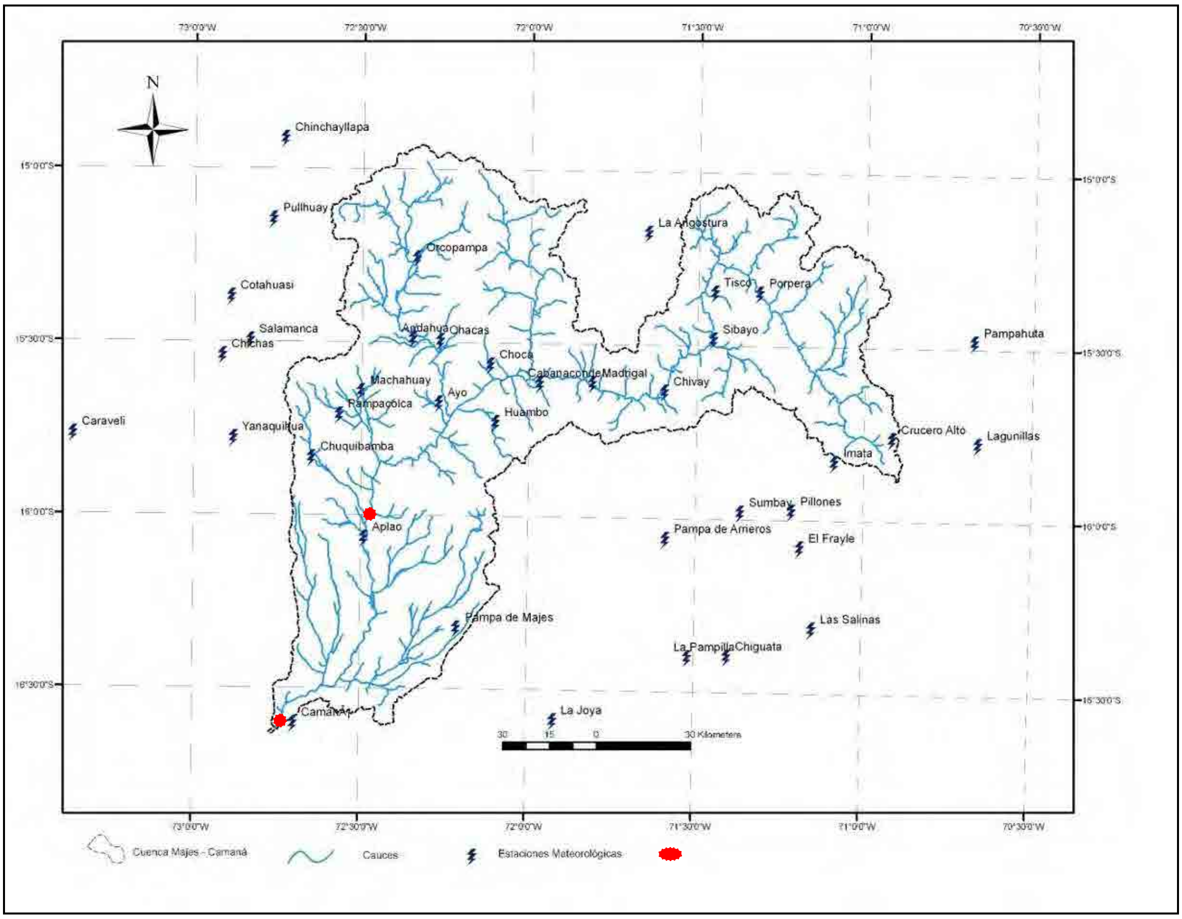


Figure-3.1.9.1-10 Location of rainfall and discharge observation station (Majes-Camana river)

2) Monthly Rainfall

Among 48 rainfall observation stations in Majes-Camana basin and adjacent basin the rainfall data of 38 stations is used for analysis, excluding 10 stations due to short observation period less than 20 years, lack of recent 10 years data, far location from the objective basin.

The monthly rainfall data in TISCO with good quality of data is shown in the Table-3.1.9.1-14 as an example.

Table-3.1.9.1-14 Monthly rainfall in TISCO

TOTAL MONTHLY PRECIPITATION (mm)

BASIN	GAGE	DEPARTMENT	LONGITUDE	LATITUDE
Camaná - Majes	TISCO	AREQUIPA	71° 27'1	15° 21'1

Year	Month												Total
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1963											41.1	131.8	
1964	86.1	72.9	114.4	42.9	22.0	0.0	0.0	6.1	4.4	17.9	59.7	57.6	484.0
1965	75.0	161.1	85.9	42.5	0.3	0.0	9.2	0.0	24.0	22.0	10.4	151.7	582.1
1966	110.3	184.9	64.6	10.6	45.1	0.0	0.0	4.5	0.0	43.3	79.7	55.0	598.0
1967	103.8	161.0	220.2	64.5	13.1	0.6	8.2	9.4	41.8	23.6	12.7	90.5	749.4
1968	266.0	119.6	179.4	31.6	4.0	5.1	5.5	5.8	20.0	52.9	84.6	31.7	806.3
1969	150.1	113.0	52.5	0.0	0.0	0.0	0.0	0.0	0.0	4.0	60.8	97.7	478.0
1970	139.6	150.5	138.5	22.4	9.5	0.0	1.0	1.1	35.6	5.1	4.7	146.8	654.9
1971	140.0	183.5	101.2	30.1	2.6	0.9	0.0	0.0	0.0	5.0	2.2	132.7	598.2
1972	362.1	188.7	235.5	32.7	0.1	0.0	2.3	0.1	55.1	32.9	32.1	90.1	1031.7
1973	297.8	190.2	159.2	81.1	15.9	0.0	8.2	10.2	31.1	7.6	60.6	53.9	915.7
1974	290.2	172.9	44.7	80.7	1.5	14.5	0.0	111.1	9.3	4.3	7.5	50.2	786.8
1975	146.6	246.7	122.4	30.2	20.8	3.2	0.0	1.0	8.0	48.3	1.4	131.4	760.1
1976	153.0	107.7	166.8	41.6	9.3	7.5	4.6	2.3	58.9	0.5	0.6	71.9	624.7
1977	67.0	239.2	118.8	7.1	4.1	0.0	2.3	0.0	11.7	16.3	110.2	49.8	626.6
1978	317.6	24.1	78.7	68.9	0.0	4.0	0.0	1.0	2.3	26.9	78.6	60.0	662.2
1979	127.4	88.0	123.3	16.5	0.0	0.0	2.5	2.5	0.0	59.2	71.2	93.7	584.4
1980	72.5	43.1	183.6	2.2	0.0	0.0	13.5	25.9	28.1	94.1	2.1	30.2	495.3
1981	205.2		52.0	73.0	2.0	0.0	0.0	46.8	9.0	24.8	52.3	110.6	
1982	161.0	45.9	122.8	34.9	0.0	0.5	0.0	0.0	80.9	105.5	150.5	70.0	772.0
1983	46.7	93.7	81.0	47.9	12.0	0.5	0.5	0.0	35.2	18.0	2.5	32.4	370.5
1984	178.4	256.0	284.8	11.1	10.5	3.0	0.0	28.4	0.0	46.3	135.5	125.6	1079.6
1985	32.9	263.0	134.4	49.7	10.0	14.8	0.0	0.0	15.4	0.0	70.0	142.4	732.6
1986	105.9	162.7	178.9	98.4	12.5	0.0	2.8	52.2	18.1	11.0	11.0	149.6	803.1
1987	212.5	42.9	26.2	23.6	3.4	2.1	27.0	4.5	2.0	23.3	24.6	29.0	421.1
1988	216.9	72.5	97.0	63.5	8.5	0.0	0.0	4.0	6.8	0.0	4.0	30.2	503.4
1989	123.9	93.0	159.5	50.7	0.0	0.0	0.0	3.0	0.0	0.0	12.0	4.0	446.1
1990	118.4	27.6	58.5	25.6	12.5	39.5	0.0	13.0	5.0	52.5	0.0		
1991	150.6	72.7	162.3	10.7	3.5	30.7	3.0	1.6	3.5	29.2	48.6	0.0	516.4
1992	51.6	73.8	32.9	4.8	0.0	2.7	2.8	40.0	1.0	25.2	24.7	85.6	345.1
1993	230.9	82.4	133.9	49.9	6.2	1.3	0.3	25.1	15.5	34.2	63.7	106.1	749.5
1994	241.6	218.1	74.3	45.6	10.1	2.8	1.5	1.7	0.0	1.0	25.2	72.7	694.6
1995	121.5	135.0	215.7	27.8	3.7	0.1	0.0	2.8	8.6	13.1	22.3	122.0	672.7
1996	187.3	156.8	83.0	61.6	12.0	0.0	0.3	14.1	11.7	10.6	41.3	146.6	725.4
1997	175.0	201.8	86.5	31.7	18.1	0.0	0.0	33.1	64.8	14.0	60.1	102.2	787.3
1998	271.1	114.9	96.6	15.9	0.5	3.0	0.0	0.8	0.5	9.6	48.5	75.9	637.4
1999	199.2	273.9	198.2	30.5	6.0	0.1	1.2	0.6	23.5	75.3	10.7	90.3	909.5
2000	194.3	242.5	157.2	21.5	28.7	7.8	0.4	11.4	1.6	70.9	22.1	97.9	856.4
2001	240.3	239.0	144.2	108.9	31.3	5.4	16.5	12.0	8.4	18.7	8.6	35.9	869.0
2002	123.6	241.6	186.8	134.9	17.4	8.0	31.8	0.6	19.1	44.7	82.2	113.3	1004.1
2003	83.5		193.1	29.2	11.8	1.5	3.6	4.1	13.2	14.8		114.6	
2004	208.7	176.4	138.0	39.4	2.4	0.5	20.3	14.9	15.4	3.2	7.0	72.7	698.8
2005	124.4	207.0	127.5	56.9	0.5	0.0	0.1	0.7	23.2	11.6	18.8	103.4	674.1
2006	202.0	200.4	195.5	62.4	6.1	4.1	0.0	7.7	25.6	29.3	61.6	78.8	873.4
2007	187.0	179.7	180.4	38.4	9.1	0.1	9.7	0.8	16.1	13.7	22.9	96.2	753.8
2008	257.8	123.5	70.0	5.5	3.2	2.7	0.1	0.6	1.7	17.1	5.0	95.6	582.7
2009	104.6	203.6	133.3	65.6	2.8	0.0	11.1	2.4	23.9	9.9	47.9	64.6	669.7
2010	179.1	164.6	73.0	69.3	6.4	2.1	2.2	1.0	6.2	21.2	13.4	142.9	681.4
2011		233.8	96.9	104.8									
Pp Maxima	362.1	273.9	284.8	134.9	45.1	39.5	31.8	111.1	80.9	105.5	150.5	151.7	1079.6
Pp Media	166.8	153.2	128.4	43.7	8.5	3.6	4.1	10.8	16.7	25.8	38.7	85.9	687.9
Pp Minima	32.9	24.1	26.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	345.1

3) Yearly maximum of 24-hour rainfall

The yearly maximum of 24-hour rainfall (daily rainfall) of each observation station in Majes-Camana basin is as shown in the Table-3.1.9.1-15.

Table-3.1.9.1-15 yearly maximum of 24-hour rainfall (daily rainfall) in Majes-Camana basin(1/2) (mm)

Year	Andahua	Aplao	Ayo	Cabanaconde	Camaná	Caravelí	Chachas	Chichas	Chiguata	Chinchayllapa	Chivay	Choco	Chuquibamba	Cotahuasi	Crucero Alto	El Frayle	Huambo
1963													20.0				
1964		7.2						13.0					10.5	11.8	21.5		28.8
1965		2.2				10.0	18.2	24.0	7.5	20.0	14.2	8.0	0.9	16.3	38.1		23.3
1966		2.2			6.0	0.0	15.8	23.0	9.3	7.0	24.0	8.4	13.3	17.2	31.5		17.7
1967		7.3			2.5	14.0	16.7	3.8	17.1	18.9		8.2	29.5	18.8	34.7		28.4
1968		0.6			2.5	29.0	22.0	19.7	16.3	30.0		9.8	23.3	30.1	38.5		22.5
1969		1.5			13.0	7.0	27.0	30.2	9.0	19.3		11.1	37.4	18.2	26.8		17.8
1970	18.0	7.5	11.5	24.8	0.4	19.6	30.5	25.6	8.2	25.2		14.3	35.3	14.2	21.9		23.7
1971	22.0	4.7	13.5	31.1	5.2	4.5	34.5	22.0	16.0	50.0	21.5	31.5	28.5	17.1	18.5	24.1	25.1
1972	30.1	2.8	12.0	26.9	5.4	19.3	23.6	10.0	39.0	28.9	21.5	18.2	32.5	59.4	27.2	19.7	40.3
1973	21.9	6.3	9.1	25.0	16.4	7.3	21.7	15.0	19.5	20.0	24.0	16.6	32.8	30.0	32.8	21.7	20.7
1974	23.4	1.4	7.1	22.0		4.3	18.5	8.3	30.9	21.5	30.0	15.5	18.4	16.0	27.9	25.4	31.2
1975	71.0	1.2	9.0	29.2	8.0	4.0	33.3	23.6	23.3	18.8	49.0	24.0	20.5	26.4	28.5	21.8	26.4
1976	27.5	5.4	13.4	33.4	10.3	30.0	36.7	10.1	42.9	20.0	24.5	20.2	36.6	22.5	15.0	15.8	22.7
1977	19.2	1.8	7.3	28.9	2.1	5.7	27.0	14.0	34.6	23.0	38.0	15.0	30.7	20.8	28.4	32.4	14.0
1978	19.8	0.3	10.5	26.0	1.3	0.5	22.4	7.0	12.8	16.7	17.0	33.3	19.2	19.2	14.9	31.5	28.7
1979	16.4	0.0	8.6	16.9	0.5	10.1	17.4	5.8	24.8	25.8	20.6	15.0	12.2	20.1	31.0	16.5	21.1
1980	18.7	0.3	10.0	17.1	0.0	5.3	21.6	9.8	12.4	15.5	28.3	7.7	15.8	26.7	24.7	21.7	16.7
1981	20.6	2.3	11.4	26.5	0.3	23.0	24.5	15.0	28.9	20.0	20.6	18.6	25.8	40.7	21.5	30.4	23.2
1982	20.1	0.0	4.1	31.0	6.5	2.5	13.9	6.8	9.2	17.0	29.8	19.0		13.2	38.9	27.7	16.4
1983	5.4	0.0	0.1	21.1	4.0	2.8	7.3	6.0	3.8	14.3	9.0	10.0			20.0	32.5	17.4
1984	28.6	13.0	18.9	33.5		22.7	29.0	13.8	21.0	34.1	36.2	22.1		24.3	28.3	17.8	33.9
1985	17.9	0.0	12.2	29.1		2.0	19.0	22.9	20.3	20.7	25.5	15.0		18.9	22.9	21.2	24.6
1986	22.4	6.0	12.8	71.5		11.3	21.3	23.5	37.9	18.8	27.5	18.0		30.0	19.2	18.4	34.4
1987	30.7	0.8	10.3	92.8		2.2	36.0	21.0	39.4	18.7	17.4	10.0	27.2	17.3	14.4	12.6	42.8
1988	30.7	0.4	9.9	40.0		8.4	22.8	22.2	22.7	18.4	31.3		7.2	26.9	18.8	20.0	30.4
1989	32.8	0.5	5.3	24.5		12.5	19.0	27.5	32.2	19.1	13.0	11.7	33.0		19.2	18.6	17.0
1990	20.6	1.6	4.5	23.0		6.5	35.6	12.9	18.9	18.5	34.7	13.3	23.0		18.0	58.5	36.0
1991	33.2	0.9	3.4	6.9		0.0	20.0	12.0	13.5	20.0	36.8	16.7	3.2		19.5	23.5	15.8
1992	12.4	2.8	1.8	17.0			10.5	2.3	5.2	14.8	8.0	10.4			13.9	18.2	6.3
1993	17.8	0.3	1.7	20.0		2.0	16.1	12.5	21.8	14.3	16.4	6.5	8.0		22.6	24.7	16.8
1994	31.4	1.2	8.6	23.2		11.0	23.0	26.1	35.3	21.6	16.0	16.7	36.8	0.0	32.1	39.0	16.9
1995	21.6	2.1	14.8	32.8	0.0	15.2	18.6	22.2	48.8	30.6	30.1	24.0	29.6	14.7	31.8	32.5	17.9
1996	22.4	1.3	15.6	22.2	0.9	1.9	21.1	19.5	10.2	25.0	39.7	11.8	10.0	29.8	27.6	21.4	16.9
1997	28.9	3.7	18.3	51.0	2.2	33.0	35.4	14.2	44.0	29.4	30.3	21.3	19.6	26.7	27.4	21.6	32.9
1998	33.5	1.2	16.9	38.3	3.6	18.5	25.9	29.6	12.6	34.9	23.4	24.5	82.0	26.2	23.6	20.9	25.3
1999	26.6	1.4	14.5	32.9	2.3	7.1	35.3	23.0	25.0	24.0	29.2	19.2	26.0	33.0	32.7	25.7	26.6
2000	24.9	1.0	8.6	24.6	2.9	15.6	15.8	19.8	36.2	45.1	24.4	18.4	28.0	26.6	21.9	15.9	18.7
2001	30.6	2.0	15.4	48.6	1.4	11.5	19.0	17.4	20.9	31.5	29.8	19.8	70.4	22.8	25.9	13.4	17.0
2002	27.3	4.8	16.6	30.6	4.4	13.7	22.5	22.6	24.3	28.8	28.1	20.9	47.7	27.5	30.6	17.8	27.9
2003	17.5	0.0	8.7	19.3	0.4	0.0	17.8	8.7	9.2	31.6	14.7	13.7	14.5	18.0	15.7	11.7	25.5
2004	23.0	9.0	35.6	22.9	0.5	1.5	21.4	18.9	18.7	25.8	24.8	24.6	16.6	25.7	28.2	28.4	30.4
2005	21.1	1.7	12.1	24.4	0.8	16.5	12.8	10.7	13.0	39.1	27.8	13.6	14.6	11.0	35.3	20.1	18.3
2006	25.0	0.9	9.4	25.3	0.6	4.2	19.6	18.3	14.4	30.9	26.5	17.7	18.2	13.5	23.4	28.3	31.8
2007	21.6	2.7	14.0	27.4	3.0	2.6	28.6	10.6	23.4	30.2	24.7	40.0	10.9	25.4	32.5	21.2	21.0
2008	23.3	6.4	23.5	24.0	9.8	5.0	18.0	25.7	20.7	30.8	35.7	23.8	15.4	17.4	15.4	28.2	29.2
2009	19.7	0.0	10.2	16.8	3.2	9.1	17.1	23.0	9.9	28.6	30.6	20.6	15.7	11.8	32.7	43.6	16.8
2010	27.2	0.9	7.8	23.9	4.5	1.3	18.7	9.3	9.7	25.6	26.9	11.9	17.0	17.7	33.8		23.3
2011	21.2	2.0	13.3	26.6		7.2	31.2	15.1	19.2		27.7	19.8	17.0	21.7	27.9		32.9

Table-3.1.9.1-15 Yearly maximum of 24-hour rainfall (daily rainfall) in majes-camana basin(2/2) (mm)

Year	Imata	La Angostura	La Joya	La Pampilla	Lagunillas	Las Salinas	Machahuay	Madrigal	Orcopampa	Pampa de Arrieros	Pampa de Majes	Pampacolca	Pampahuta	Pillones	Porpera	Pullhuay	Salamanca	Sibayo	Sumbay	Tisco	Yanaquihua
1963																					20.5
1964						21.5				15.3		12.7								28.2	7.2
1965						18.0	8.0	18.7		20.0		17.7		60.7		30.2	15.0			47.8	
1966			0.0			19.9		18.4		11.6		8.2		19.0	32.7	12.2	10.5		12.5	33.5	17.6
1967			1.0			19.2	20.3	20.1		34.0		29.9		23.1	26.7	28.5	22.6		22.3	45.6	14.1
1968			3.0			17.2	23.5	28.1		15.0		21.2		33.7	36.7	21.6	18.5		30.7	30.9	23.8
1969			0.0			20.0	16.1	20.7		17.3		43.8		21.5	45.8		21.5		67.5	50.0	17.5
1970	21.5	34.6	5.1		34.2	11.0	22.9	18.9	83.1	16.3	1.9	22.1	33.3	23.2	40.5	26.3	24.6	35.9	18.6	36.0	42.6
1971	32.2	40.5	0.7		24.9	23.1	16.6	22.5	17.0	20.9	7.1	18.7	33.6	31.4	38.5	54.3	26.9	26.0	39.5	24.9	10.1
1972	33.4	38.0	1.7	21.3	24.3	13.6	40.2	33.3	27.3	41.8	1.0	27.5	35.4	22.3	36.0	40.0	30.7	51.3	36.7	44.7	55.0
1973	35.2	27.7	0.6	22.1	41.3	13.2	24.1	16.2	57.0	18.0	21.5	23.5	31.4	15.6	21.2	41.1	24.2	29.8	22.5	25.7	20.9
1974	34.7	43.7	4.0	16.0	43.6	12.4	13.5	31.6	36.7	17.2	1.8	19.5	33.1	9.4	27.5	29.2	17.5	40.0	44.0	37.4	17.2
1975	23.7	56.5	3.0	46.7	39.4	10.4	23.2	24.9	29.2	19.8	1.2	18.8	26.2	18.3	21.0	44.1	32.4	26.1	27.2	37.7	15.9
1976	24.1	44.0	4.3	24.0	23.7	15.0	23.1	24.9	23.7	30.7	2.2	25.2	35.2	17.6	13.5	35.3	22.3	31.4	23.8	38.5	18.7
1977	24.2	52.2	0.0	6.8	25.8	16.9	9.6	20.1	21.9	27.3	1.8	31.6	27.0	28.3	21.5	25.5	20.2	30.5	18.3	38.5	34.5
1978	35.1	36.2	0.0	8.0	27.7	12.3	9.2	25.1	26.5	20.0	0.0	27.4	34.0	38.5	22.4	21.8	15.3	31.3	36.8	33.2	9.3
1979	30.6	22.2	0.0	10.9	32.5	13.9	17.0	15.8	25.7	9.5	0.0	27.6	31.8	19.4	17.5	22.3	17.7	40.8	22.0	49.0	15.1
1980	21.2	38.7	3.0	6.2	26.2	24.8	29.0	19.5	18.9	29.8	0.8	15.7	36.5	17.4	21.2	19.5	10.8	23.6	16.8	42.5	13.5
1981	36.3	37.9	0.0	5.4	36.4	18.6	14.0	33.8	21.8	26.4	0.3	19.6	45.3	28.1	19.2	33.1	34.2	31.2	24.5	52.0	21.6
1982	20.7	31.0	0.0	3.9	25.6	17.1	9.2	18.8	19.1	20.9	0.0	18.5	22.9	16.1	15.0	15.5	14.8	35.8	18.9	37.0	12.1
1983	15.4	38.2	0.0	1.5	33.0	10.0		10.0	15.3		0.1	15.0	30.4	23.8	16.0	13.8	12.9	21.5		30.0	38.0
1984	29.3	89.9	3.0	14.7	32.0	13.4	24.0	24.6	32.2	50.6	0.9	26.6	43.6	28.0	14.7	33.9	49.0	40.1	25.7	33.0	41.0
1985	34.9	53.2	2.3	15.3	28.3	14.5	18.4	31.1	18.1	20.3	0.8		32.6	20.1	21.5	23.7	14.7	23.4		26.5	14.0
1986	27.8	35.9	18.7	18.4	25.3	10.1	37.5	20.7	14.9	50.7	21.1		35.7	32.0	16.5	26.1	21.8	25.9		50.0	53.0
1987	23.9	24.4	0.0	19.0	29.4	12.5	9.0	19.8	19.6		0.6	39.0	25.2	13.6	11.0	15.5	25.0	19.3	30.0	35.0	68.5
1988	20.1	56.3	0.1	11.5	23.5	11.7	30.0	34.4	28.8	6.0	1.0	0.0	32.4	30.1	17.5	14.2	28.9	47.2	39.0	39.0	11.5
1989	18.2	26.6	1.3	22.9	28.1	13.6	38.0	16.7	22.0	37.7	1.8	0.0	34.3	17.0	15.4	20.6	17.6	18.2	56.4	30.0	43.1
1990	37.0	33.1	4.0	11.5	28.9	9.6	18.5	24.6	29.0		6.1		27.1	31.7	17.0		23.1	41.3	58.0	48.0	22.3
1991	31.0	48.4	0.0	7.7	23.1	9.6	18.4	12.4	15.7	19.6	11.6		32.1	36.0	22.0		19.5	24.6	32.0	30.5	11.9
1992	27.1	34.8	1.2	3.4	19.2	9.3	5.2	22.0	13.0	4.4	8.4	0.5	36.6	23.8	12.0	18.2	6.8	19.2	28.0	23.2	0.3
1993	27.6	32.0	0.7	13.5	36.7	14.1	20.0	12.1	15.0	29.4	0.1	0.0	36.3	50.5	27.6	31.8	15.6	27.3	35.0	32.0	13.8
1994	28.6	35.8	0.0	13.6	23.7	25.5	44.5	17.3	30.0	18.2	2.2	6.7	37.3	30.8	35.4	33.9	29.5	34.9	35.8	35.0	27.9
1995	27.7	48.6	0.0	28.0	29.5	41.2	27.5	33.9	19.0	14.0	10.5	28.2	25.4	22.6	46.0	14.9	22.6	36.3	31.3	43.8	44.1
1996	23.9	49.0	0.0	12.1	21.5	21.1	15.0	25.4	27.0	1.2	0.0	16.0	39.8	16.9	38.4	18.2	13.3	21.3	25.4	32.9	11.3
1997	22.7	31.4	1.9	33.4	22.8	21.5	38.0	30.7	18.5	14.8	2.7	27.9	42.3	21.0	42.3	20.6	32.7	33.6	27.8	32.0	63.9
1998	30.6	40.9	0.5	9.5	31.2	24.5	17.1	24.6	23.3	15.7	1.8	42.4	38.0	26.4	36.9	18.7	24.7	30.0	27.7	120.0	39.4
1999	57.2	39.0	0.0	12.3	30.0	42.3	20.6	27.9	32.8	18.5	2.5	24.2	38.6	26.6	88.3	19.0	31.7	30.5	27.0	43.8	22.2
2000	21.9	31.4	0.5	23.7	22.5	20.6	26.2	26.3	24.3	25.6	3.7	27.4	34.4	22.1	38.8	26.1	21.4	27.8	27.9	32.2	17.1
2001	52.5	49.3	2.4	30.0	34.5	27.2	34.7	36.2	20.8	20.8	1.0	27.4	49.9	25.1	30.1	29.6	26.2	30.3	26.6	33.0	30.1
2002	25.5	37.5	1.0	15.4	26.3	42.0	28.0	29.8	27.6	72.4	6.8	39.8	47.9	35.7	31.3	22.5	18.5	42.4	23.0	39.2	26.2
2003	23.8	31.5	0.0	5.5	37.8	19.5	16.7	15.1	18.3	7.2	0.4	17.3	36.4	15.6	37.0	23.1	21.0	31.5	14.3	28.5	6.7
2004	32.5	22.9	2.3	8.4	29.7	39.6	19.4	21.2	26.5	13.4	3.5	15.4	40.0	26.4	31.5	34.8	22.6	47.2	16.9	30.6	13.4
2005	31.4	32.2	0.0	5.2	37.8	28.4	25.0	35.7	27.0	8.8	0.2	23.2	43.3	21.3	30.7	25.0	12.9	33.5	21.7	29.7	12.1
2006	55.4	37.5	0.0	14.9	33.2	21.2	28.0	38.2	17.0	5.2	0.0	29.1	33.1	30.4	38.9	32.0	20.8	30.6	21.5	34.6	13.6
2007	28.2	26.3	6.7	7.9	16.4	24.4	23.1	20.4	24.4	8.6	11.0	18.4	33.0	25.6	36.1	23.8	18.2	25.2	16.0	27.6	10.6
2008	30.2	34.3	5.4	25.5		32.8	21.5	18.8	19.2	22.7	9.0	17.3	38.6	23.1	37.8	19.8	10.4	45.2	15.8	44.0	21.5
2009	33.0	29.2	0.0	8.4		18.2	30.8	28.0	18.3	19.2	1.5	19.1	26.3	22.3	35.2	28.7	16.4	29.4	16.1	30.7	17.4
2010	27.5	33.2	0.6	4.7		13.6	10.7	29.6	22.2	10.6	1.0	21.7	32.7	21.0	29.4	19.9	14.7	34.5	20.6	25.6	9.2
2011	30.7	31.7	1.5	17.0		24.8	22.9	34.1	20.5	15.8	4.9	15.3	28.3	32.1	44.7	30.7	20.3	40.6		32.0	17.8

4) Isohyetal map of yearly average rainfall

The isohyetal map of yearly average rainfall in Majes-Camana basin is as shown in the Figure-3.1.9.1-11.

There is big difference in the yearly rainfall data by areas in Majes-Camana basin, for instance yearly rainfall is approximately 50mm in the minimum, on the other hand 750mm in the maximum, and the amount is small in the downstream area near the Pacific Oceans and becomes large toward the upstream with higher elevation.

In the objective section for flood protection, the yearly rainfall is not so much from 50～200mm.

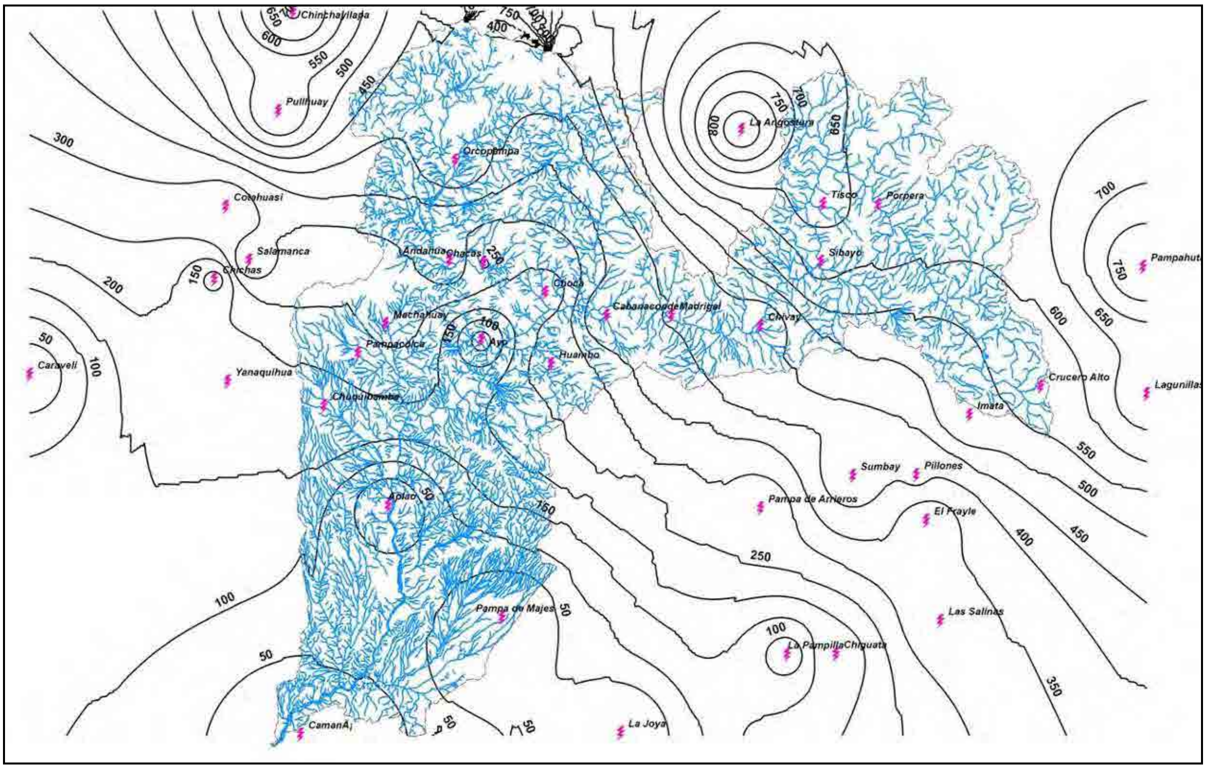


Figure-3.1.9.1-11 Isohyetal map of yearly rainfall (Majes-Camana basin)

3.1.9.2 Discharge

The discharge observation method is generally not automatic but manual at regular time of a day, once a day at 7 a.m. or twice a day at 7a.m. and 7p.m. for all of the stations in the study area so that there is no hourly data but only daily data (24 hour -discharge data). Being a fixed monitoring times, is not likely to have registered maximum instantaneous flows as flood peak flows.

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

However, from 2006 at the discharge gauging station at Huatiapa (Majes-Camana river) the water level measurements made by SENAMHI 4 times a day (7:00, 10:00, 14:00 and 18:00) using a staff gauge are compared to the water levels recorded by an automatic float type water level gauging system (starting in 2006). In times of flood the water level measurements are made every hour.

On the other hand, although the Huatiapa gauging station at the valley of Majes-Camana is recording water levels using an automatic float type gauging system, the data is only partially being ordered digitally through a computer, the in charge operator is making a manual record. The data of maximum annual discharge published by SENAMHI before year 2006, represents the maximum of daily mean discharges obtained from the mean discharge measured 2 or 4 times a day. Therefore it is necessary to establish measurement system to obtain real-time water level and discharge values and organize those observed data during inundation time by means of installation of an automatic telemetry system in each gauge in each watershed.

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

(1) Cañete river

1) Discharge observation station

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

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

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

2) Yearly Maximum Daily Discharge

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

Table-3.1.9.2-2 Yearly maximum daily discharge(Cañete river) (m^3/s)

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

1947	-	353.00
1948	-	279.00
1949	-	198.00
1950	-	244.74
1951	-	485.00
1952	-	360.00
1953	-	555.00
1954	-	657.00
1955	-	700.00
1956	-	470.00
1957	-	228.32
1958	-	270.40
1959	-	700.00
1960	-	488.75
1961	-	597.62
1962	-	566.24
1963	-	242.37
1964	-	153.06
1965	214.70	214.70
1966	207.00	201.00
1967	343.00	343.00
1968	154.00	154.00
1969	316.00	316.00
1970	408.00	408.00
1971	430.00	430.00
1972	900.00	900.00
1973	484.20	450.10
1974	-	326.00
1975	-	298.00
1976	294.92	332.00
1977	-	249.00
1978	-	216.00
1979	-	182.80
1980	-	100.10
1981	-	257.10
1982	-	120.00
1983	-	228.00
1984	-	425.50
1985	-	165.60
1986	-	370.50
1987	-	487.30
1988	206.00	420.30
1989	-	377.00
1990	-	189.00
1991	-	372.00
1992	-	164.30
1993	-	390.00
1994	-	550.00
1995	-	500.00
1996	-	310.00
1997	-	350.00
1998	-	348.00
1999	-	420.00
2000	-	350.00
2001	-	255.00
2002	-	204.00
2003	-	215.00
2004	-	196.00
2005	-	167.00
2006	-	250.00

(2) Chincha river

1) Discharge observation station

The discharge observation station in Cañete River is as shown in the Table-3.1.9.2-3. The observation is performed by SENAMHI and the water users committee.

Table-3.1.9.2-3 Discharge observation station (Chincha river)

Observation Station	Latitude	Longitude	Elevation (m.a.s.l.)
CONTA	13° 27'	75° 58'	320

2) Yearly maximum daily discharge

The yearly maximum daily discharge of each year is as shown in the Table-3.1.9.2-4.

The Chincha river diverts to Chico river and Matagente river so that the discharge of Chincha river is a total of Chico and Matagente river.

Table-3.1.9.2-4 Yearly maximum daily discharge (Chincha river) (m^3/s)

year	SENAMHI	Water Users Committee			Adopted
	Total	Rio Chico	Rio Matagente	Total	Discharge
1950	155.43	-	-	-	155.43
1951	395.75	-	-	-	395.75
1952	354.00	-	-	-	354.00
1953	1,268.80	-	-	-	1,268.80
1954	664.40	-	-	-	664.40
1955	241.45	-	-	-	241.45
1956	227.83	-	-	-	227.83
1957	226.53	-	-	-	226.53
1958	88.36	35.34	53.02	88.36	88.36
1959	301.42	120.57	180.85	301.42	301.42
1960	245.17	98.07	147.10	245.17	245.17
1961	492.83	197.13	295.69	492.82	492.82
1962	395.06	158.02	237.03	395.05	395.05
1963	337.84	135.14	202.70	337.84	337.84
1964	66.95	26.78	40.17	66.95	66.95
1965	154.12	61.65	92.47	154.12	154.12
1966	139.13	55.65	83.48	139.13	139.13
1967	1,202.58	481.03	721.55	1,202.58	1,202.58
1968	43.92	17.57	26.35	43.92	43.92
1969	72.14	28.86	43.28	72.14	72.14

1970	271.57	108.63	162.94	271.57	271.57
1971	497.84	199.13	298.71	497.84	497.84
1972	784.16	313.66	470.50	784.16	784.16
1973	137.53	55.01	82.52	137.53	137.53
1974	215.66	86.26	129.40	215.66	215.66
1975	246.87	98.75	148.12	246.87	246.87
1976	311.13	124.45	186.68	311.13	311.13
1977	97.10	38.84	58.26	97.10	97.10
1978	33.00	13.20	19.80	33.00	33.00
1979	51.90	20.76	31.14	51.90	51.90
1980	33.70	13.48	20.22	33.70	33.70
1981	83.95	33.58	50.37	83.95	83.95
1982	183.60	73.44	110.16	183.60	183.60
1983	81.20	32.48	48.72	81.20	81.20
1984	292.87	117.15	175.72	292.87	292.87
1985	71.42	51.88	77.82	129.70	129.70
1986	106.26	46.00	69.00	115.00	115.00
1987	-	42.00	63.00	105.00	105.00
1988	-	28.51	42.76	71.27	71.27
1989	-	71.38	107.07	178.45	178.45
1990	24.34	9.74	14.60	24.34	24.34
1991	-	41.00	61.49	102.49	102.49
1992	-	5.95	8.92	14.87	14.87
1993	-	51.73	77.59	129.32	129.32
1994	-	75.61	113.41	189.02	189.02
1995	-	121.47	182.21	303.68	303.68
1996	-	49.85	74.77	124.62	124.62
1997	-	10.60	15.89	26.49	26.49
1998	-	112.00	168.00	280.00	280.00
1999	-	165.74	248.61	414.35	414.35
2000	-	114.93	172.39	287.32	287.32
2001	-	81.72	122.59	204.31	204.31
2002	-	47.65	71.48	119.13	119.13
2003	-	52.38	78.57	130.95	130.95
2004	-	63.73	95.60	159.33	159.33
2005	-	14.24	21.36	35.60	35.60
2006	-	62.48	93.72	156.20	156.20

(3) Pisco river

1) Discharge observation station

The discharge observation station in Pisco River is as shown in the Table-3.1.9.2-5.

Table-3.1.9.2-5 Discharge observation station (Pisco river)

Observation Station	Latitude	Longitude	Elevation (m.a.s.l.)
LETRAYOC	13°40’	75°45’	640

2) Yearly maximum daily discharge

The yearly maximum daily discharge of each year is as shown in the Table-3.1.9.2-6.

Table-3.1.9.2-6 Yearly maximum daily discharge (Pisco river) (m^3/s)

Year	Yearly Maximum Daily Discharge	Year	Yearly Maximum Daily Discharge
1933	227.50	1971	194.45
1934	264.50	1972	509.87
1935	311.00	1973	293.62
1936	360.50	1974	194.68
1937	956.03	1975	141.88
1938	253.70	1976	237.62
1939	328.67	1977	231.26
1940	155.34	1978	80.33
1941	212.25	1979	213.13
1942	326.79	1980	91.23
1943	301.93	1981	252.00
1944	295.05	1982	274.00
1945	250.01	1983	273.00
1946	528.14	1984	485.65
1947	144.09	1985	200.50
1948	765.10	1986	355.00
1949	148.26	1987	146.20
1950	156.33	1988	369.50
1951	289.09	1989	272.50
1952	208.05	1990	49.38

1953	427.20	1991	325.00
1954	536.64	1992	47.75
1955	403.42	1993	118.00
1956	330.99	1994	312.50
1957	256.19	1995	354.37
1958	169.35	1996	190.00
1959	378.26	1997	150.00
1960	312.85	1998	800.00
1961	272.04	1999	355.00
1962	423.06	2000	215.00
1963	255.85	2001	240.00
1964	238.45	2002	300.00
1965	162.44	2003	176.25
1966	710.02	2004	215.00
1967	521.91	2005	137.50
1968	189.11	2006	350.00
1969	314.07	2007	250.00
1970	454.31	2008	300.00

(4) Majes-Camana river

1) Discharge observation station

The discharge observation station in Majes-Camana river is as shown in the Table-3.1.9.2-7.

Table-3.1.9.2-7 Discharge observation station(Majes-Camana river)

Observation Station	Latitude	Longitude	Elevation (m.a.s.l.)
Huatiapa	15°59'41.0" S	72°28'13.0" W	700
Puente Carretera Camaná	16°36'00.0" S	72°44'00.0"W	122

2) Yearly maximum daily discharge

The yearly maximum daily discharge of each year is as shown in the Table-3.1.9.2-8.

Table-3.1.9.2-8 Yearly maximum daily discharge (Majes-Camana river) (m^3/s)

Huatiapa

Year	Max.Discharge
1945	620.00
1946	619.00
1947	580.79
1948	506.50
1949	1012.80
1950	458.33
1951	687.32
1952	592.50
1953	980.00
1954	980.00
1955	2400.00
1956	445.30
1957	316.00
1958	985.50
1959	1400.00
1960	600.00
1965	171.94
1966	237.00
1967	420.00
1968	442.55
1969	308.60
1970	362.00
1971	356.00
1972	633.00
1973	1040.00
1974	902.00
1975	748.00
1976	514.00
1977	592.00
1978	1600.00
1979	410.00
1980	415.00
1981	1000.00
1982	345.00
1983	23.20
1984	1025.00
1986	750.00
2006	590.87
2007	366.33
2008	418.50
2009	400.22

Puente Carretera Camaná

Year	Max.Discharge
1961	301.10
1962	399.87
1963	340.16
1971	340.72
1972	800.42
1973	750.19
1974	950.00
1975	890.00
1977	1200.00
1978	2000.00
1979	150.70
1980	89.00
1981	530.00
1982	300.00
1983	40.00
1984	1300.00
1986	600.00

3.1.9.3 Probable Flood Discharge Based on Observation Data

The reference point for run-off analysis was selected among the observation stations in each basin, and where the flood discharge with return period from 2years to 100 years are calculated based on the observation data of yearly maximum daily discharge by statistical processing.

The results of calculation are as shown in the Table-3.1.9.3-1.

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

・Distribution Normal or Gaussiana

・Log - Normal 3 parameters

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

Table-3.1.9.3-1 Probable discharge at reference point

(m^3/s)

River/Reference Point	Return Period of 2years	Return Period of 5years	Return Period of 10years	Return Period of 25 years	Return Period of 50 years	Return Period of 100 years
Cañete/ Socsi	313	454	547	665	753	840
Chincha/ Conta	179	378	536	763	951	1,156
Pisco/ Letrayoc	267	398	500	648	774	914
Majes-Camana/ Huatiapa	560	901	1,169	1,565	1,906	2,292

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

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

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

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

(1) Summary of HEC-HMS system

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

Constant, Exponential, Green Ampt etc.

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

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

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

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

(1) Preparation of basin model
(2) Rainfall analysis
  1) Calculation of probable 24-hour rainfall in each station
  2) Calculation of 24-hour rainfall in each sub-basin
  3) Selection of type of 24-hour rainfall curve
(3) Calculation of infiltration loss by SSC method
  1) Selection of initial curve number in each sub-basin
  2) Selection of final curve number in each sub-basin
  3) Verification of model
(4) Calculation of probable flood discharges and their flood hydrograph

(2) Preparation of basin model

1) Division of basin

Majes-Camana basin is divided into 4 sub-basins each of which has similar hydraulic characteristics, such as topography, distribution pattern of river channel, forestation conditions, surface soil conditions etc. The division of the basin is as shown in the Figure -3.1.9.4-1.

2) Preparation of basin model

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

Figure-3.1.9.4-1 Division of Majes-Camana basin

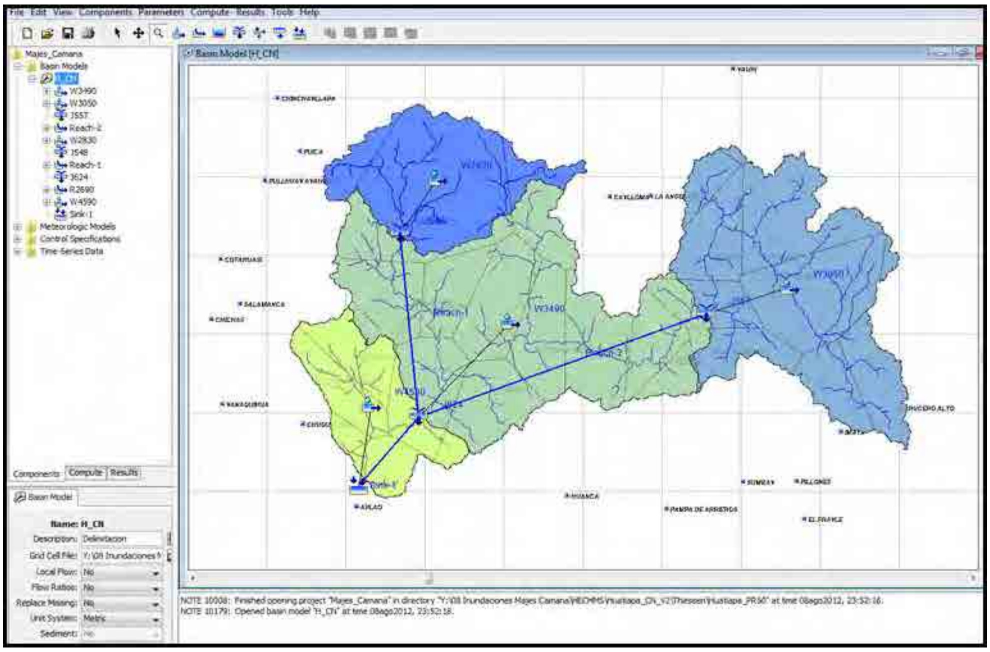


Figure-3.1.9.4-2 HEC-HMS model of Majes-Camana basin

(3) Rainfall analysis

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

1) Probable 24-hour daily rainfall

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

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

	Coordinates			Precipitation for T (years)						
Station	Latitude	Longitude	Altitude (masl)	2	5	10	25	50	100	200
Andahua	15° 29'37	72° 20'57	3538	24.30	31.33	34.83	38.29	40.33	42.02	43.43
Aplao	16° 04'10	72° 29'26	625	1.71	5.03	7.26	9.51	10.71	11.56	12.14
Ayo	15° 40'45	72° 16'13	1950	10.28	16.43	20.51	25.66	29.48	33.27	37.05
Cabanaconde	15° 37'7	71° 58'7	3369	26.58	37.88	45.89	56.58	64.95	73.67	82.79
Camaná	16° 36'24	72° 41'49	29	3.18	7.16	9.79	13.11	15.58	18.03	20.46
Caravelí	15° 46'17	73° 21'42	1757	7.67	16.07	22.60	31.46	38.30	45.21	52.15
Chachas	15° 29'56	72° 16'2	3130	22.21	28.60	32.08	35.83	38.24	40.37	42.30
Chichas	15° 32'41	72° 54'59.7	2120	16.28	23.47	27.01	30.37	32.23	33.67	34.80
Chiguata	16° 24'1	71° 24'1	2945	18.88	29.98	37.33	46.40	52.94	59.27	65.42
Chinchayllapa	14° 55'1	72° 44'1	4514	23.12	31.21	36.57	43.34	48.37	53.35	58.32
Chivay	15° 38'17	71° 35'49	3663	24.50	32.74	38.20	45.09	50.21	55.29	60.35
Choco	15° 34'1	72° 07'1	3160	16.10	22.92	27.45	33.16	37.39	41.60	45.79
Chuquibamba	15° 50'17	72° 38'55	2839	21.65	36.96	47.09	59.89	69.39	78.82	88.21
Cotahuasi	15° 22'29	72° 53'28	5086	21.20	29.97	35.78	43.12	48.56	53.96	59.35
Crucero Alto	15° 46'1	70° 55'1	4486	25.33	31.66	35.20	39.10	41.67	44.02	46.17
El Frayle	16° 05'5	71° 11'14	4110	22.33	29.95	35.43	42.89	48.83	55.12	61.82
Huambo	15° 44'1	72° 06'1	3500	22.87	30.14	34.96	41.05	45.57	50.05	54.52
Imata	15° 50'12	71° 05'16	4451	28.35	37.09	42.87	50.18	55.60	60.98	66.34
La Angostura	15° 10'47	71° 38'58	4260	35.90	45.89	53.22	63.31	71.46	80.18	89.57
La Joya	16°35'33	71°55'9	1279	1.22	4.74	7.89	11.93	14.65	16.98	18.92
La Pampilla	16° 24'12.2	71° 31'.6	2388	12.65	21.64	27.66	35.01	40.23	45.20	49.94
Lagunillas	15° 46'46	70° 39'38	4385	28.55	34.30	37.75	41.81	44.67	47.40	50.05
Las Salinas	16° 19'5	71° 08'54	3369	18.05	25.72	30.80	37.22	41.98	46.70	51.41
Machahuay	15° 38'43	72° 30'8	3000	21.06	29.80	34.71	40.03	43.45	46.46	49.14
Madrigal	15° 36'59.7	71° 48'42	3238	23.63	30.07	33.66	37.59	40.17	42.50	44.63
Orcopampa	15° 15'39	72° 20'20	3805	21.51	29.58	36.83	48.66	59.81	73.37	89.92
Pampa de Arrieros	16° 03'48	71° 35'21	3720	18.86	32.08	40.82	51.88	60.07	68.21	76.32
Pampa de Majes	16° 19'40	72° 12'39	1442	2.07	6.68	10.56	15.55	18.98	22.04	24.69
Pampacolca	15° 42'51	72° 34'3	2895	21.13	29.11	34.40	41.08	46.04	50.95	55.86
Pampahuta	15° 29'1	70° 40'33.3	4317	34.18	39.66	42.87	46.58	49.14	51.57	53.89
Pillones	15° 58'44	71° 12'49	4428	24.00	32.95	38.88	46.36	51.92	57.43	62.92
Porpera	15° 21'1	71° 19'1	4142	27.40	40.61	49.37	60.42	68.63	76.77	84.88
Pullhuay	15° 09'1	72° 46'1	3098	24.47	32.43	37.63	44.15	48.97	53.77	58.60
Salamanca	15° 30'1	72° 50'1	3153	19.86	26.64	31.13	36.81	41.02	45.20	49.36
Sibayo	15° 29'8	71° 27'11	3839	31.25	38.61	42.98	48.06	51.59	54.93	58.13
Sumbay	15° 59'1	71° 22'1	4300	25.43	35.57	43.10	53.56	62.08	71.26	81.17
Tisco	15° 21'1	71° 27'1	4198	33.41	42.74	51.24	65.12	78.15	93.95	113.15
Yanaquihua	15° 46'59.8	72° 52'57	2834	20.70	35.78	45.76	58.38	67.74	77.03	86.29

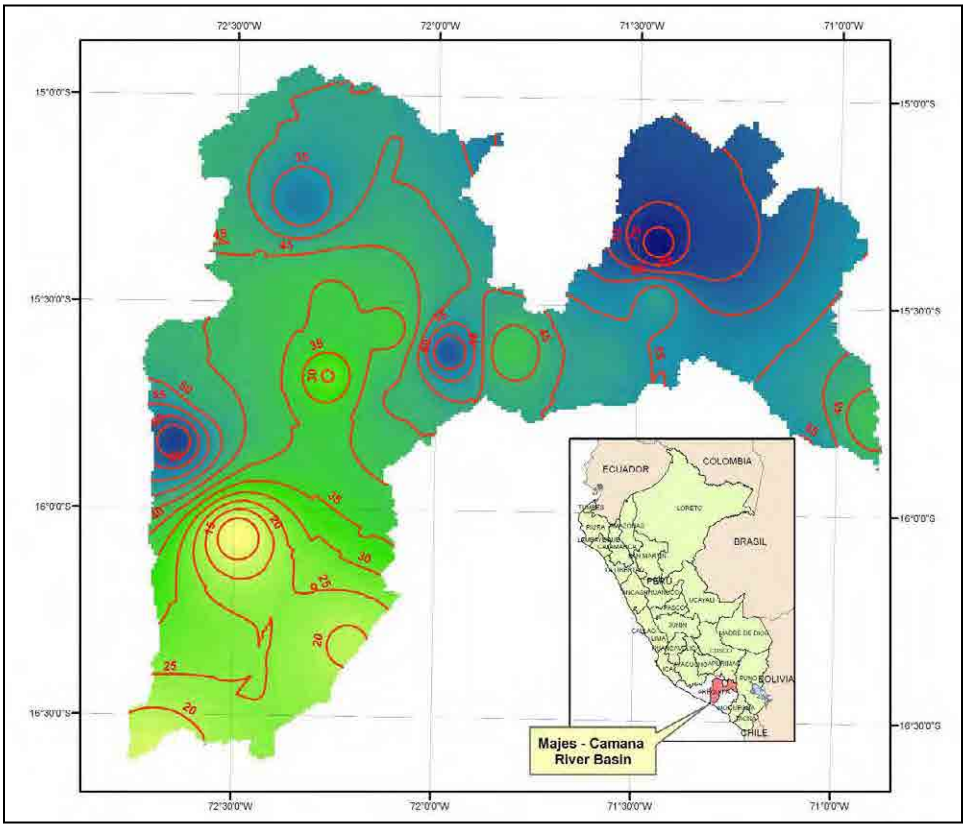


Figure-3.1.9.4-3 Isohyetal map of 24-hour rainfall with return period of 50-year (Majes-Camana basin)

2) 24-hour Rainfall in Sub-basin

Based on the 24-hour maximum rainfall and using the method of Thiessen polygons rainfalls were calculated for each sub-basin. Figure- 3.1.9.4-4 shows the Thiessen polygons and distribution of rainfall stations.

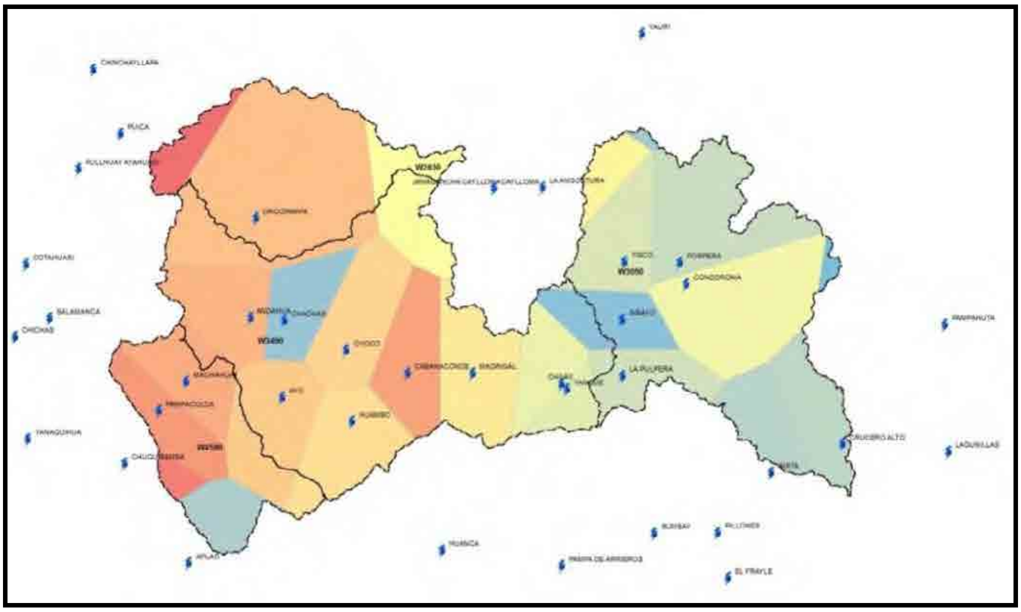


Figure- 3.1.9.4-4 Thiessen polygons and distribution of rainfall stations

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

Table -3.1.9.4-2 Probabilistic rainfall for each sub-basin (Majes-Camaná)

Sub-Basin	Average Areal Rainfall (mm.)				
	T5	T10	T25	T50	T100
W2830	29.60	36.80	48.68	59.96	73.45
W3050	38.20	46.10	55.14	62.47	70.23
W3490	29.25	34.14	40.63	45.15	50.03
W4590	23.05	27.70	33.23	36.98	40.77

3) Selection of type of 24-hour rainfall curve

There is not hourly rainfall observation data but 24-hour rainfall observation data (daily rainfall data) so that the hourly data cannot but being estimated by 24-hour rainfall data.

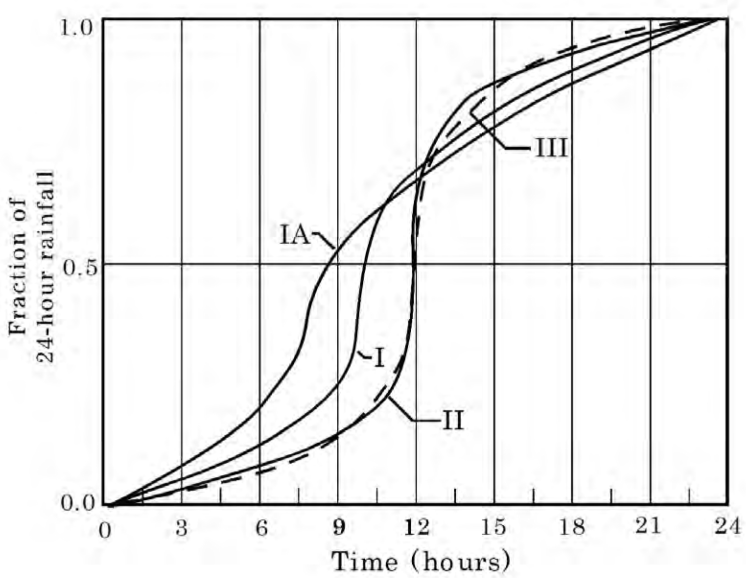
SCS (Soil Conservation Service) hypothetical storm which is generally used in HEC-HMS is used for 24-hour rainfall curve.

This method is developed through the analysis of rainfall data in USA, which is expressed 4 types of rainfall curve with non-dimension as shown in the Table-3.1.9.4-3 and the Figure-3.1.9.4-5. The distribution of rainfall is as shown in the Figure-3.1.9.4-6 assuming time interval. And the applied area of 4 types in USA is as shown in the Figure-3.1.9.4-7, according to which the type II is recommended to be applied to major part of USA. In addition to this it is said that 24-hour rainfall can be applicable for most of basins.

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

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

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



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

Figure-3.1.9.4-5 Distribution of 24hour rainfall in each type

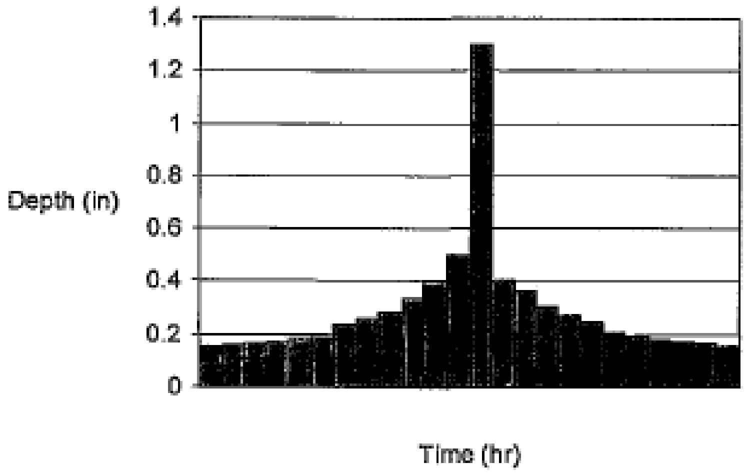
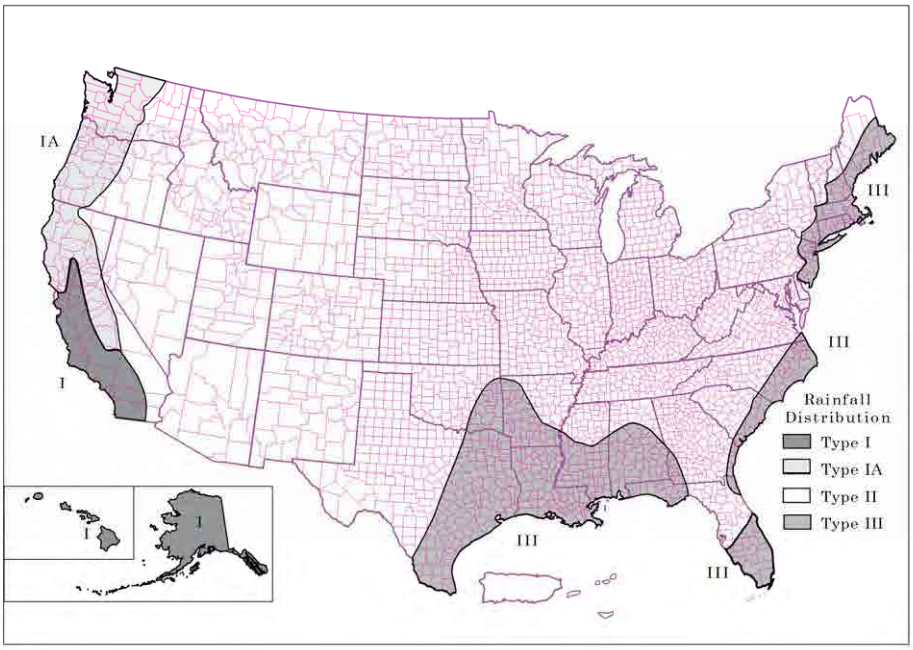


Figure-3.1.9.4-6 Division of 24-hour rainfall



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

Figure-3.1.9.4-7 Type of 24-hour rainfall and applied area

(4) Excess rainfall by SSC method

1) Basic formula

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

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

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

Assuming Ia = 0.2 S

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

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

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

Assuming CN, the relation Pe and P is calculated as shown the Figure-3.1.9.4-8.

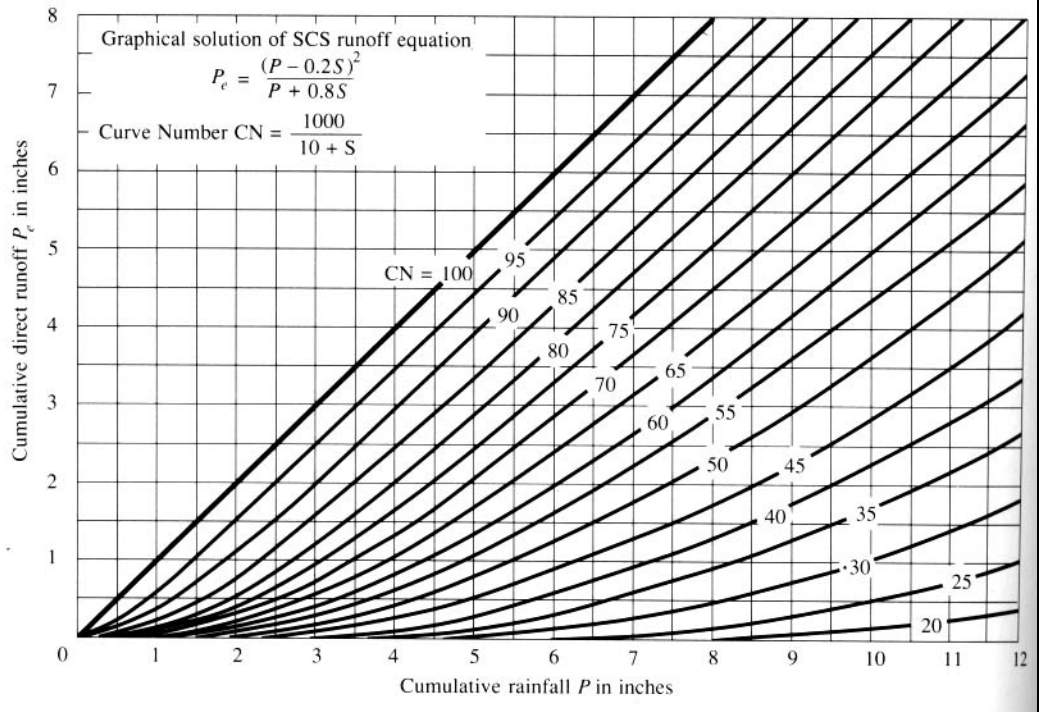


FIGURE 5.5.2
Solution of the SCS runoff equations. (*Source:* Soil Conservation Service, 1972, Fig. 10.1, p. 10.21)

Figure-3.1.9.4-8 Relation among CN, P and P_e

2) Selection of CN in sub-basin

Referring to the Table-3.1.9.4-5 and based on the land use and soil conditions, CN of each sub-division is determined as shown in the Figure-3.1.9.4-9 and the Table-3.1.9.4-4.

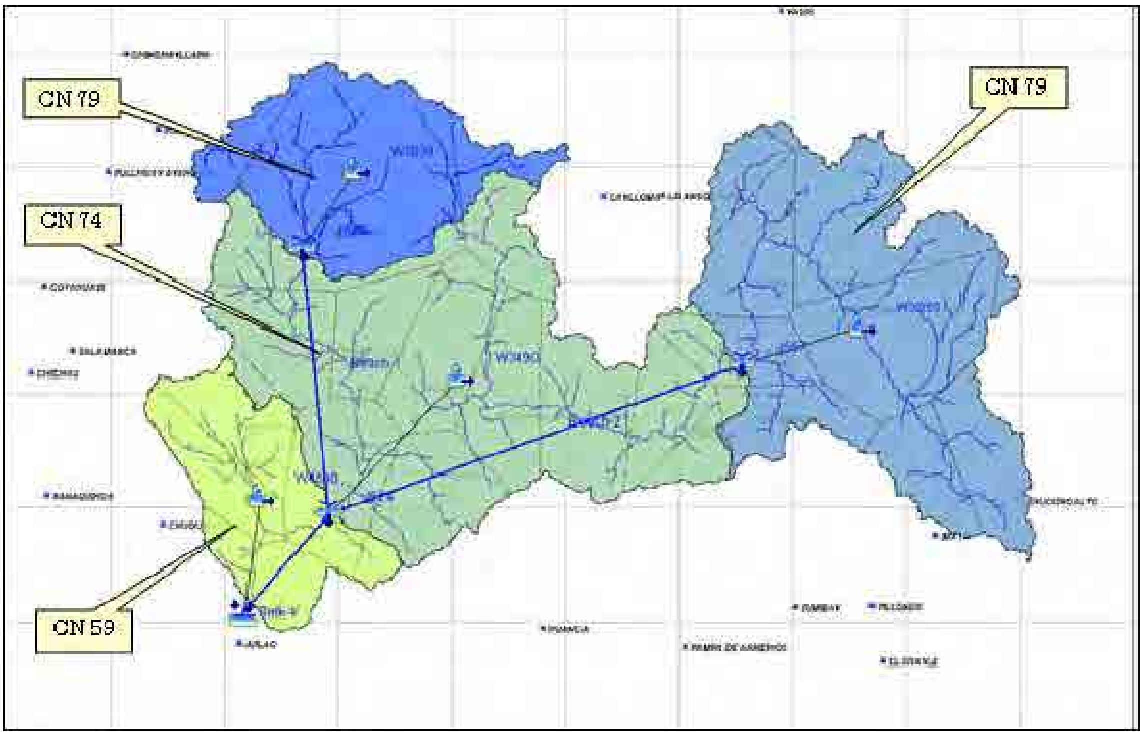


Figure-3.1.9.4-9 Final CN value in Majes-Camana basin

Table-3.1.9.4-4 Final CN value in Majes-Camana basin

Sub-basin	Condition of Sub-basin	CN Value
Upper Basin – Colca(W3050)	Barren area with scarce vegetation.	79
Middle Basin – Colca(W3490)	Pastures, shrub, small trees.	74
Upper Basin – Andahua(W2830)	Barren area with scarce vegetation.	79
Lower Basin – Majes(W4590)	Desert, hyper arid area	59

Table-3.1.9.4-5(1) CN value depending on land use and soil conditions (1/3)

TABLE 5.5.2
Runoff curve numbers for selected agricultural, suburban, and urban land uses (antecedent moisture condition II, $I_a = 0.2S$)

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

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

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

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

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

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

Table3.1.9.4-5(2) CN value depending on land use and soil conditions (2/3)

TABLE 5.5.1 SCS Runoff Curve Numbers *(Continued)*

c. Other agricultural areas

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

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

d. Arid and semiarid range areas

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

Table-3.1.9.4-5(3) CN value depending on land use and soil conditions (3/3)

TABLE 5.5.1 SCS Runoff Curve Numbers *(Continued)*

d. Arid and semiarid range areas

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

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

Source: Maidment (1993).

Note: Hydrological Soil Group

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

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

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

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

(5) Probable flood discharge and hydrograph

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

The calculation results are as shown in the Table-3.1.9.4-6～3.1.9.4-8 and the Figure-3.1.9.4

-10~Figure-3.1.9.4-13, and which are to be used for discharge capacity analysis of river channel, inundation analysis and flood protection planning.

Table 3.1.9.4-6 Probable flood discharge

(m^3/s)

River/Reference Point	Return Period of 2-year	Return Period of 5-year	Return Period of 10-year	Return Period of 25-year	Return Period of 50-year	Return Period of 100-year
Cañete/ Socsi	331	408	822	1,496	2,175	2,751
Chincha/ Conta	203	472	580	807	917	1,171
Pisco/ Letrayoc	213	287	451	688	855	962
Majes-Camana/ Huatiapa	360	638	1,007	1,566	2,084	2,703

Table 3.1.9.4-7 Probable specific flood discharge

($m^3/s/km^2$)

River/Reference Point	ReturnPeriod of 2-year	ReturnPeriod of 5-year	ReturnPeriod of 10-year	ReturnPeriod of 25-year	ReturnPeriod of 50-year	ReturnPeriod of 100-year	BasinArea Km2
Cañete/ Socsi	0.058	0.072	0.145	0.264	0.383	0.485	5,676
Chincha/ Conta	0.068	0.158	0.195	0.271	0.308	0.393	2,981
Pisco/ Letrayoc	0.069	0.093	0.147	0.224	0.279	0.313	3,070
Majes-Camana/ Huatiapa	0.024	0.050	0.078	0.122	0.162	0.210	12,854

＊Basin area is up stream of reference point

Table 3.1.9.4-8 Comparison of historical maximum discharge and the peak discharge calculated (t=50)

(m^3/s)

Basin/Base point	Historical Maximum Discharge	Measurement Period	Calculated Peak Discharge (t=1/50)
Cañete Socsi	900	81	2,175
Chincha Conta	1,203	57	917
Pisco Letrayoc	957	76	855
Majes-Camaná Huatiapa	2,400	41	2,084

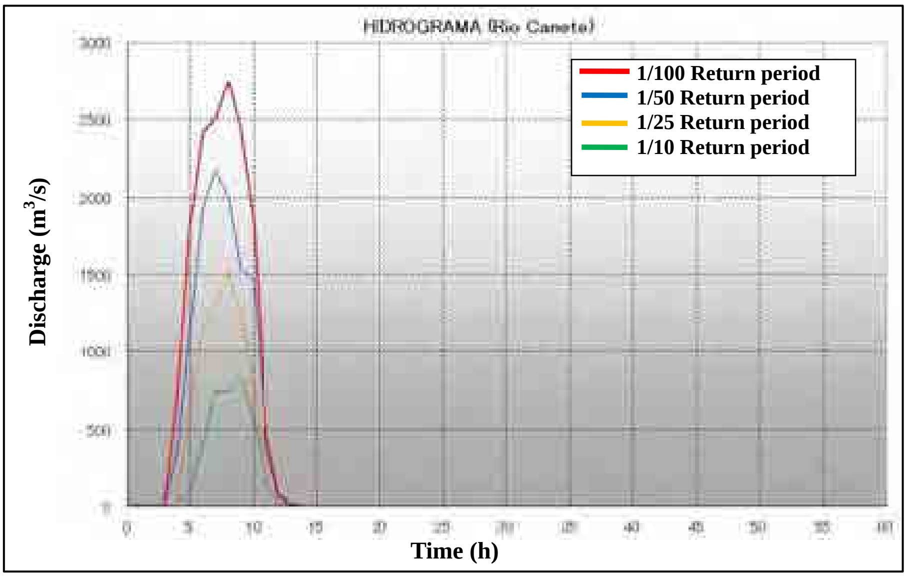


Figure-3.1.9.4-10 Flood hydrograph in Cañete basin

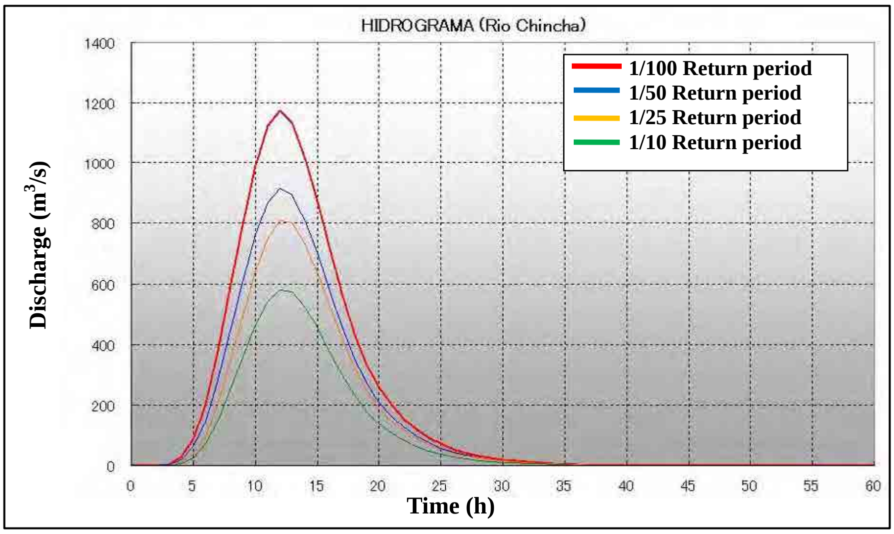


Figure-3.1.9.4-11 Flood hydrograph in Chincha basin

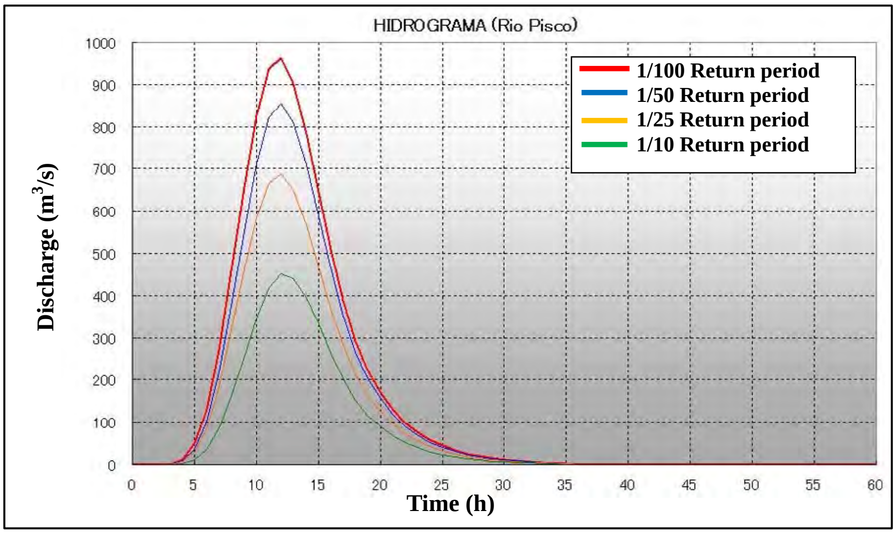


Figure-3.1.9.4-12 Flood hydrograph in Pisco basin

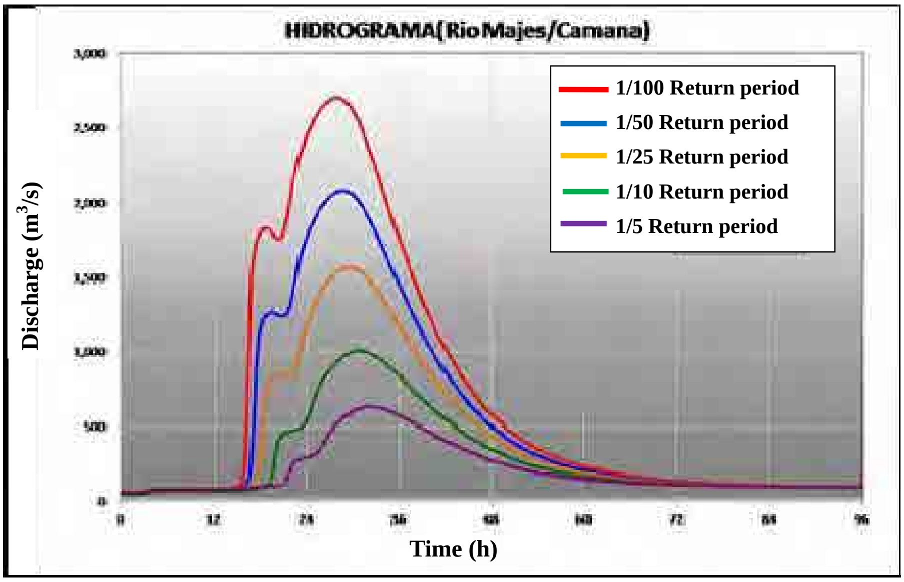


Figure-3.1.9.4-13 Flood hydrograph in Majes-Camana basin

3.1.9.5 Consideration on Results of Analysis

(1) Verification of peak discharge

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

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

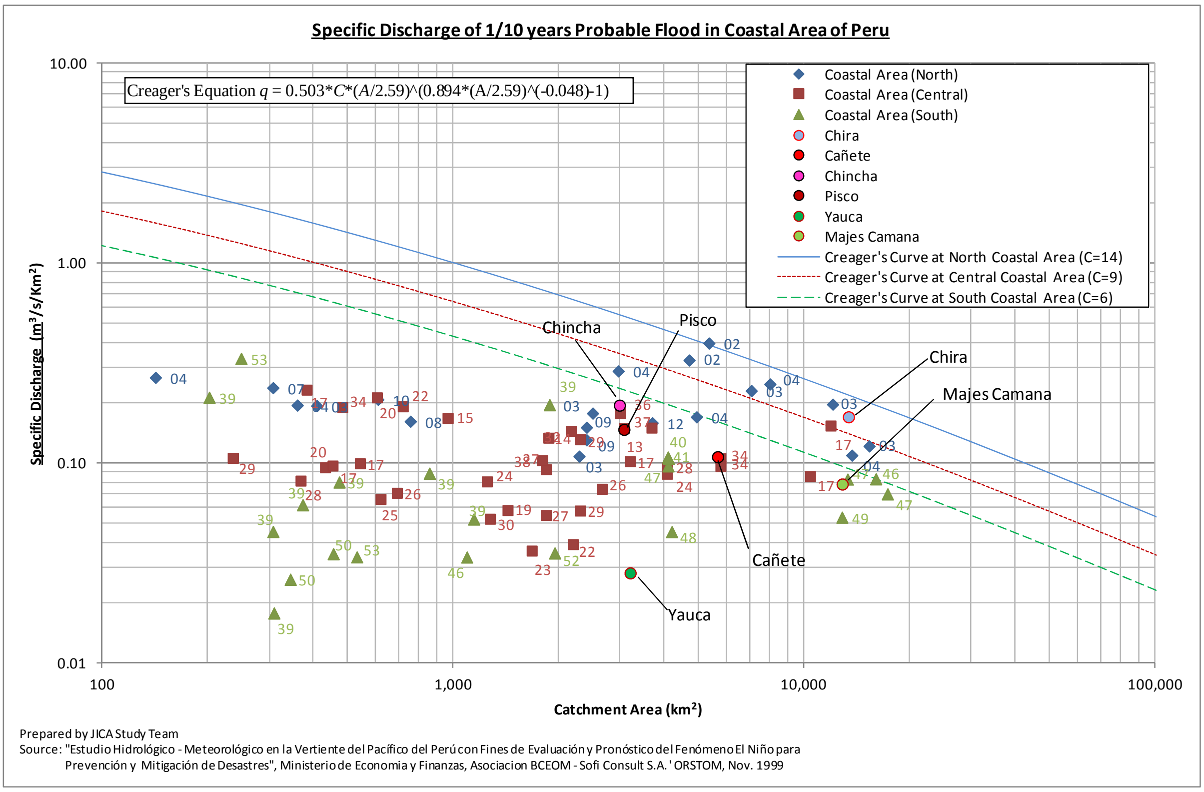


Figure 3.1.9.5-1 Probabilistic specific discharges and calculated peak discharges (t=1/10)

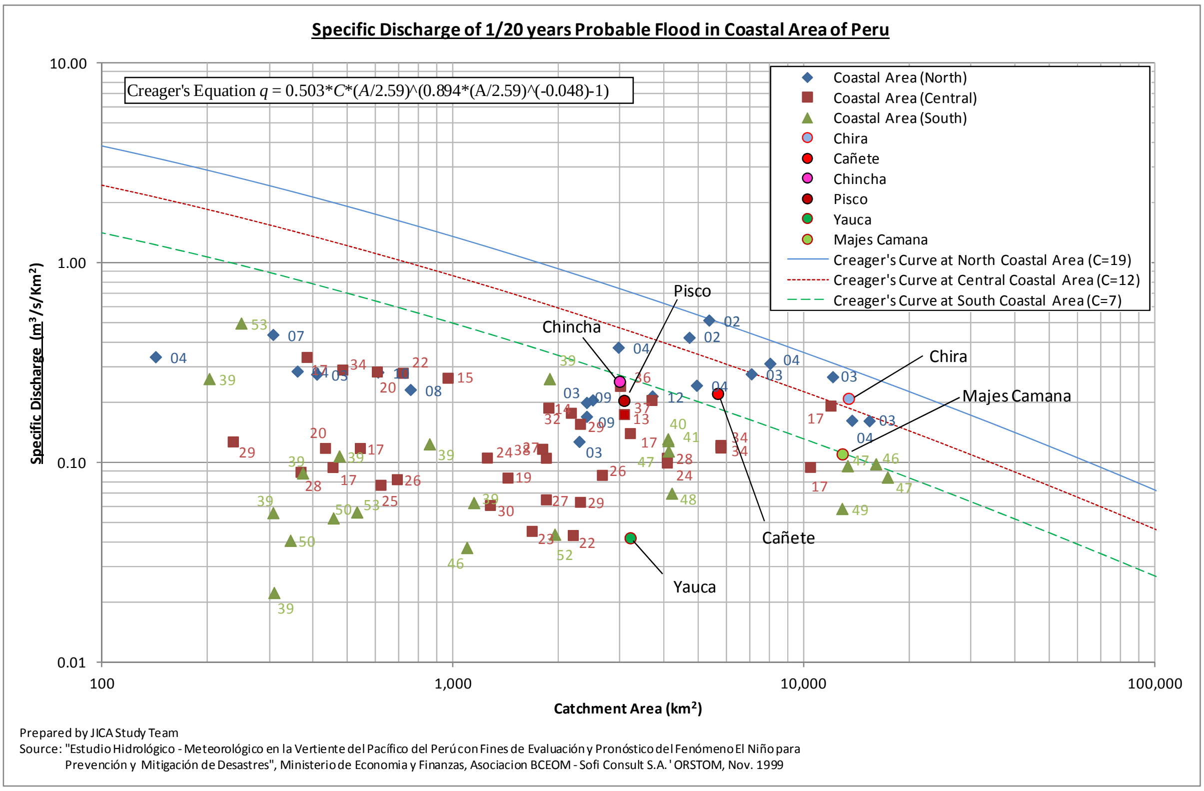


Figure 3.1.9.5-2 Probabilistic specific discharges and calculated peak discharges (t=1/20)

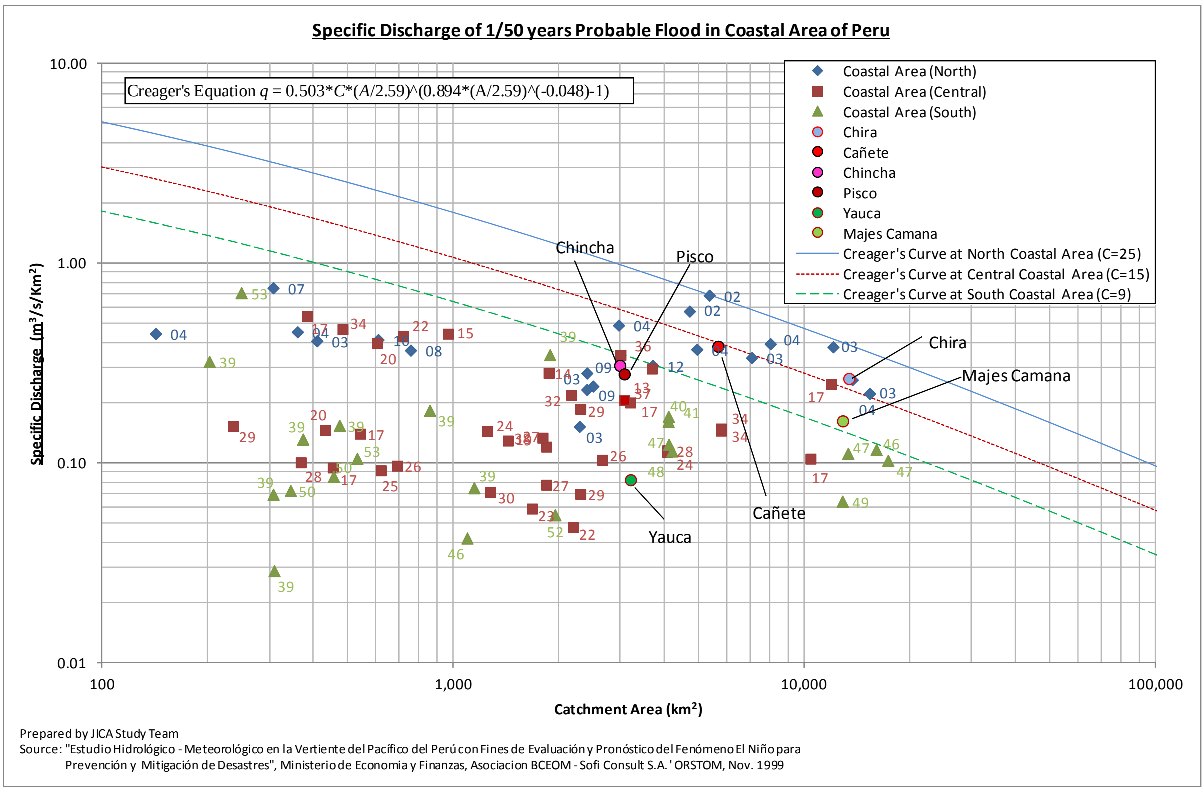


Figure 3.1.9.5-3 Probabilistic specific discharges and calculated peak discharges (t=1/50)

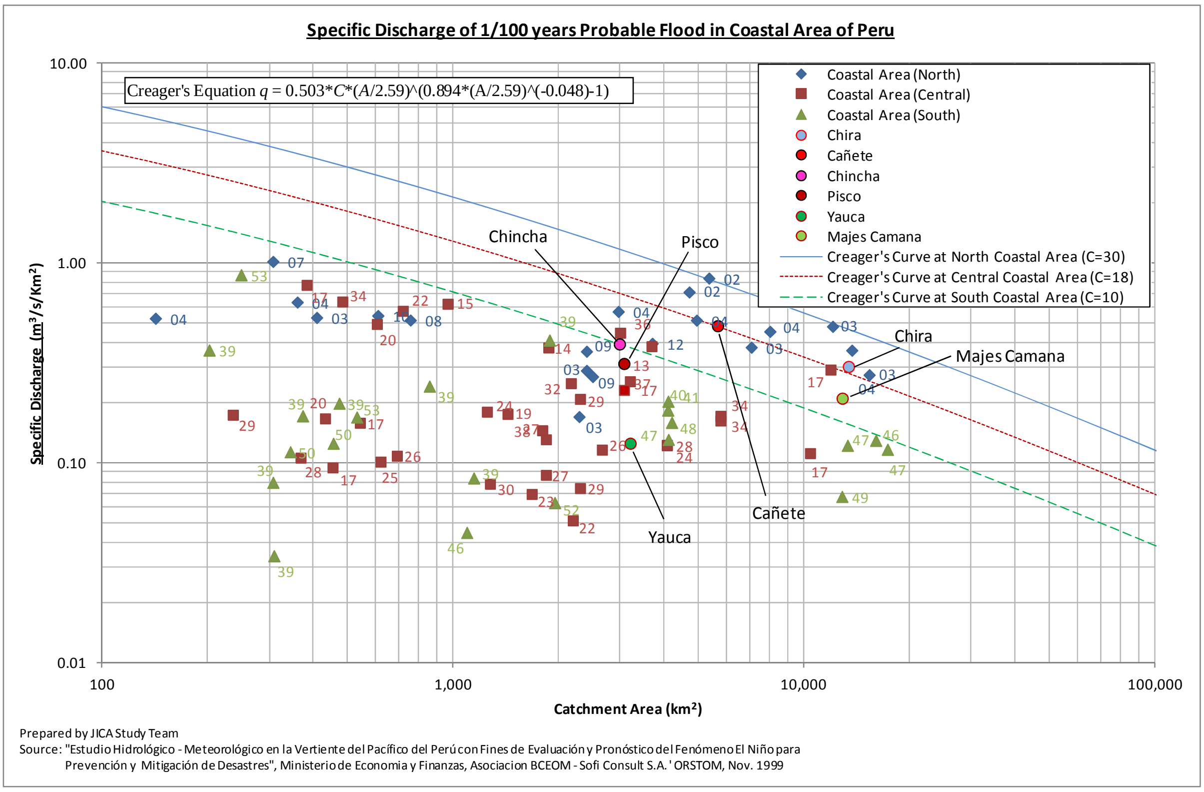


Figure 3.1.9.5-4 Probabilistic specific discharges and calculated peak discharges (t=1/100)

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

1) Upper Limit of Discharge Observation in Socsi Station

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

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

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

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

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

The maximum observation record in the past is 900 m3/sec, and which is almost equal to the above discharge, that is to say, the discharge more than this value is difficult to measure in this station. The Socsi observation station seems to have the upper limit of measurable discharge as shown above, therefore the observation station is to be removed to the appropriate place as soon as possible.

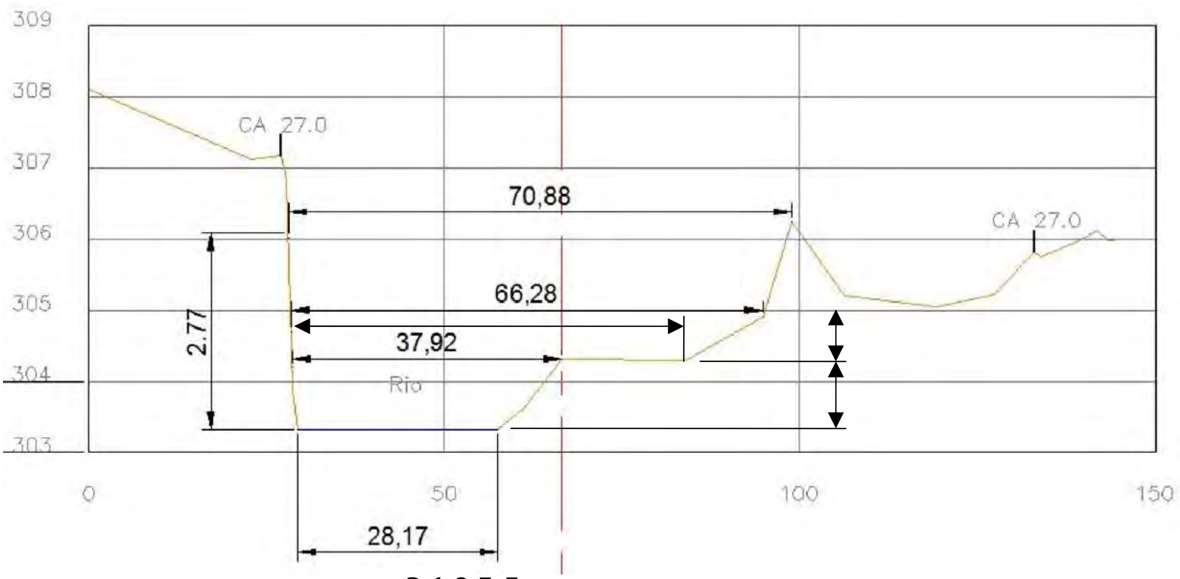


Figure-3.1.9.5-5 Cross section at Socsi station

2) Comparison with adjacent basin for probable flood discharge

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

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

i) Run-off characteristics

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

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

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

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

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

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

ii) Rainfall characteristics

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

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

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

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

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

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

3) Evaluation of probable observation discharge in Cañete basin

a) Probable Specific Discharge at Reference Point

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

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

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

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

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

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

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

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

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

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

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

(ratio, m3/sec)

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

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

(Conclusion)

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

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

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

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

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

3.1.10 Analysis of Inundation

(1) River surveys

Prior to the flood analysis, the transversal survey 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 Summary of the river surveys

Item	Unit	Qty	Remarks
1.Base Point Survey			one point/10km
Chincha	No.	6	
Pisco	No.	5	
Cañete	No.	4	
Majes-Camana	No.	13	
Total	No.	28	
2.Longitudinal Survey of Bank			
Chincha	km	50	25kmx2 rivers
Pisco	km	45	
Cañete	km	33	
Majes-Camana	km	130	
Total		258	
3.Cross Section Survey of River			Interval:500m
Chincha	km	38.0	
Pisco	km	54.6	
Cañete	km	46.9	
Majes-Camana	km	78.0	
Total		217.5	
4. Base Point Installation			
Base Point & BM	No.	28	
Distance Mark	No.	258	one point/ 1.0km

(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 use this method, and review and modify it, if necessary.

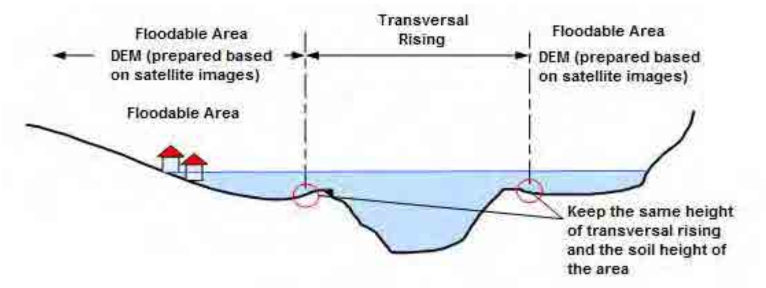
1) Analysis basis

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

① Varied flow uni-dimensional model

② Tank model

③ Varied flow horizontal bi-dimensional model

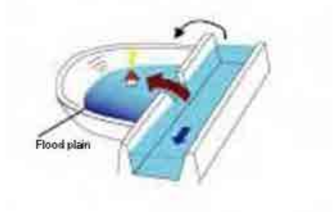
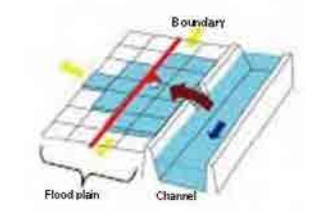


3.1.10-1 Image of one dimension model

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 Model	**One-dimensional non uniform-flow model**	**Pond model**	**Horizontal-two-dimensional-unsteady-flow model**
Concept for setup of inundation areas	The flood plain is also treated as a part of main channel, and the inundation area is set up by the computation of water level in the main channel equivalent to the peak discharge of the flood.	The flood plain and the main channel are separated and the flood plain is dealt with as one “closed domain”. This unified domain is called "pond" and the flood water level in it is the same. The inundation area is set up from the relation of the flood volume overflowed from the main channel into the flood plain and the topographical feature (water level-capacity (volume)-area) in the flood plain.	The flood plain and the main channel are dealt with separately. The inundation area is set up by analyzing the behavior of the inundation flow from the channel to the flood plain as two-dimensional fluid movement.
Image of models			
Characteristics of the Model	It can apply to the “flow-down-type” flood which inundation flow down along river. The inundation analysis area is dealt as “non-dike condition” taking account the characteristic of the analysis model.	It can apply to the “non-spreading-type” flood which is surrounded by mountains, high lands embankments, etc. Since the inundation in the closing domain treats as same water surface gradient and no flow velocity, and water level is assumed as the same. However, when continuous embankments exist in the inundation area, the domain of hinterland is classified and required to be treated as “multi-pond model”.	It is fundamentally applicable in any Inundation Type. Not only the maximum inundation area or the maximum flood level but also the inundation flow velocity or those temporal changes are reproducible. Moreover, the calculation accuracy is also generally high as compared with other methods. Therefore, there are many operating experiences also in the creation of the possible inundation area map. However, the inundation analysis accuracy is limited depending on the grid size of the analytic model on the characteristic of the model.

2） Overflow analysis method

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

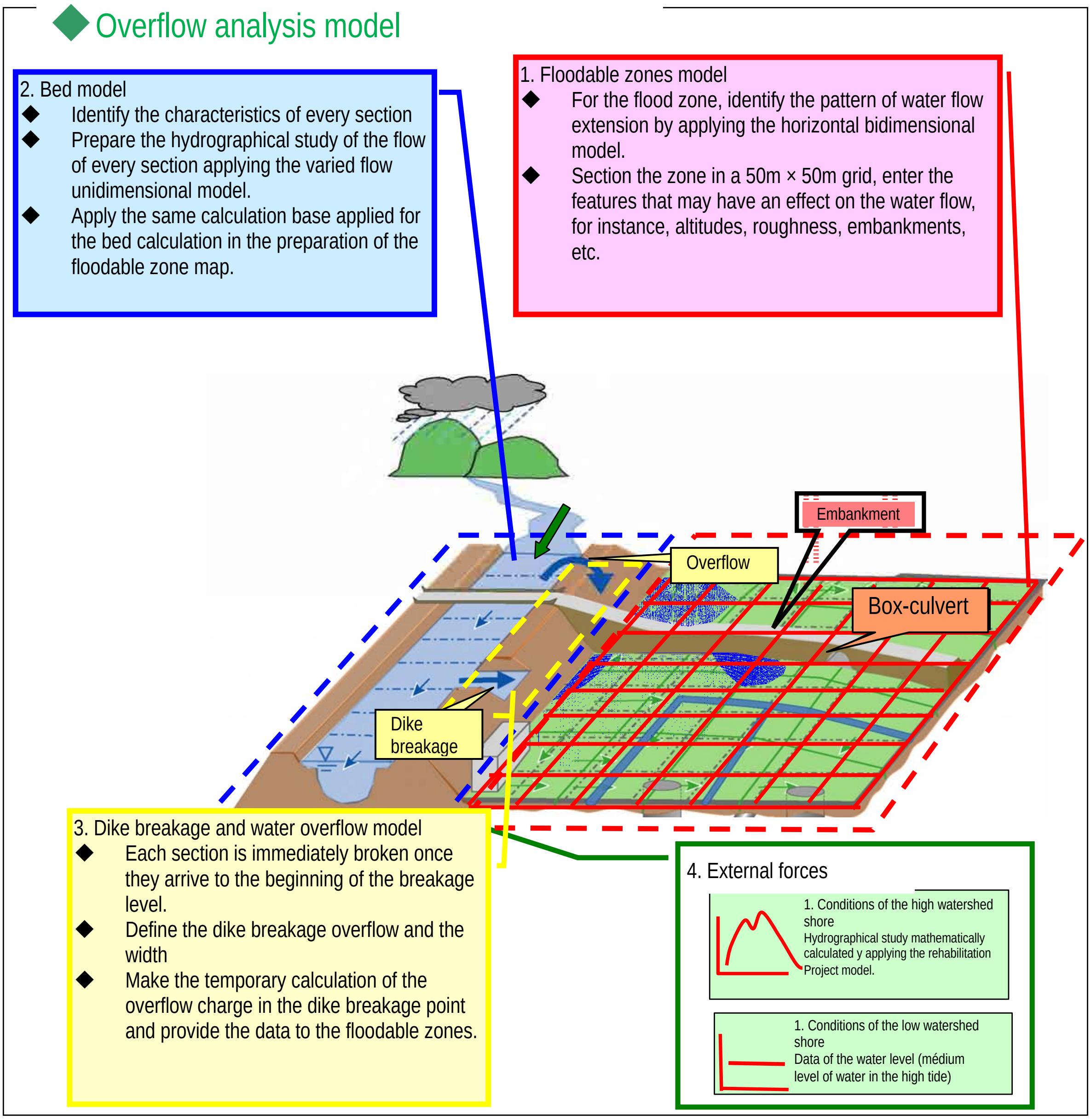


Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge capacity analysis

The current discharge capacity of the river 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~Figure 3.1.10-8. This Figure also shows the flooding flows of different return periods obtained by run-off analysis, which allow evaluating in what points of each watershed inundation may happen and what magnitude of flood flow may they have.

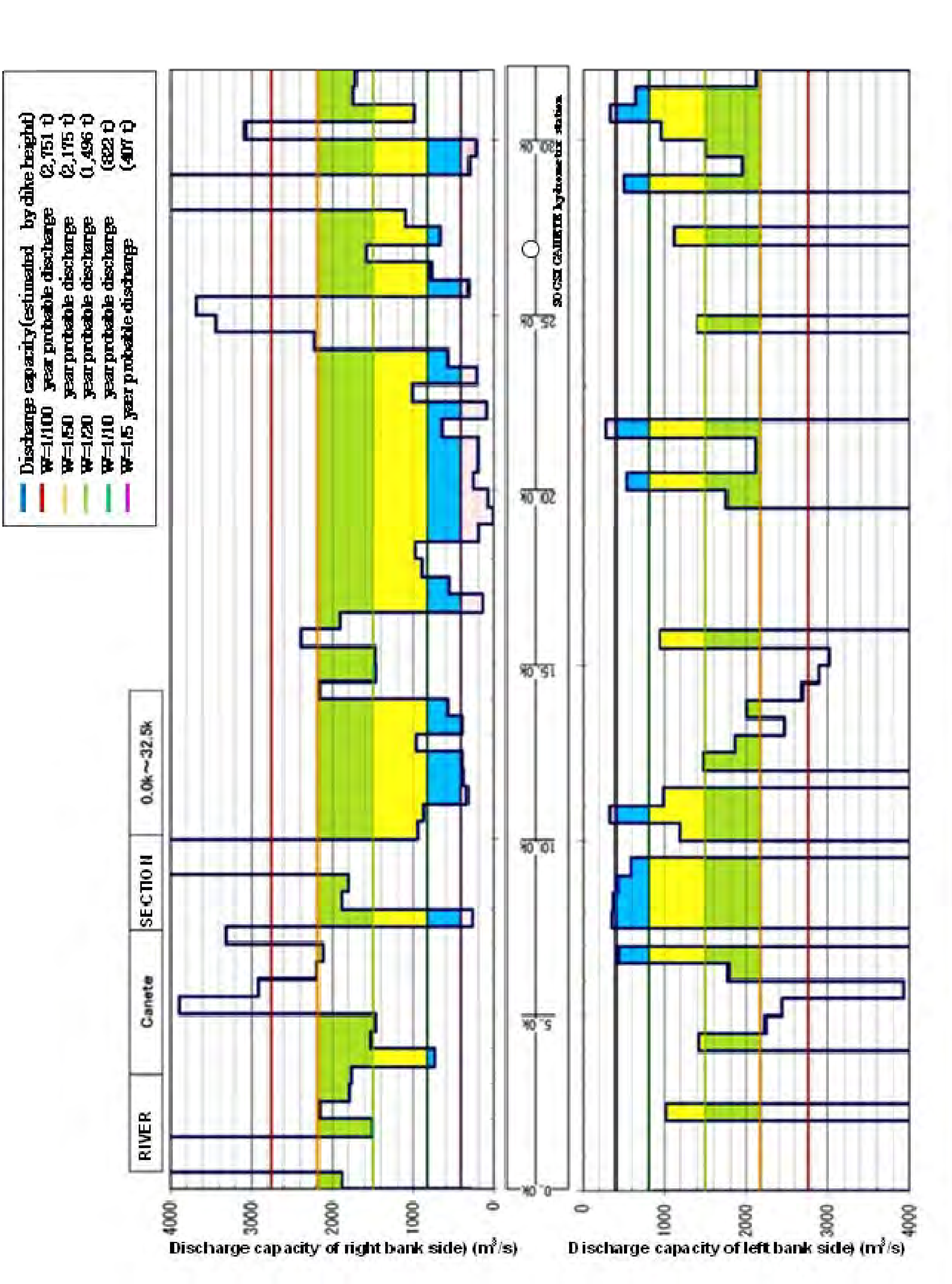


Figure 3.1.10-3 Current discharge capacity of Cañete river

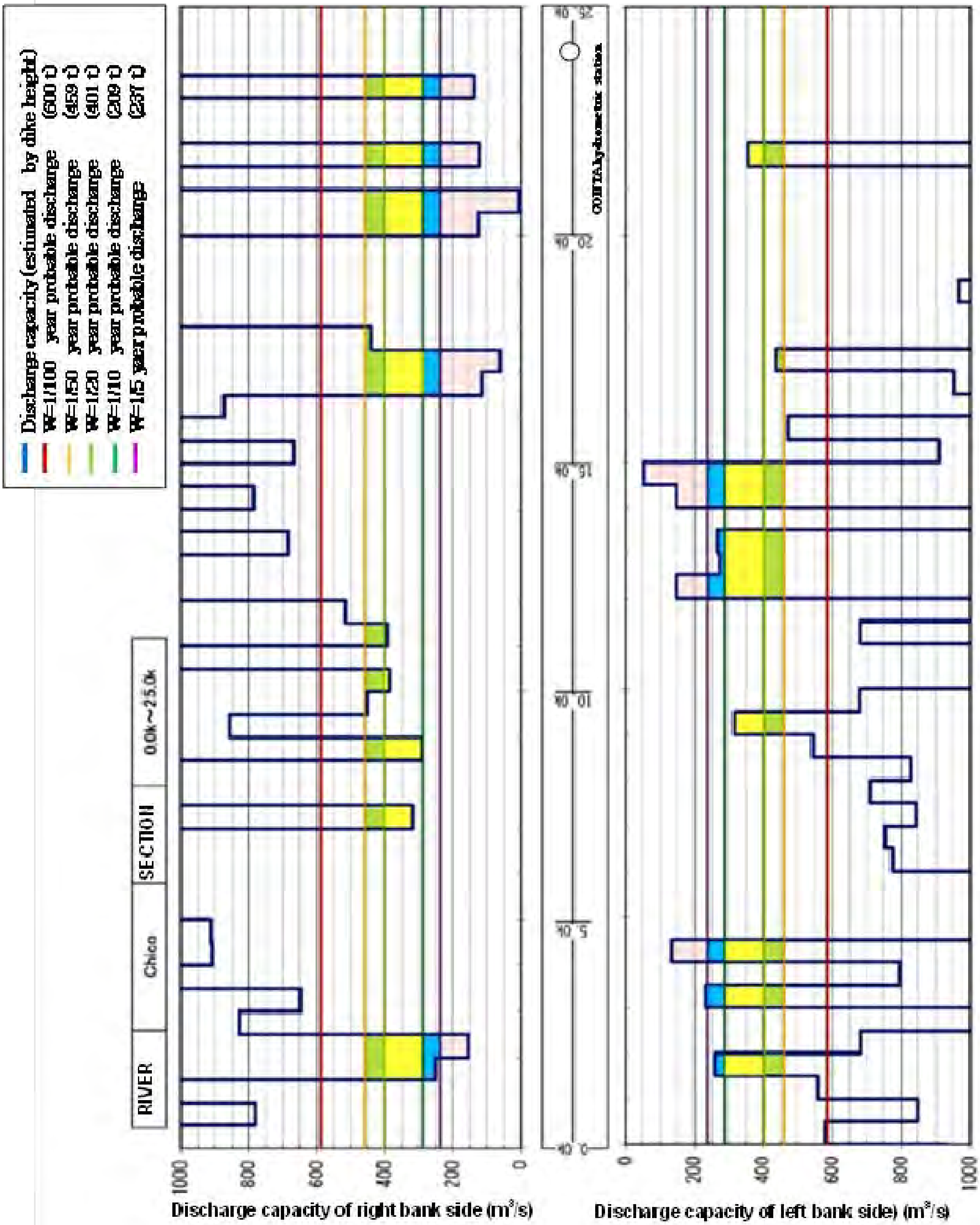


Figure 3.1.10-4 Current discharge capacity of Chico river

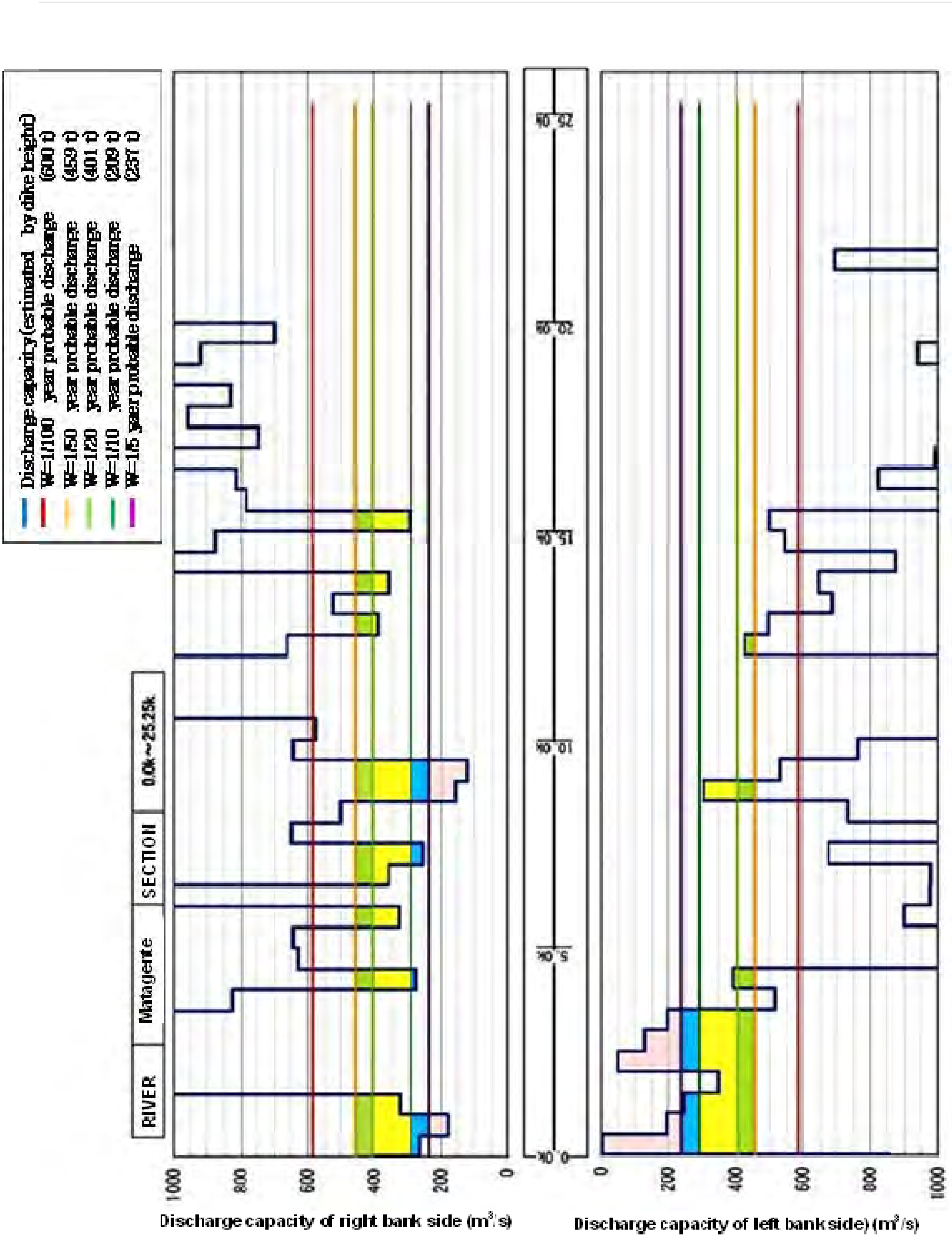


Figure 3.1.10-5 Current discharge capacity of Matagente river

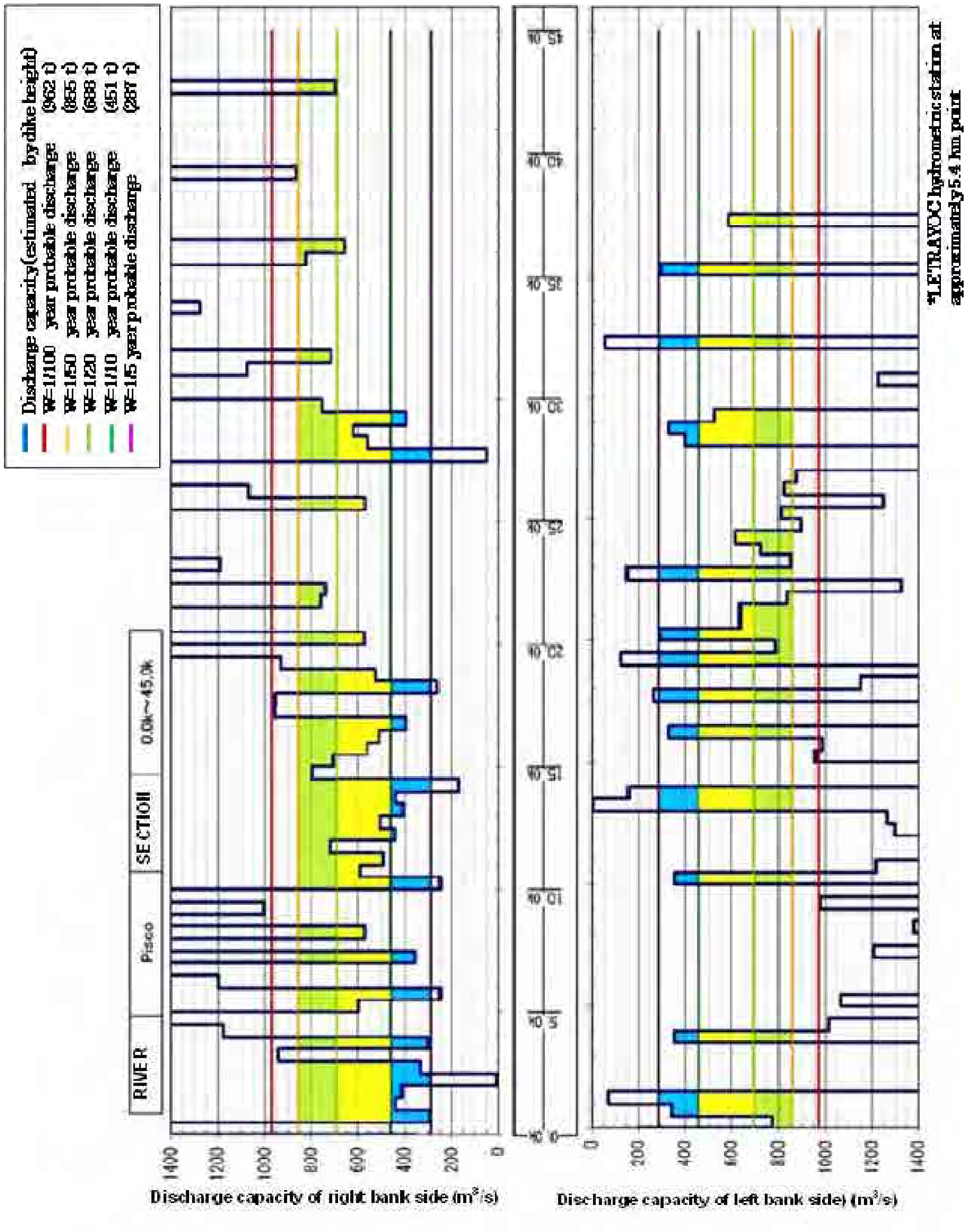


Figure 3.1.10-6 Current discharge capacity of Pisco river

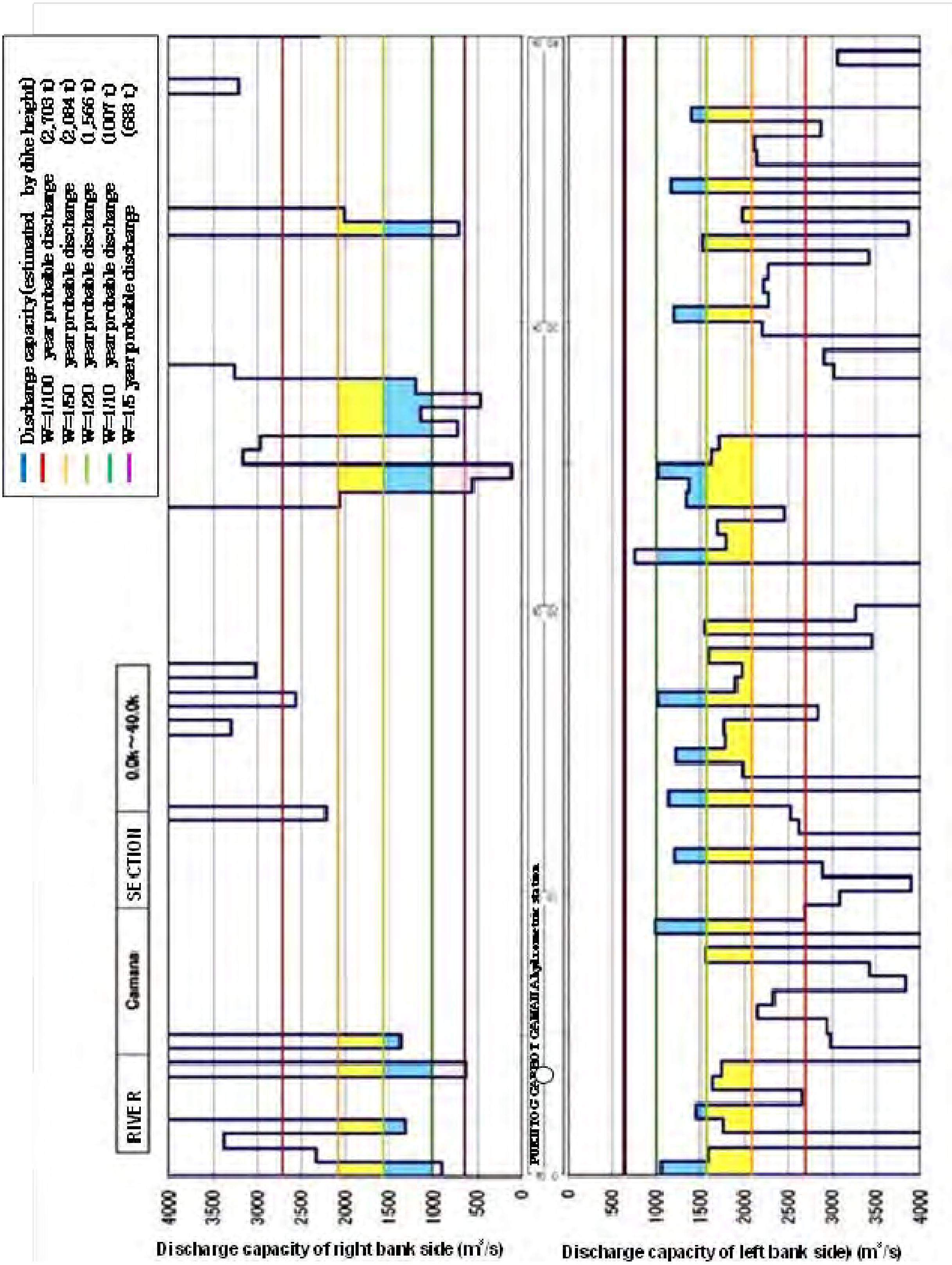


Figure 3.1.10-7 Current discharge capacity of Camana river

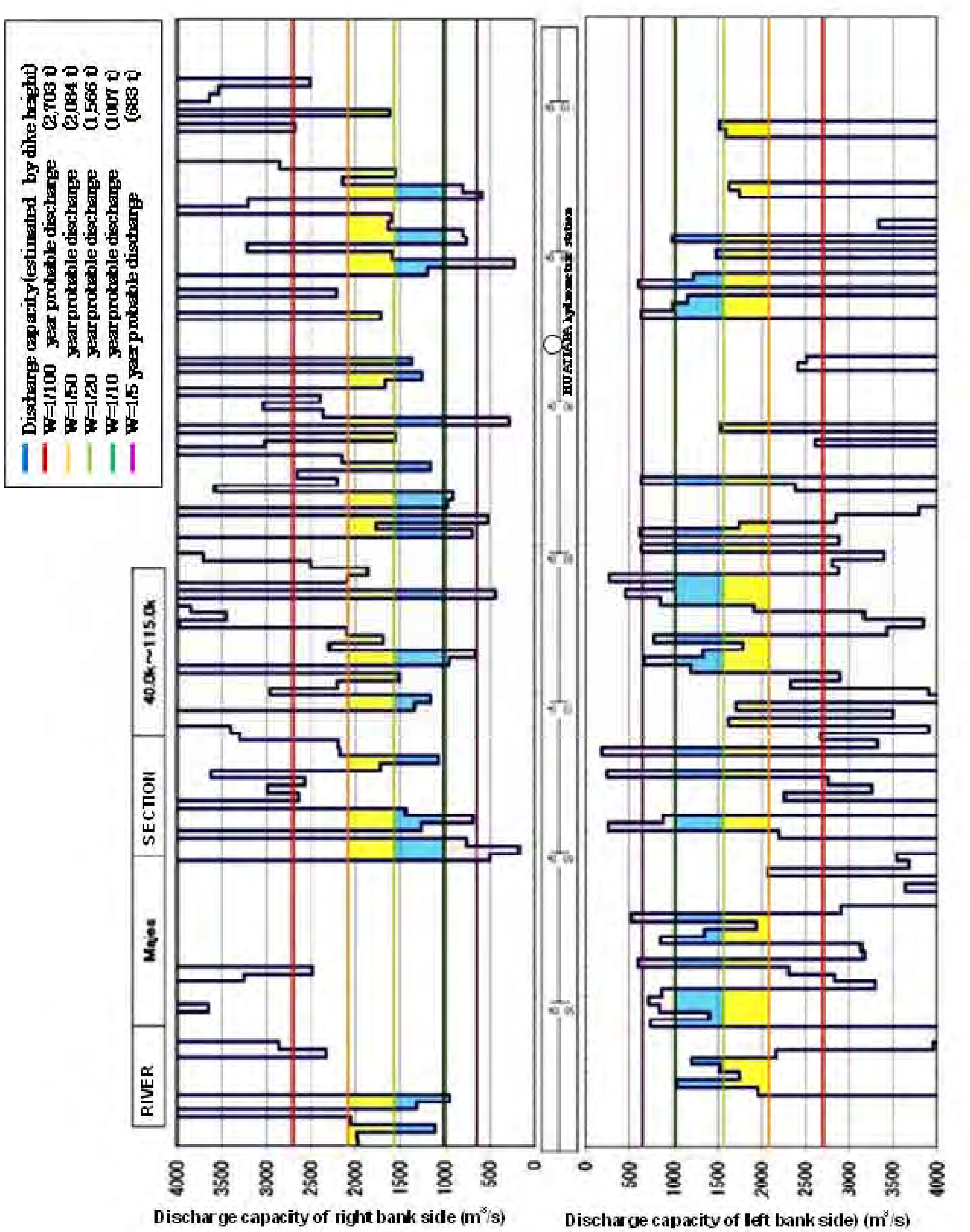


Figure 3.1.10-8 Current discharge capacity of Majes river

(4) Inundation area

As a reference, Figures 3.1.10-9 and 3.1.10-13 show the results of the inundation area calculation in each watershed compared to the flooding flow with a 50 year return period.

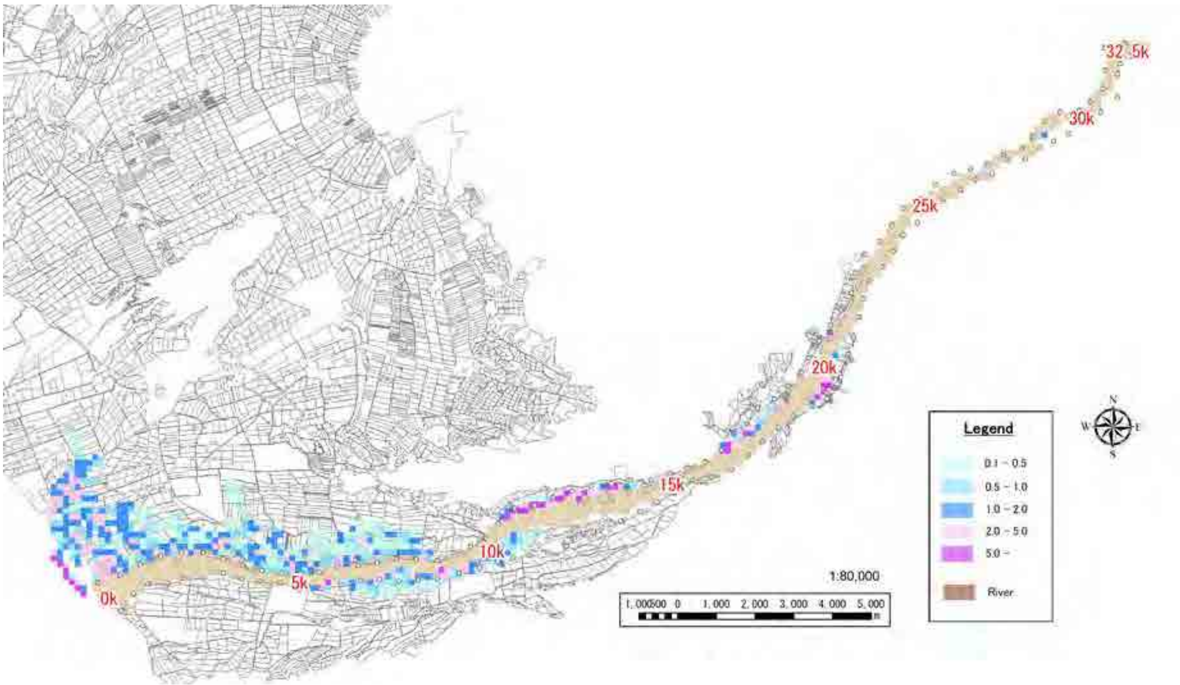


Figure 3.1.10-9 Inundation area of Cañete river (50 year period floods)

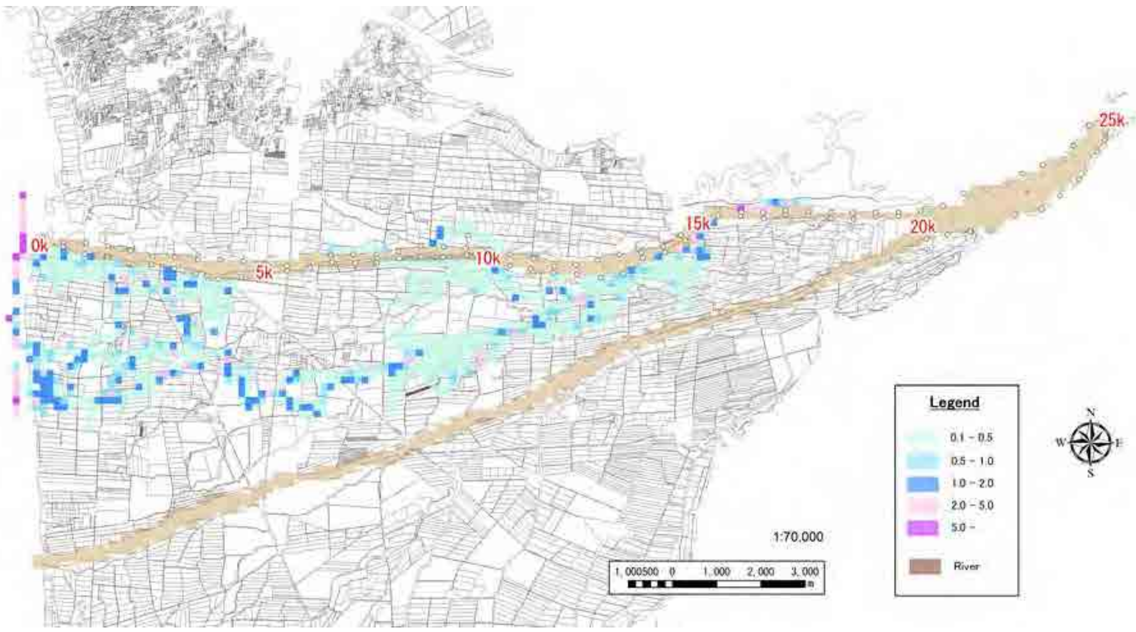


Figure 3.1.10-10 Inundation area of Chincha river – Chico (50 year period floods)

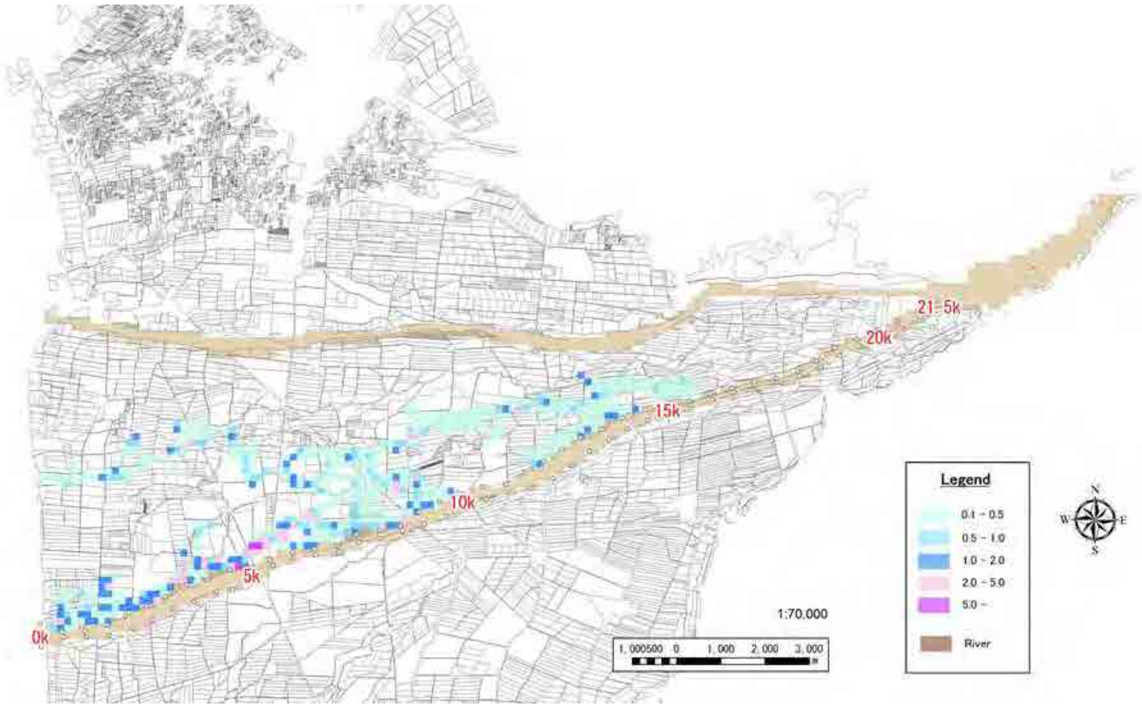


Figure 3.1.10-11 Inundation area of Chincha river (Matagente) - (50 year period floods)

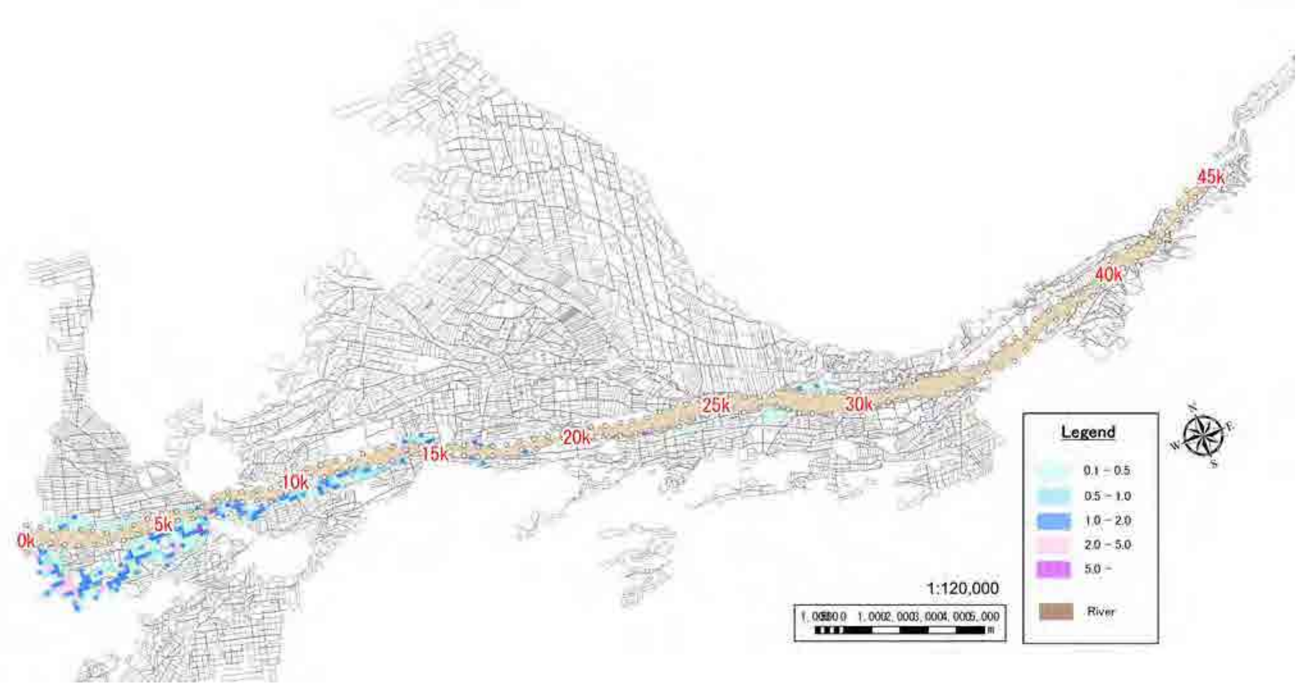


Figure 3.1.10-12 Inundation area of Pisco river - (50 year period floods)

Figure 3.1.10-13(1) Inundation area of Majes-Camana river - (50 year period floods)

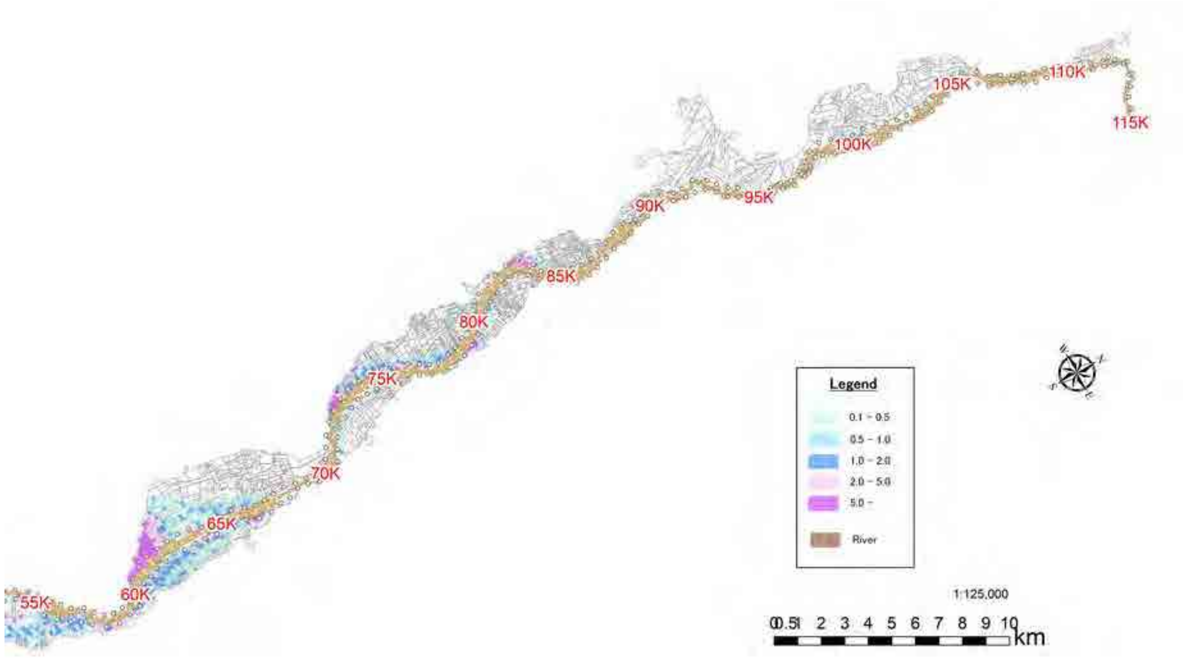


Figure 3.1.10-13(2) Inundation area of Majes-Camana river - (50 year period floods)

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 six selected watersheds study, 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		○					
	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 margins 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 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.

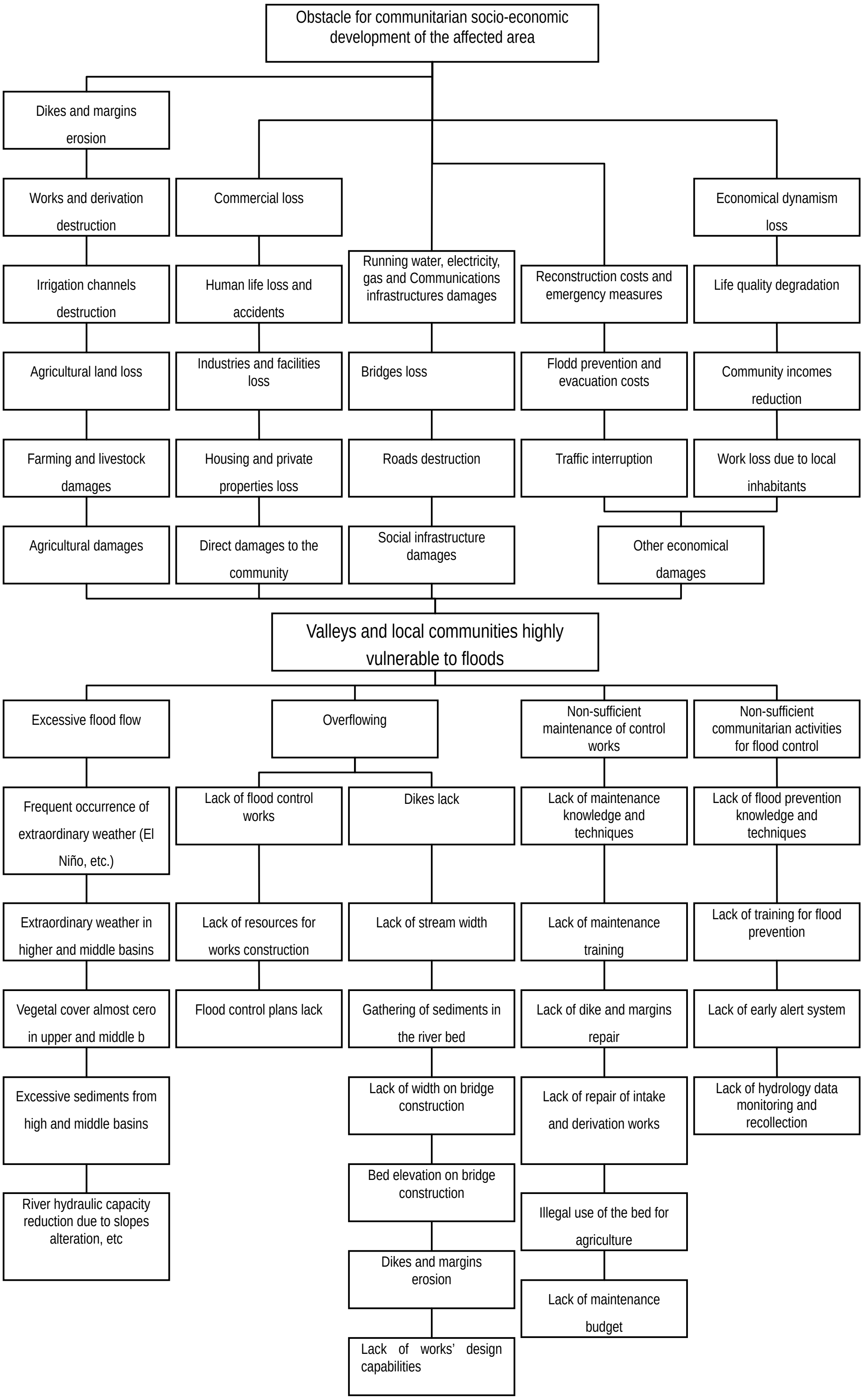


Figure 3.2.4-1 Causes and effects diagram

3.2.5 Objective of the Project

(1) Main objective

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.

(2) Direct and indirect measures

In Table 3.2.5-1, direct and indirect solutions measures for the problem are shown.

Table 3.2.5-1 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		

3.2.6 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 3.2.6-1 direct and indirect impacts expected to fulfill the main objective to achieve the final impact are shown.

Table 3.2.6-1 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

3.2.7 Measures - Objectives – Impacts Diagram

In Figure 3.2.7-1 the measures - objectives – impacts diagram is shown.

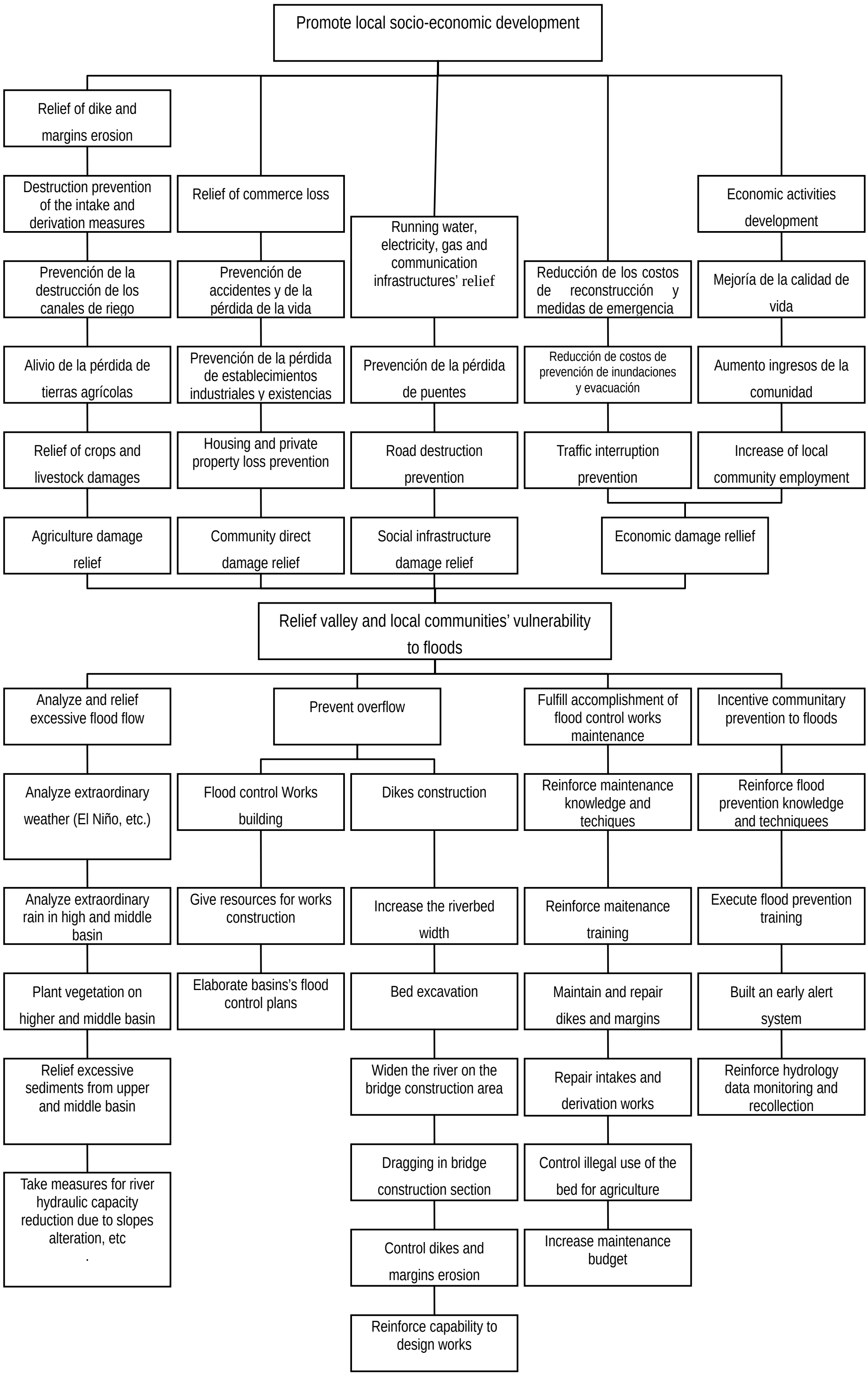


Figure 3.2.7-1 Measures - objectives – impacts diagram