(3) Challenges and measures

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

1) Challenge 1: 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

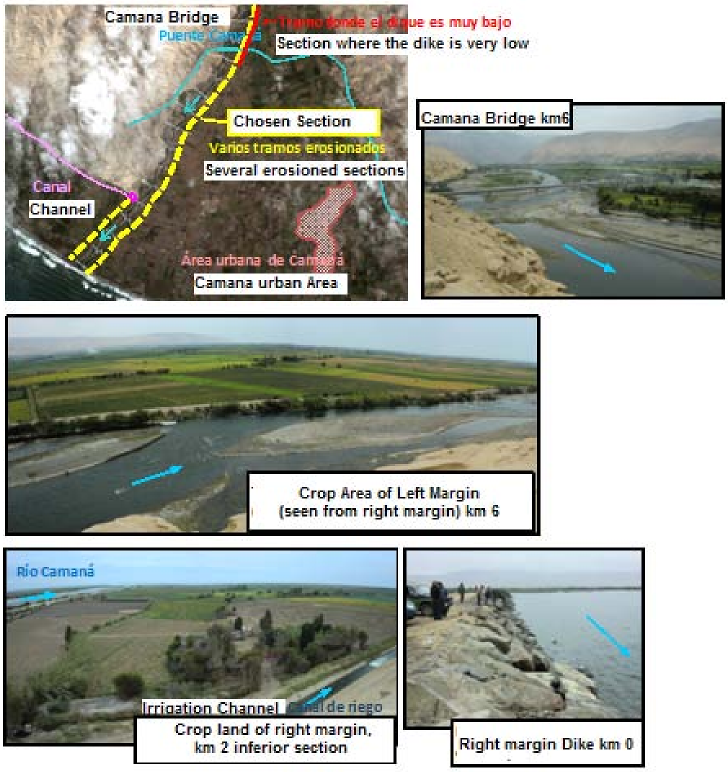


Figure 3.1.6-3 Local conditions related with Challenge 1 (Camana River)

2) 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

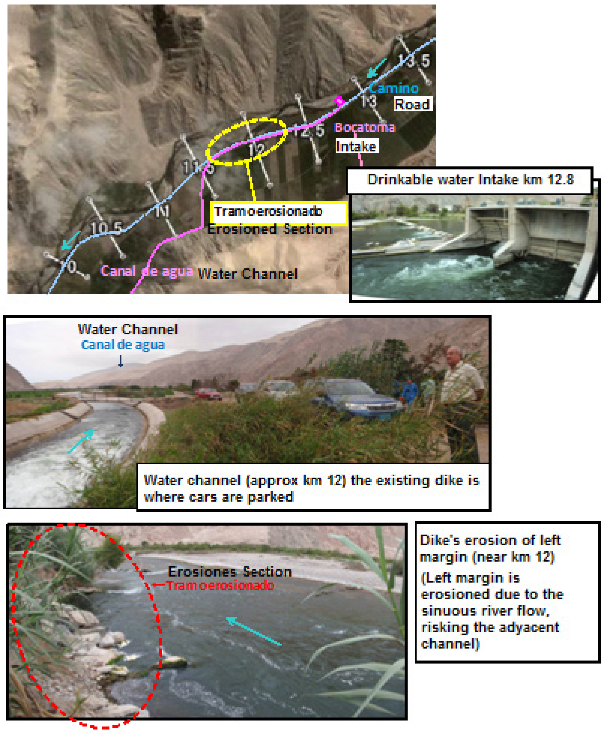


Figure 3.1.6-4 Local conditions related with Challenge 2 (Camana River)

3) 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

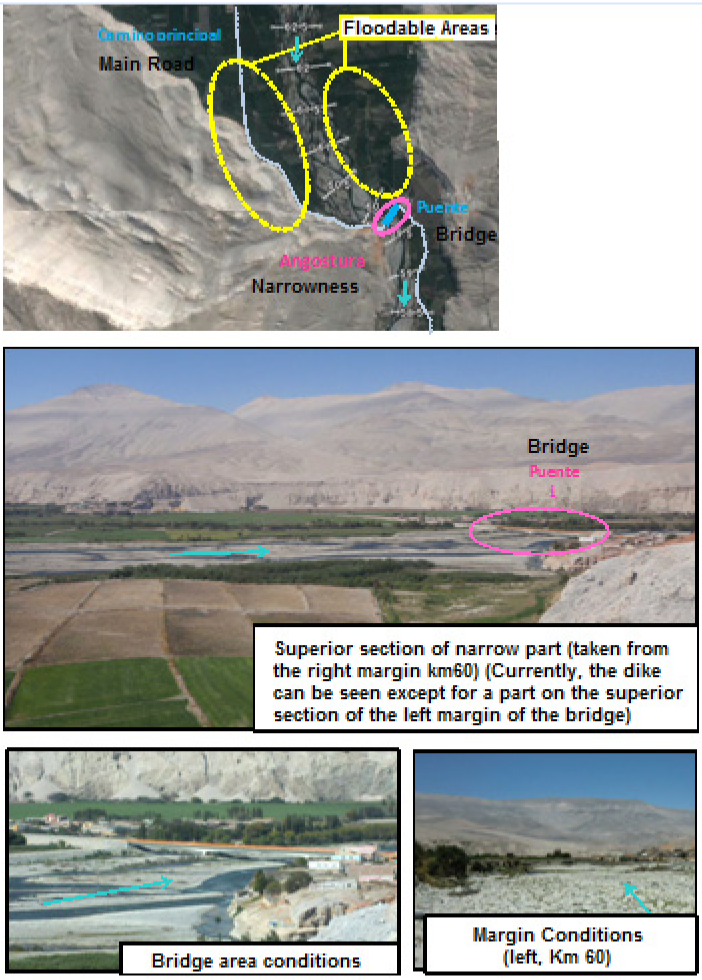


Figure 3.1.6-5 Local conditions related with Challenge 3 (Majes River)

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

Current situation and challenges	・There is a community, Deque, 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

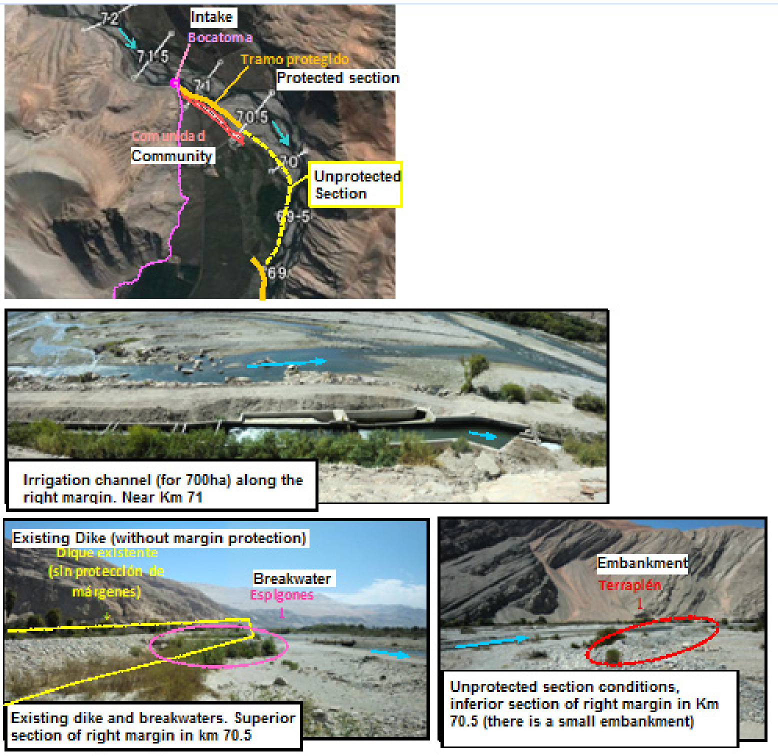


Figure 3.1.6-6 Local conditions related to Challenge 4 (Majes River)

5) 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 3.1.6-7 Local Conditions related to Challenge 5 (Majes River)

6) 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

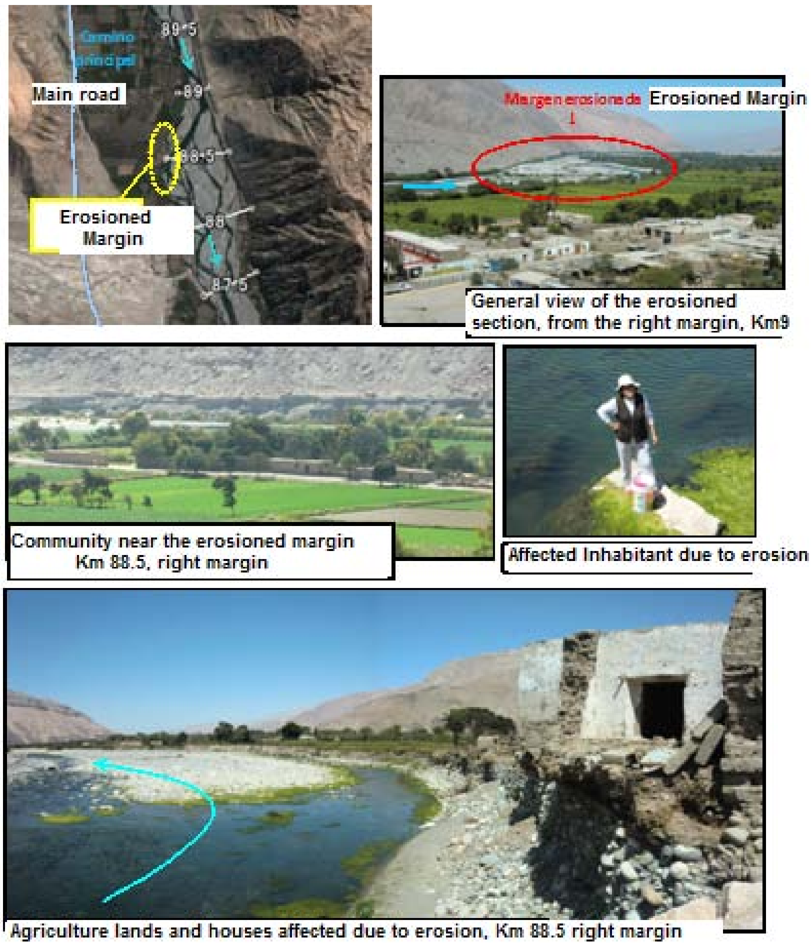


Figure 3.1.6-8 Local conditions related to Challenge 6 (Majes River)

3.1.7 Current situation of vegetation and reforestation

(1) Current Vegetation

The most recent study[1] 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[2] in Spanish).

In this study the 1995 Forest Map was used as database and its Explanatory Guide[3] prepared by INRENA and the Forest General Direction. Likewise, during the 70's 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 distribution of the watersheds extend from the coast to the Andean mountains; usually, they feature different vegetal coverage according to the altitude (see Table 3.1.7-1.). In this watersheds, the zones from coast up to the 2,500msnm (Cu, Dc) have scarce vegetation, and they are featured by arid lands mainly covered by grass and cactus; some meters above in altitude, there are only scarce bushes disseminated in the area. In zones from 2,500 m.a.s.l up to 3,500 m.a.s.l, small bushy forests are formed thanks to the optimal rainfall, while in higher altitude areas the low temperature hardens the vegetal growth, so grassy species mainly grow on it. Although the bushes forming thicket generally reach up to 4 m high, in zones close to the rivers, high trees are mainly develop.

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

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

Source: Prepared by the JICA Team base don the Forest Map. 1995

Each life zone is described below.

[1] Use of Landsat-TM (Data from 1999 y 2000).
[2] Subsequently, INRENA was dissolved and its functions were assumed by the Wild Forest and Fauna General Direction.
[3] Use of Landsat-MSS (Data from 1998).

(i) Cu (Coastal crops)

Cultivated lands of the coast region developed in fluvial influence zones.

(ii) Dc (Coastal Desert)

It covers surface of 10,01% (128.575km^2) of the Peruvian territory, it extends along the Peruvian coast, from Tumbes to Tacna. It includes from sea level up to approximately 1.500msnm. The weather is arid and warm in summer (December-March), mist in winter (May-September). In areas with altitude of 700m.a.s.l to 1.000msnm vegetal formations called hills may appear. Besides the hills, it is common to see that in years with strong mists, tiny grass of few centimeters cover the surface, especially in the South of Peru. Close to the rivers, bushes appear.

(iii) Ms (Dry Thicket)

It covers 2,18% (28.026Km2) of Peruvian territory, it is distributed from the first elevations of the west spring of Tumbes. In Tacna, located in the South extreme of Peru, it reaches 3.900 m.a.s.l. In central and south zones, this bush appears at 1.500 m.a.s.l, and includes the medium areas of Andean western spring. Annual average temperature is 11°C~25°C, while annual average rainfall ranges from 120 to 220mm, except a High Andean sector of Tacna where the annual average temperature and rainfall are lower than 6°C and 125mm respectively. The extreme weather conditions the vegetal presence; it limits it to cactus and grass. The bushes growing in this zone completely eliminate leaves and the grass also disappeared as a way to counteract the prolonged period of drought, thus recovering the greenness in rainy season.

(iv) Msh (Sub-humid Forest)

It covers 2,91% (37.278Km^2) of Peruvian territory. It is distributed after the dry thicket, located from 2.900m.a.s.l to 3.500m.a.s.l in North-Central zones, and in the inter-Andean valleys from 2.000m.a.s.l to 3.700m.a.s.l. Annual average temperature ranges from 9^{o}C to 18^{o}C and the annual average rainfall ranges from 220mm to 1.000mm. The dominant bushes in this zone are perennial and generally do grow more than 4m.

(v) Mh (Humid Forest)

It covers 3,17% (40.777Km^2) of the Peruvian territory, located between 2.500m.a.s.l and 3.400m.a.s.l in the North Zone, while in the Center-South zones, it is located between 3,000m.a.s.l and 3.900m.a.s.l; that means, between the Sub-humid Forest and high Andean grasslands. The annual average temperature ranges from 6°C to 14°C, the annual average rainfall is from 500 to 2.000mm, except in some zones where the rainfall reaches 4,000mm. The bush community of this zone is characterized by its perennial foliage and its high level of resistance to low temperatures and drought; it does not grow higher than 4m. Small woods are formed in inaccessible places.

(vi) Cp (Puna grass)

It covers a surface of 1,89% (24,249km^2) of the Peruvian territory and it is located in the high and cold zones of the Andes, generally above 3,800m.a.s.l in the Center-South zones. The Pj (Scrubland) zone is also located in the same climactic zone. It is feature by the predominant presence of gramineae, then Cyperaceae, Juncaceae and Leguminoceae.

(vii) Pj (Scrublands)

It coves the cold high Andean surfaces, from 3.200m.a.s.l to 3.300m.a.s.l, except for center-south zones where it reaches 3.800m.a.s.l. The weather is variable, and in the south it is more arid than in the Center and North, such as that zone which annual rainfall is lower than 125mm, while in the east springs there are places with more than 4.000mm of rainfall. The temperature ranges from 1,5°C and 6°C. Gramineae dominate and form scrublands. In the south, such as Arequipa, a mixed community of herbaceae and bushes known as tolars is seen. However, these vegetal communities are overexploited and degraded for energy purposes.

(viii) Nv: Ice-Capped Mountains

The distribution of the vegetal formations in the Majes-Camana River watershed is similar to that from the abovementioned zones, except that the vegetal formations representative from this watershed differ from the other remaining four watersheds in three aspects: i) they do not have cost crops (Cu), ii) There are hills (Lo), iii) there are moors (Bf).

The explanations in this watershed only and not in the remaining watersheds are the following. In Figure 1.1.5 the vegetal formations map of Majes-Camana watershed appears.

(ix) Lo：Hills[4]

It appears from 0 to 1,000msnm. It covers from the north coast dessert of Peruvian North to Chile. In winter (May to September) the mist comino from the sea allows the development of plant communities. It is characterized by predominant species such as *Tillandsia spp*, tara (*Caesalpinea spinosa*), Amancaes flower (*Ismene amancae*), cactus (*Haageocereus spp.),* Clover (*Oxalis spp*.), wild potato (*Solanum spp*), among others. On the other side, the coast dessert is 11% of Peruvian territory, 2.000Km along of the coast from north to south, besides the area is 14.000Km^2. The area of the coast hills in the study watershed could not be found.

[4] (Source1) Proyecto Atiquipa
http://www.lomasdeatiquipa.com/lomas.htm
(Source 2) Plan Maestro de la Reserva Nacional de Lomas de Lachay (2003 – 2007)
http://www.sernanp.gob.pe/sernanp/archivos/biblioteca/publicaciones/RN_Lachay/Plan_maestro_2003-2007_RN%20Lachay.pdf

(x)Bf：Moors[5]

It appears from 3.900 to 4.800 m.a.s.l, which topography includes plain lands, slight slopes or with slight depressions. They appear where the ground water is shallow, where there are springs and a permanent supply of water the entire year, by means of run-off that come from the ice-capped mountains or by springs. It is characterized by the predominant 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)*, amog others. These plants are low, the American Camelids (llama, alpaca, vicuna and guanaco) feed themselves with them.

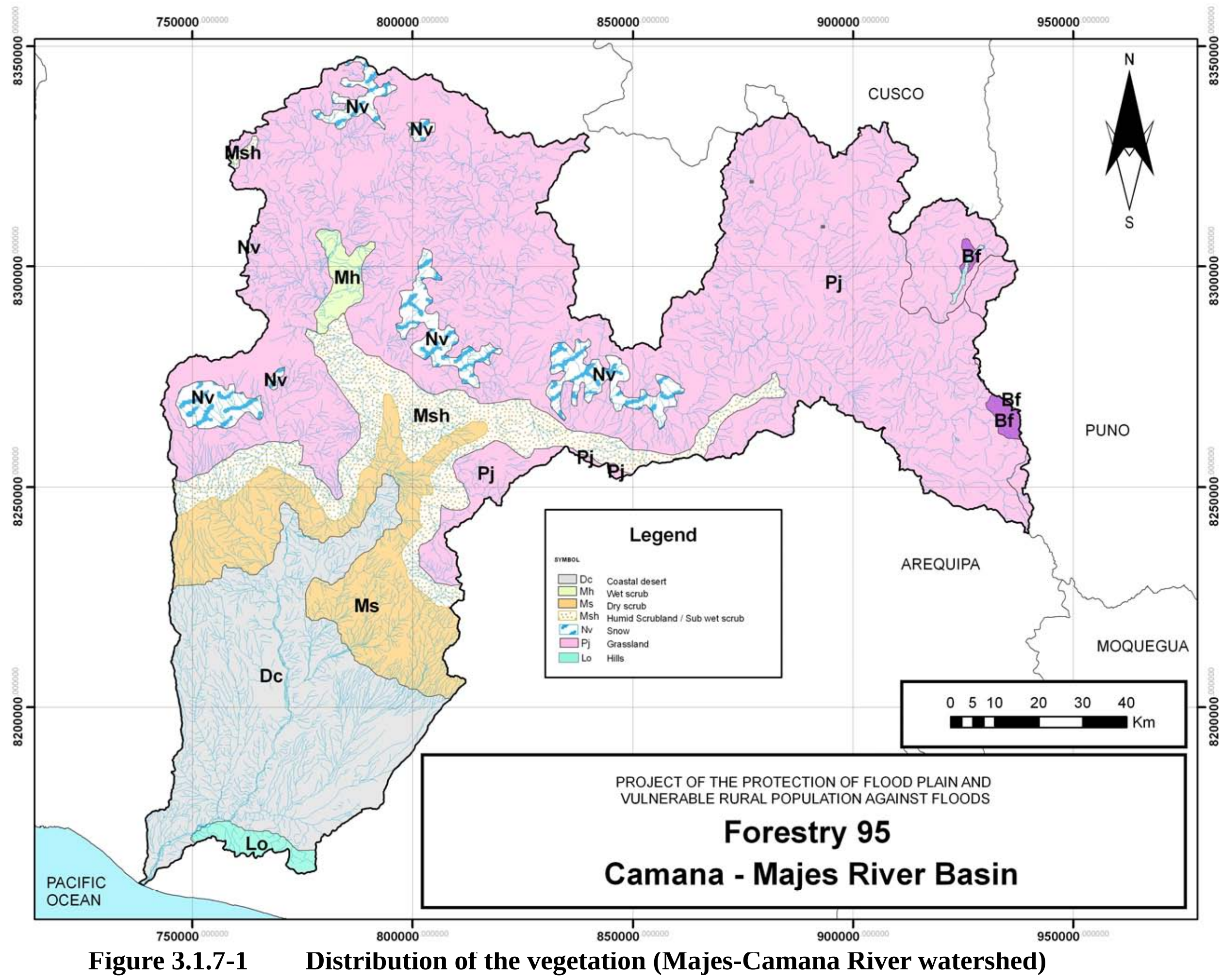


Figure 3.1.7-1 Distribution of the vegetation (Majes-Camana River watershed)

(Source: INRENA, Prepared by the JICA Team based on the Forest Map. 1995)

5 (Source 1) Cosecha de agua, Una práctica ancestral. Manejo sostenible de las praderas naturals, DESCO (Centro de Estudio y Promocion de desarrollo)
HP：http://www.descosur.org.pe/publicaiones/Manual004.pdf
HP：http://www.desco.org.pe/quienessomos.shtml
(Source) Monografia: Biodiversidad del Valle del Colca (Arequipa),Wilmer Paredes
HP:http://www.monografias.com/trabajos53/biodiversidad-colca/biodiversidad-colca2.shtml

(2) Area and distribution of vegetation

Rio Camana-Majes watershed compared the results of 1995 INRENA study to tose of SIG, and the area percentage of the watershed of each classification of vegetation was obtained. (See Table 3.1.7-2).

Table 3.1.7-2 Area of each classification of vegetation (Majes-Camana River 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 of

If the classification is added to this result, Table 3.1.7-3 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 4.000m.a.s.l, which cover most of the scrublands.

Table 3.1.7-3 Area and percentages of each classification of vegetation gathered (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

(3) Forest area variation

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

However, in relation to the Arequipa Region, data are not available.

Table 3.1.7-4 Area Deforested Until 2005

Department	Area (ha)	Area deforested accumulated (ha) and the percentage of such area in the department area (%)	Post-Felling Situation	
			Non used Area (ha)	Used area(ha)
Arequipa	6.286.456	–	–	–

Source: National Reforestation Plan, INRENA, 2005

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

From 1995 to 2000, the semi-humid and humid thicket diminished on 30km^2 (2,3%) and 5km^2 (3,2%) respectively, scrublands (Pj), ice-capped mountains (Nv) have significantly diminished on 364km^2 (3,6%) and 60km^2 (9,4%) respectively, moors (Bf) are increasing approximately on 12km^2 (18,2%). The area with higher increase is the coast dessert (Dc) approximately on 40km^2 (13%).

Table 3.1.7-5 Changes in the areas of distribution of vegetation from 1995 to 2000 (Majes-Camana river Watershed)

Area	Classification of vegetation							
	Lo	Dc	Ms	Msh	Mh	Bf	Pj	Nv
1995 (km2) (a)	104,54	3.108,12	1.570,08	1.334,76	155,20	66,16	10.069,21	641,44
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

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

(4) Current situation of forestation

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

Table 3.1.7-6 History registry of forestation 1994-2003 (formerly Department)

(Units: ha)

Department	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

Source: National Reforestation Plan, INRENA, 2005

According to the information obtained by jeans of the interviews by Agrorural, the experiences of forestation appear in Table 3.1.7-7. Forestation has been performed in 4 places, all of them very small areas, and mainly experimental forestation. On the other hand, ONG Nature Conservancy currently performs vegetation recovery activities in the hills of Peruvian coast.

Table 3.1.7-7 Forestation Experiences (Department of Arequipa)

Year	Place of plantation	Executing unit	Planted Species	Area (ha)	Observations
1992	Arequipa	Univ. Nac. San Agustín	Native species	2	Forest Diagnosis and possibilities
2004	Usuña, Bellavista District of Polobaya, Prov. Arequipa	AGRORURAL	eucalyptus, pine, cypress	3	
2005	Arequipa	University Thesis	Pepper tree	0,5	

Source: Prepared by the JICA Study Team based on the interview to AGORURAL

3.1.2 Current situation of the soil erosion

(1) Information gathering and basic data preparation

1) Information Gathering

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

Table 3.1.8-1 List of collected information

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

2) Preparation of basic data

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

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

(2) Analysis of the causes of soil erosion

1) Topographic characteristics

i) Surface pursuant to altitudes

Table 3.1.8-2 and Figure 3.1.8-1 show the percentage of surface according to altitudes of Majes-Camana River watersheds. The Cañete River and Majes-Camana river watersheds are characterized for a percentage of watersheds located at more than 4,000 m.a.s.l. The hills at this height are little pronounced and several ice-capped mountains and reservoirs are distributed in the zone. This part of the Majes-Camana River watershed is large and has plentiful and large hydrological resources compared to other watersheds. The altitudes between 4,000 and 5,000 m.a.s.l represent 53% of total surface.

Table 3.1.8-2 Surface according to altitude

Altitude (msnm)	Area (k m^2)
	Majes-Camana
0 – 1000	1040,56
1000 – 2000	2618,77
2000 – 3000	1277,54
3000 – 4000	2305,64
4000 – 5000	9171,56
5000 – More	635,44
TOTAL	17049,51
Maximum Altitude	5821

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

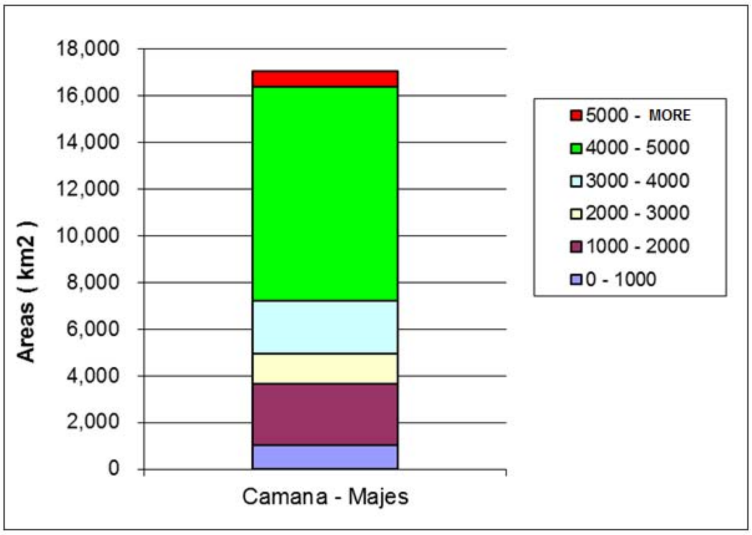


Figure 3.1.8-1 Surface according to altitude

ii) Zoning according to slopes

Table3.1.8-3 and Figure 3.1.8-2 show the slopes in Majes-Camana River watershed.

Table 3.1.8-3 Slopes and surface

Watershed slope (%)	Majes-Camana	
	Area (km^2)	Percentage
0 - 2	869,75	5%
2 - 15	6210,54	36%
15 - 35	5452,97	32%
More than 35	4516,25	26%
TOTAL	17049,51	100%

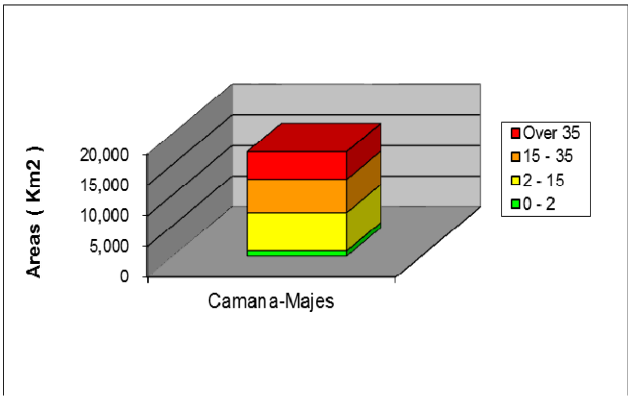


Figure 3.1.8-2 Slopes and surface

iii) River-bed slope

Table 3.1.8-4 and Figure 3.1.8-3 show the slope in every river and the length of streams including tributaries. Figure 3.1.8-4 shows the general relation of the movement of sediments and the river-bed slope. Supposedly, sections with more than 33.3 % of slope tend to produce higher amount of sediments, and hillsides with slopes between 3.33 % and 16.7 %, accumulate sediments easier.

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

River-bed slope (%)	Majes-Camana
0,00 - 1,00	263,45
1,00 - 3,33	1953,19
3,33 - 16,67	7511,73
16,67 - 25,00	1383,17
25,00 - 33,33	761,15
33,33 – More	1425,65
TOTAL	13298,34

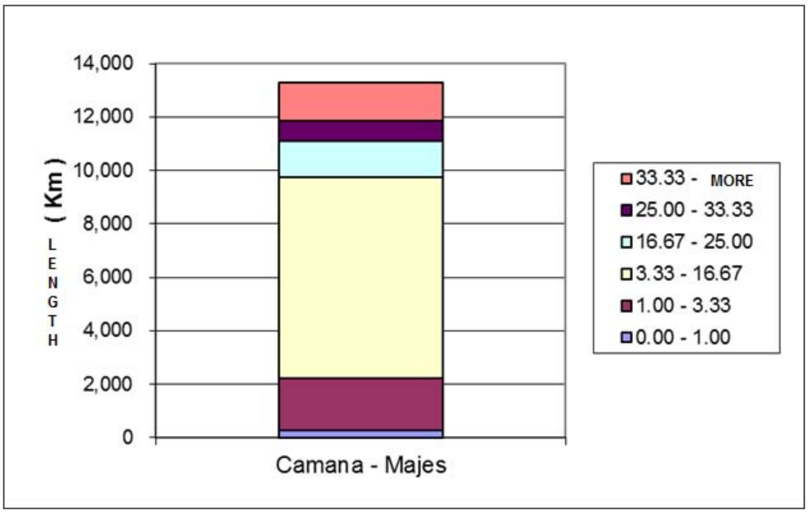


Figure 3.1.8-3 River-bed Slope and total length of streams

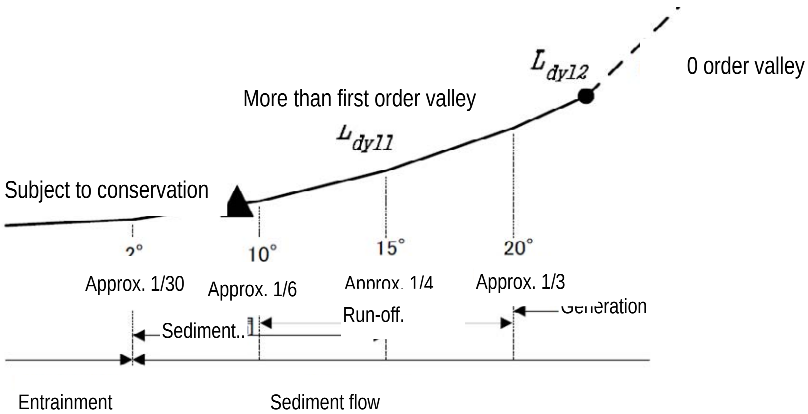
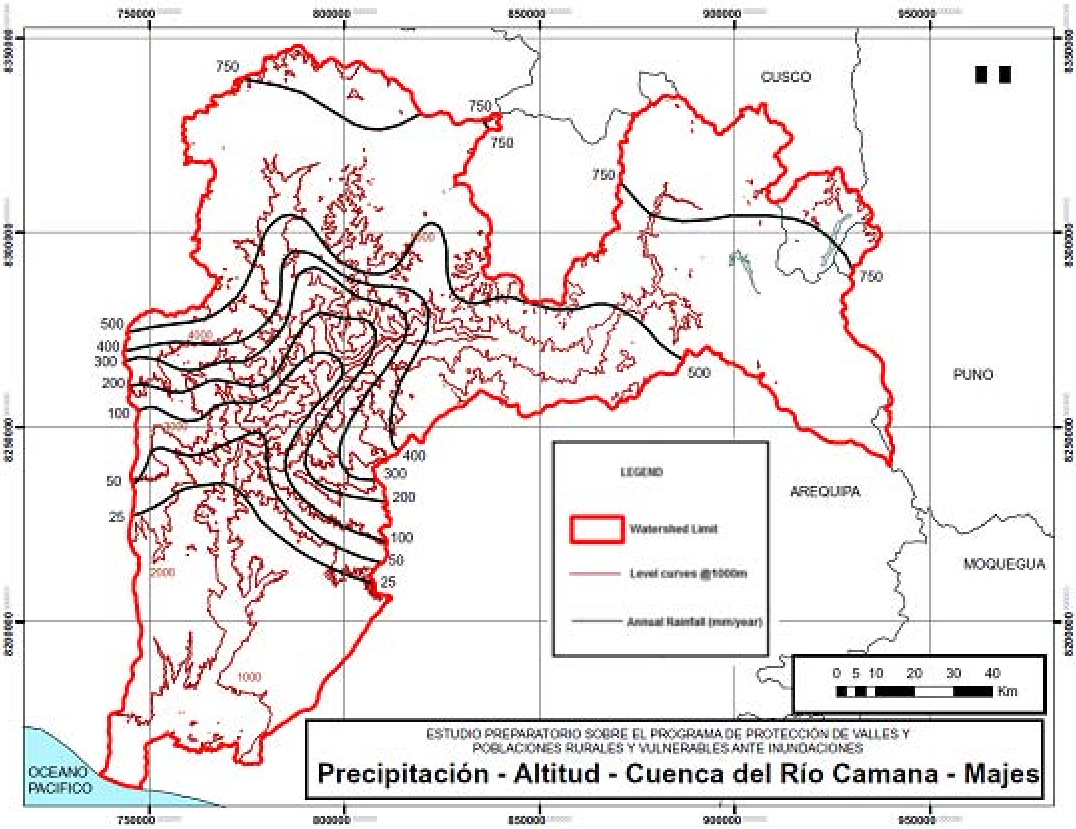


Figure 3.1.8-4 River-bed slope and sediment movement pattern

2) Rainfall

Isohyets' maps of each watershed were prepared, based on the isohyets maps prepared by SENAMHI using the rainfall data collected during 1965-1974. Figure 3.1.8-5 shows the isohyets map (annual rainfall) of Majes-Camana River watershed.

Annual rainfall in the area subject to flood analysis ranges from 0 to 50 mm. The annual mean rainfall in the zone of 4000 – 5000 m.a.s.l of the southeast ranges from 500 to 750 mm.



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

Figure 3.1.8-5 Isohyet Map of the Majes-Camana river watershed

3) Erosion

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

Figure 3.1.8-6 summarizes the watershed characteristics. Below 1,000 m.a.s.l, vegetation is scarce and rainfall is reduced (Area A). There is little erosion. Between 1,000 and 4,000 m.a.s.l, topography is pronounced and uncovered, that means, it has no vegetal coverage (Area B). Rainfall is not high, but it is deduced that in this is where higher amount of erosion happens. Above 4,000 m.a.s.l, the rainfall is high and the temperature is low. The lands are covered by bushes which adapt to local weather, likewise, the relief is not pronounced, so the erosion volume is reduced (Areas C).

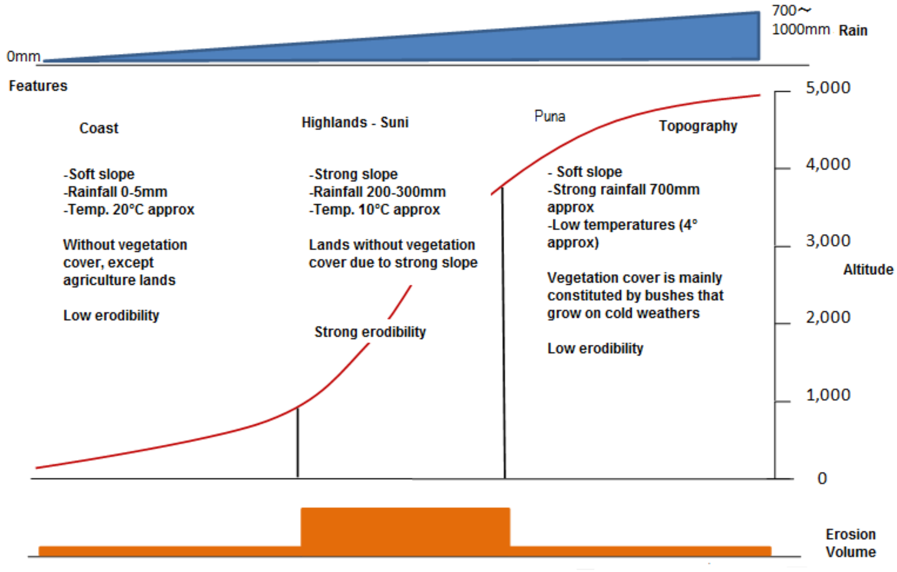


Figure 3.1.8-6 Relation between the erosion volume and the different causes

(3) Identification of the zones more vulnerable to erosion

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

The Majes-Camana watershed is characterized because its topography is very varied between 1,000 and 4,000 m.a.s.l. Colca Canyon considered one of the deepest valleys of the world is in this zone.

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

Watershed	Slope	Altitudes (m)												total
		0 - 1000		1000 - 2000		2000 - 3000		3000 - 4000		4000 - 5000		5000 - More		
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
	More than 35	230,75	5%	677,32	15%	537,05	12%	993,25	22%	1823,81	40%	290,08	6%	230,75

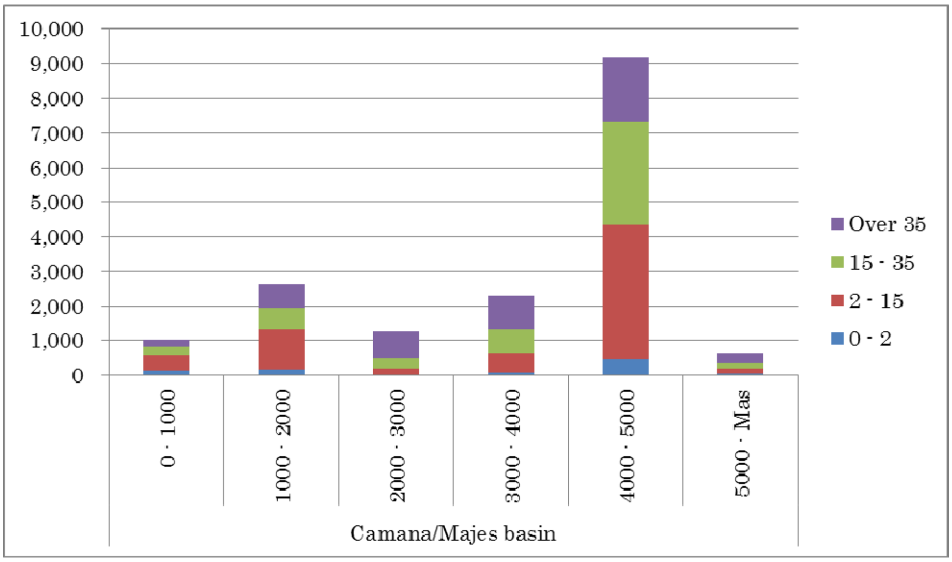


Figure 3.1.8-7 Slopes according to altitudes of Majes-Camana River

(4) Production of sediments

1) Results of the geological study

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 3.1.8-10). 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 3.1.8-16)
- 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. As shown in the picture, there is no vegetation deeply rooted by the sediment entrainment in common time (see Figure 3.1.8-10 and Figure 3.1.8-16)
- 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 3.1.8-16)
- 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 3.1.8-16)
- 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

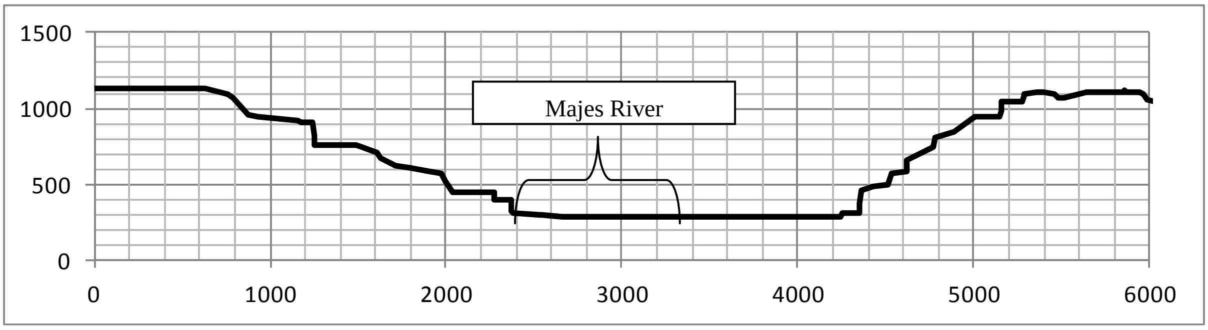


Figure 3.1.8-8 Cross-section of Majes watershed (50km approx. from the mouth)

Table 3.1.8-6 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.

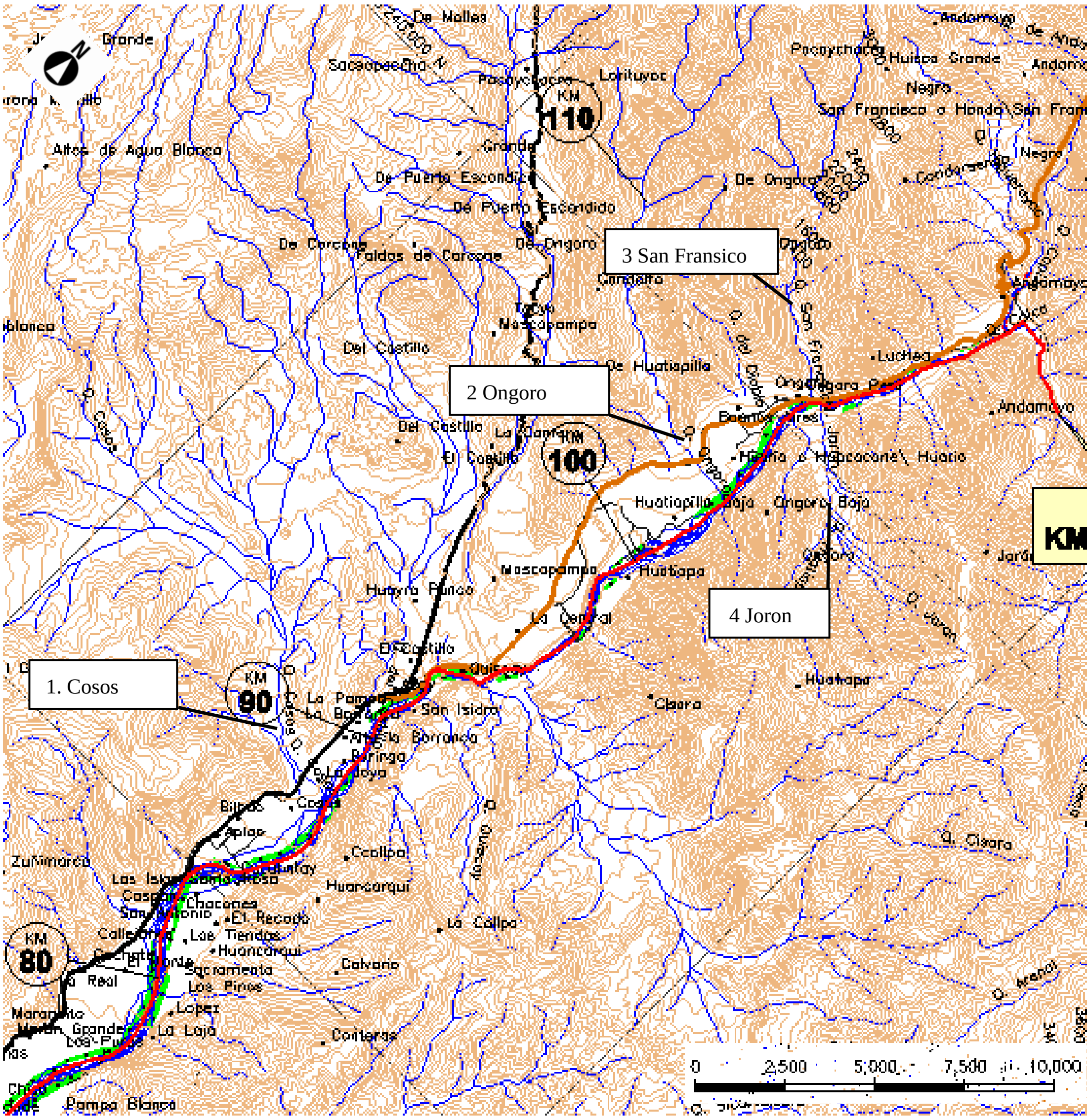


Figure 3.1.8-9 Location of the alluvium generation

Figure 3.1.8-10 Situation around Km 60 (formation of the valley approximately 5km width)

Figure 3.1.8-11 Situation of the sediment silting in Cosos river(Approx. 900m width)

Figure 3.1.8-12 Rural (=local) highway crossing the Cosos river (in rainy season the sediments cover the rural highway, however, it is restored in a day)

Figure 3.1.8-13 Situation of Ongoro (in 1998, 2 persons died due to the alluvium)

Figure 3.1.8-14 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 3.1.8-15 Situation of Jorón river (alluvium sediments arrived up to the main river in 1998)

Figure 3.1.8-16 Situation around the Km110 mouth (It may be deduced that there is low affluence of sediments from hillsides to the river channel)

Figure 3.1.8-17 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 3.1.8-7), thus obtaining the information of years with probability of higher rainfall and the larger amount of rain days on 1998, as shown in Table 3.1.8-8. 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[6], it considered 50 year rainfall; therefore, it was determined that the sediment damages were due to these rainfall.

Table 3.1.8-7 List of Pluviometric Station to check rainfall

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

Table 3.1.8-8 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

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

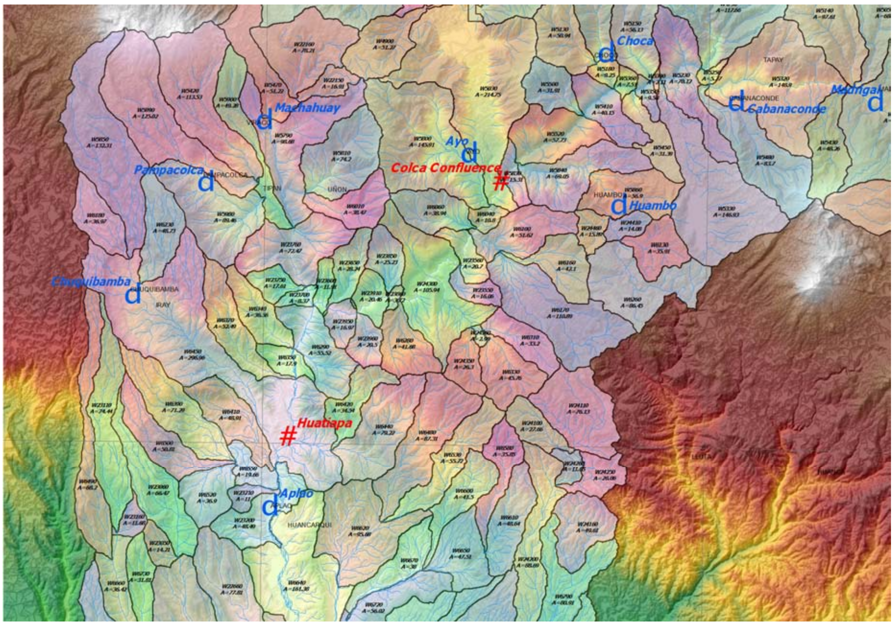
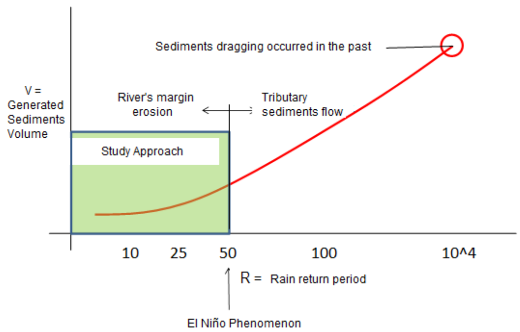


Figure 3.1.8-18 Location of the Pluviometric Station

3） Production forecast and sediments entrainment

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

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



(i) An ordinary year

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

the bed change during low overflows (see Figure 3.1.8-19)

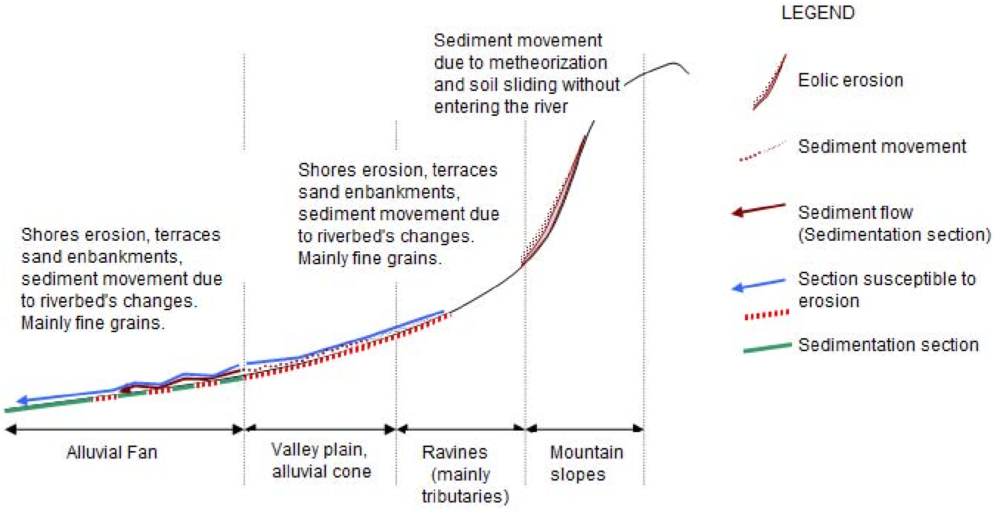


Figure 3.1.8-19 Production and entrainment of sediments in an ordinary year

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

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

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

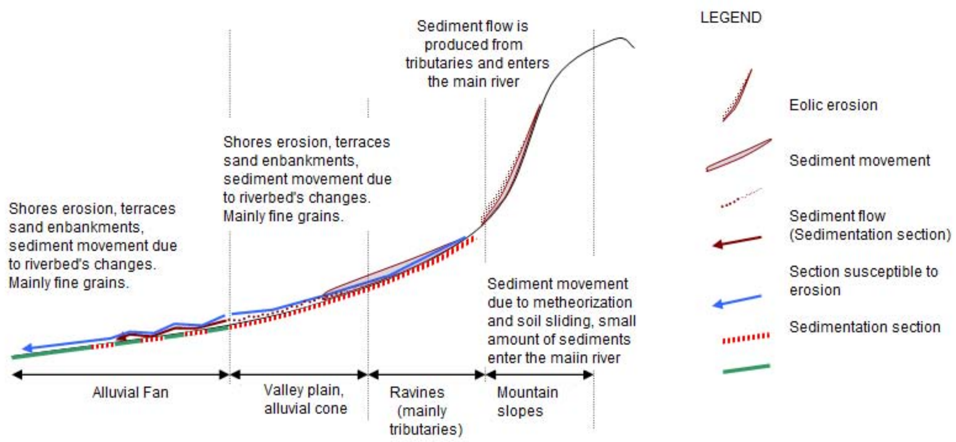


Figure 3.1.8-20 Production and entrainment of sediments during the torrencial rainfall of magnitude similar to that of El Niño (1:50 year return period)

(iii) Large magnitude overflows (which may cause the formation of terraces similar to those existing now), with a 1:10.000 year return period

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

If we suppose that rainfall occurs with extremely low possibilities, for example, 1:10.000 years, we estimate that the following situation would happen (see Figure 3.1.8-21).

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

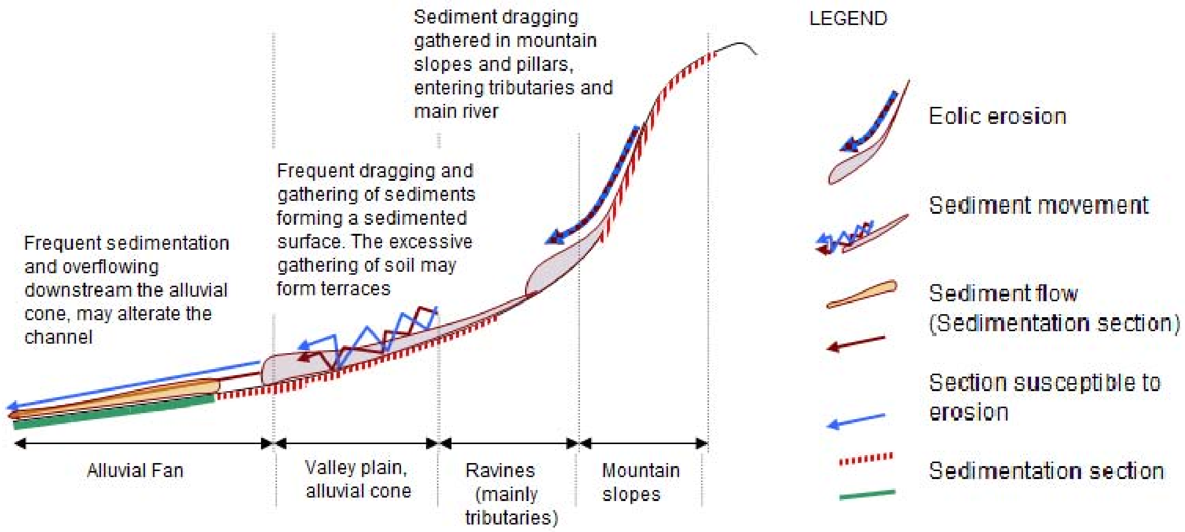


Figure 3.1.8-21 Production of sediments in large overflowing (geologic scale)

3.1.3 Run off analysis

(1) Rainfall data

1) Current rainfall monitoring system

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

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

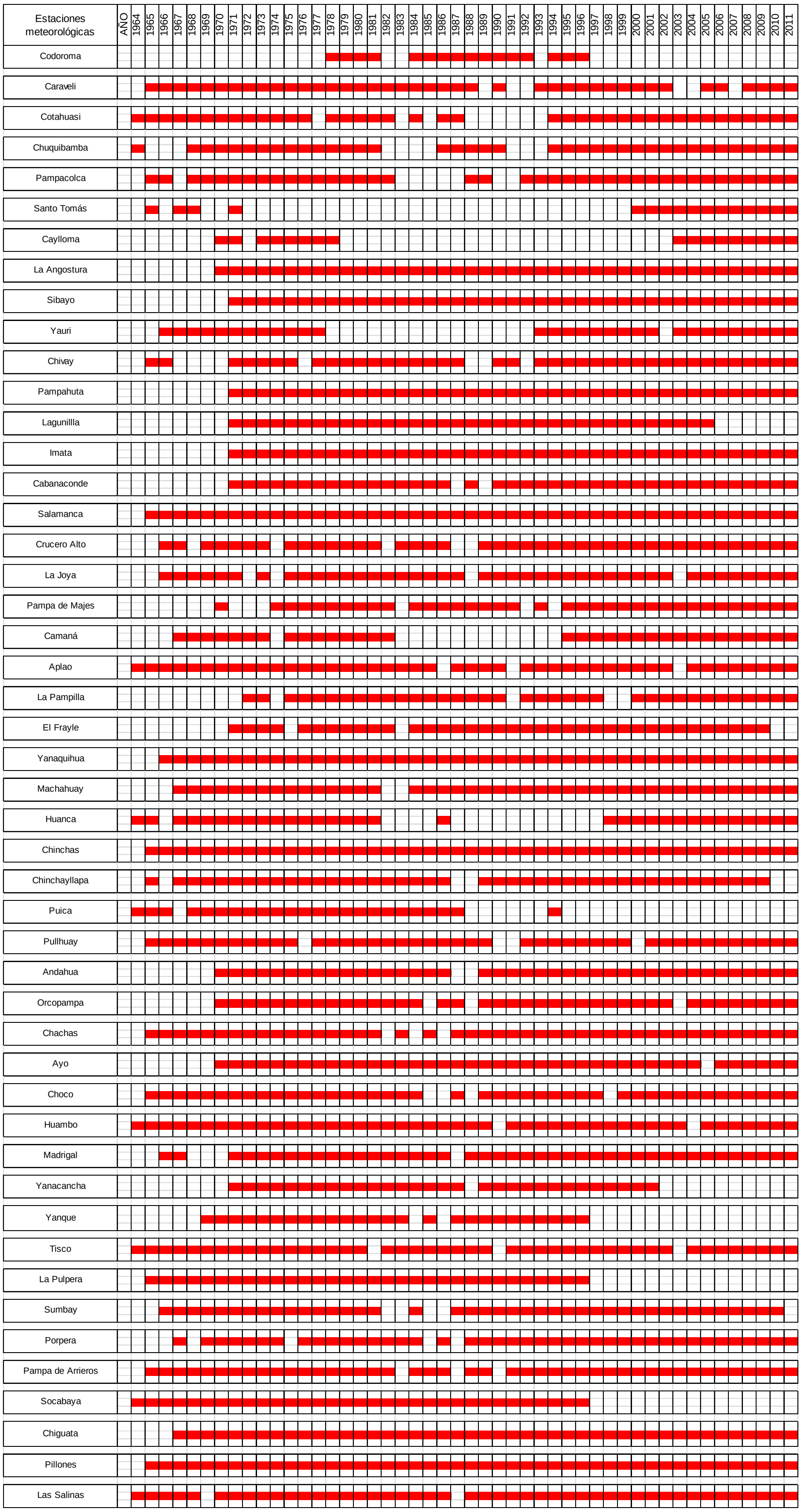
In Majes-Camana river watershed rainfall monitoring is performed in 48 stations (including those currently non-operative), since 1964.

However, it should be mentioned that in some points it was not possible to obtain the accurate data, due to a prolonged lapse where the data collection was stopped in some stations or for any other reasons. Thus, the discharge analysis was carried out using data from 38 stations which registered data relatively accurate. These stations are those indicated in Table 3.1.9-1.

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

METEOROLOGIC STATION	COORDINATES		
	LATITUDE	LENGTH	ALTITUDE (mosl)
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 3.1.9-2 Period of rainfall data collection (Majes-Camana river watershed)



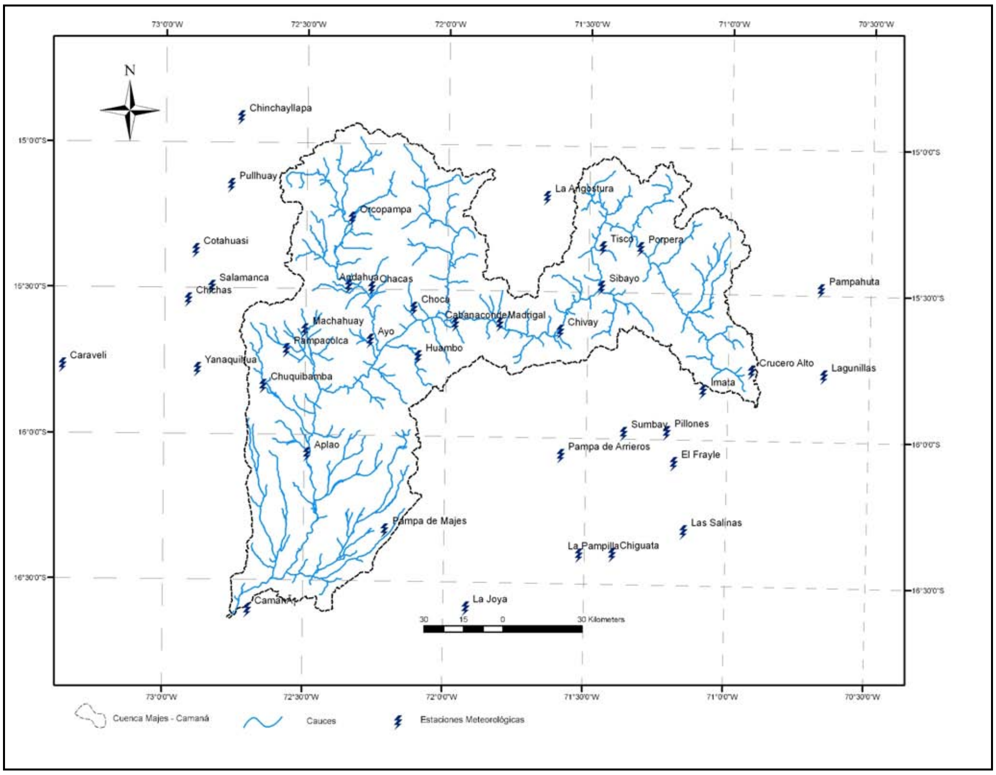


Figure 3.1.9-1 Monitoring stations location map
(Majes-Camana River watershed)

2) Isohyet map

Figure 3.1.9-2 shows a map of the isohyet of Majes-Camana River watershed. This watershed is characterized by the considerable variation of the annual rainfall depending on the zones, with a minimum of 50mm and a maximum of 750 mm approximately. The rainfall is lower when it is closer to the Pacific coast (low watershed), and it increases as the altitudes increase (high watershed).

The annual rainfall in the low watershed, subject to the control of floods, is reduced ranging from 50 to 200 mm.

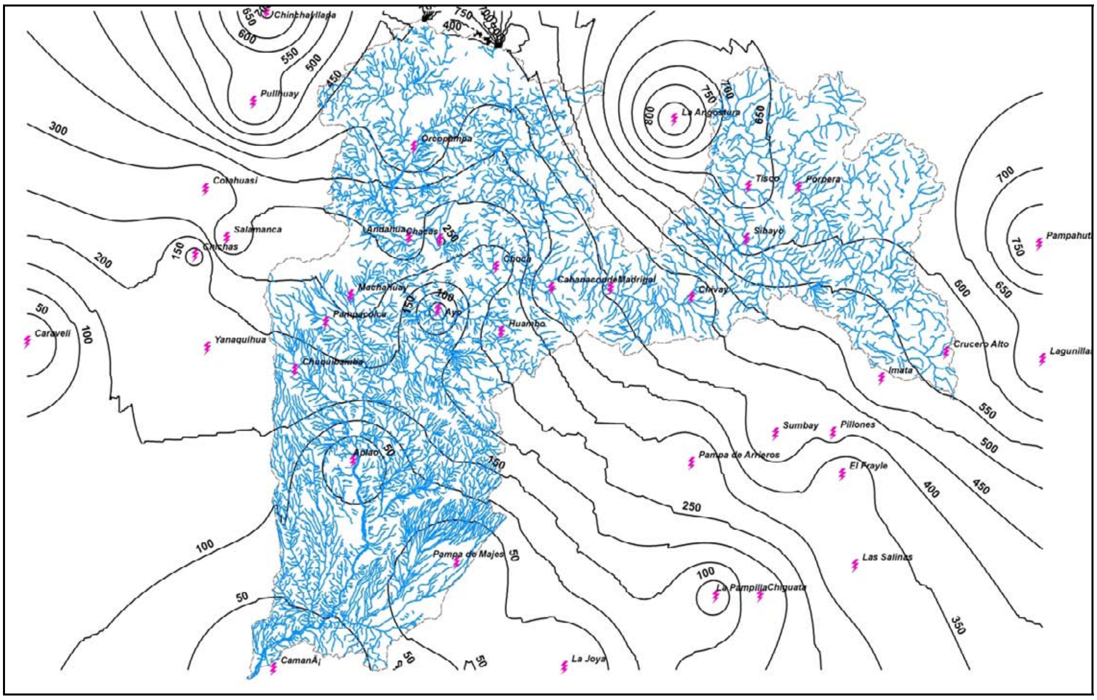


Figure 3.1.9-2 Isohyet Map (Majes-Camana River watershed)

(2) Rainfall analysis

1) Methodology

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

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

The statistic hydrologic models were.

- Normal distribution (Normal)
- Normal logarithmic distribution (Log Normal)
- Log Pearson Typo III distribution (the log Pearson III)
- Gumbel distribution (Gumbel)

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

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

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

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

	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

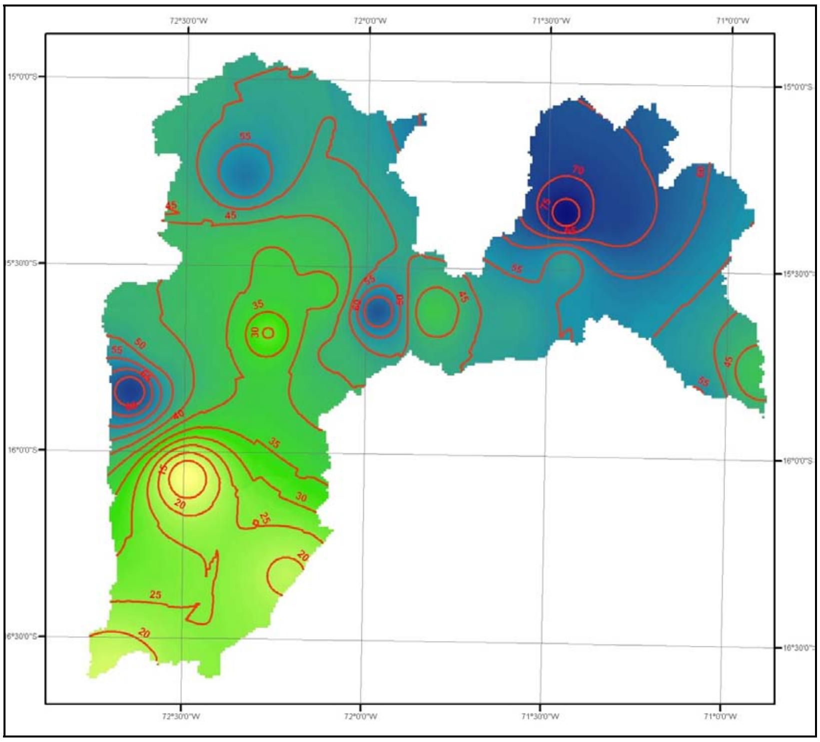


Figure 3.1.9-3 Map of isohyets of a 50 years period rainfall (Majes-Camana river watershed)

(3) Run off analysis

1) Flow monitoring

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

The monitoring of flow of the Majes-Camana river watershed corresponds to the stations Huatiapa and Camana Highway Bridge. Table 3.1.9-4 shows the data from these stations.

Table 3.1.9-4 Data from the flow monitoring stations

Stations	Latitude	Length	Altitude (m.a.s.l)
Huatiapa	15°59'41.0" S	72°28'13.0" W	700
Puente Carretera Camana	72°44'00.0" S	16°36'00.0" W	122

2) Analysis of discharge flow

The statistic hydrological calculation was made using the data of the maximum annual discharge collected and processed in the reference points, to determine the flow with different probabilities. Table 3.1.9-5 shows the probable flow with return periods between 2 and 100 years.

Table 3.1.9-5 Probable flow in control points

(m^3/s)

Rivers	Return periods					
	2 years	5 years	10 years	25 years	60 years	100 years
Huatiapa	598	1.022	1.303	1.657	1.920	2.181
Camana Highway Bridge	572	1.130	1.500	1.967	2.313	2.657

3) Run off analysis with t-years return periods

(a) Methodology

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

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

(b) Analysis results

Table 3.1.9-6 shows the flood discharge with return periods between 2 and 100 years of the Majes-Camana river watershed.

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

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

(m^3/s)

	Return period					
Rivers	2 years	5 years	10 years	25 years	50 years	100 years
Huatiapa	270	728	1.166	1.921	2.659	3.586

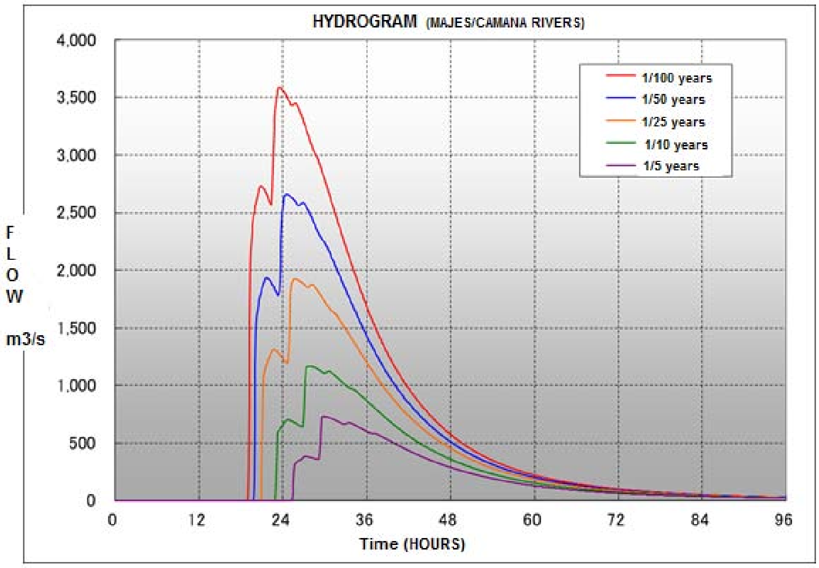


Figure 3.1.9-4 Hydrograph of Majes-Camana river

3.1.10 Analysis of inundation

(1) River surveys

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

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

Table 3.1.10-1 Summary of the river surveys

Survey	Unit	Quantity	Notes
1. Control points survey			
Majes-Camana river	No.	13	
2. Dikes transversal survey			250m Interval, only one shore
Majes-Camana river	km	143	
3. River transversal survey			500m Interval
Majes-Camana river	km	86	
4. Benchmarks			
Type A	No.	13	Every control point
Type B	No.	130	130km x one point/km

(2) Flood analysis methods

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

1) Analysis basis

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

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

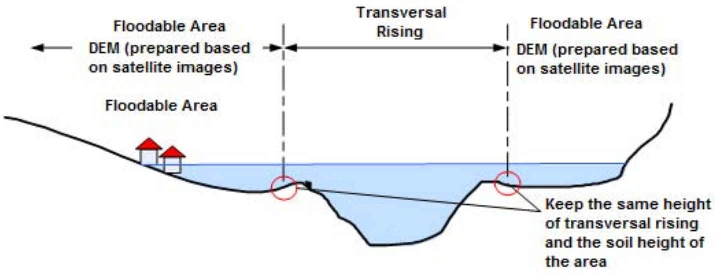
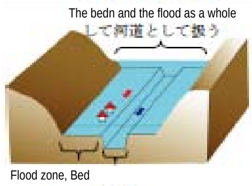
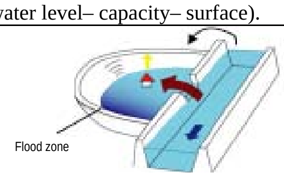
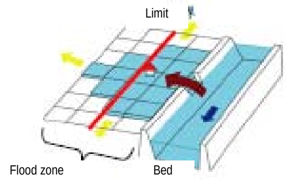


Figure 3.1.10-1 Idea of unidimensional model

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

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

Table 3.1.10-2 Methodology of flooding analysis

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

2） Inundation analysis method

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

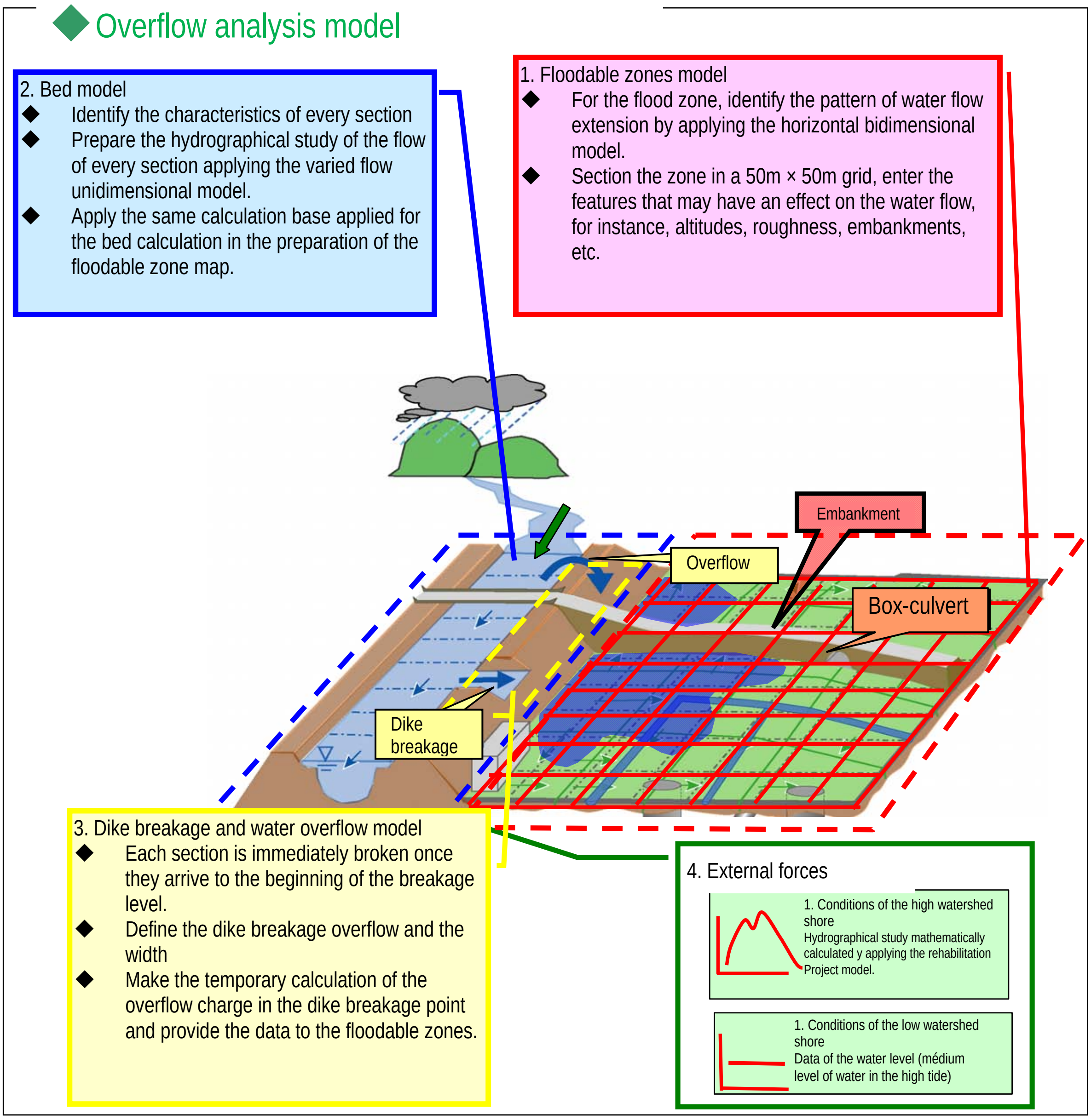


Figure 3.1.10-2 Conceptual scheme of the overflow analysis model

(3) Discharge capacity analysis

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

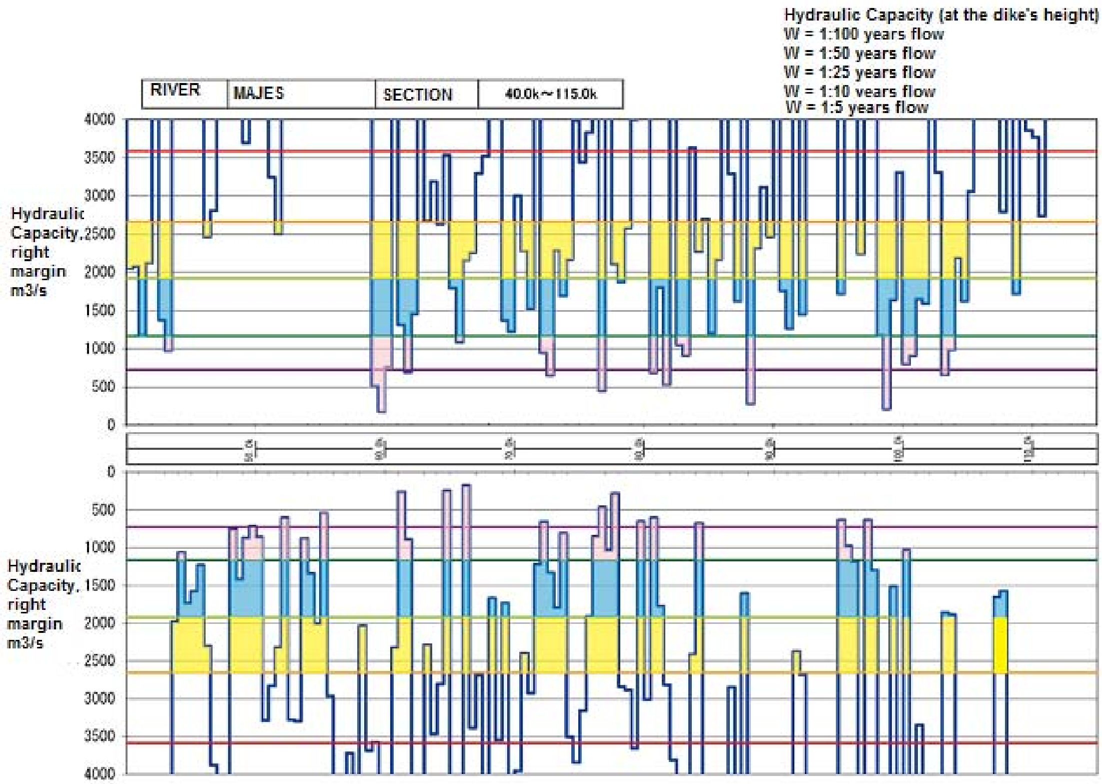


Figure 3.1.10-3(1) Current discharge capacity of Majes River

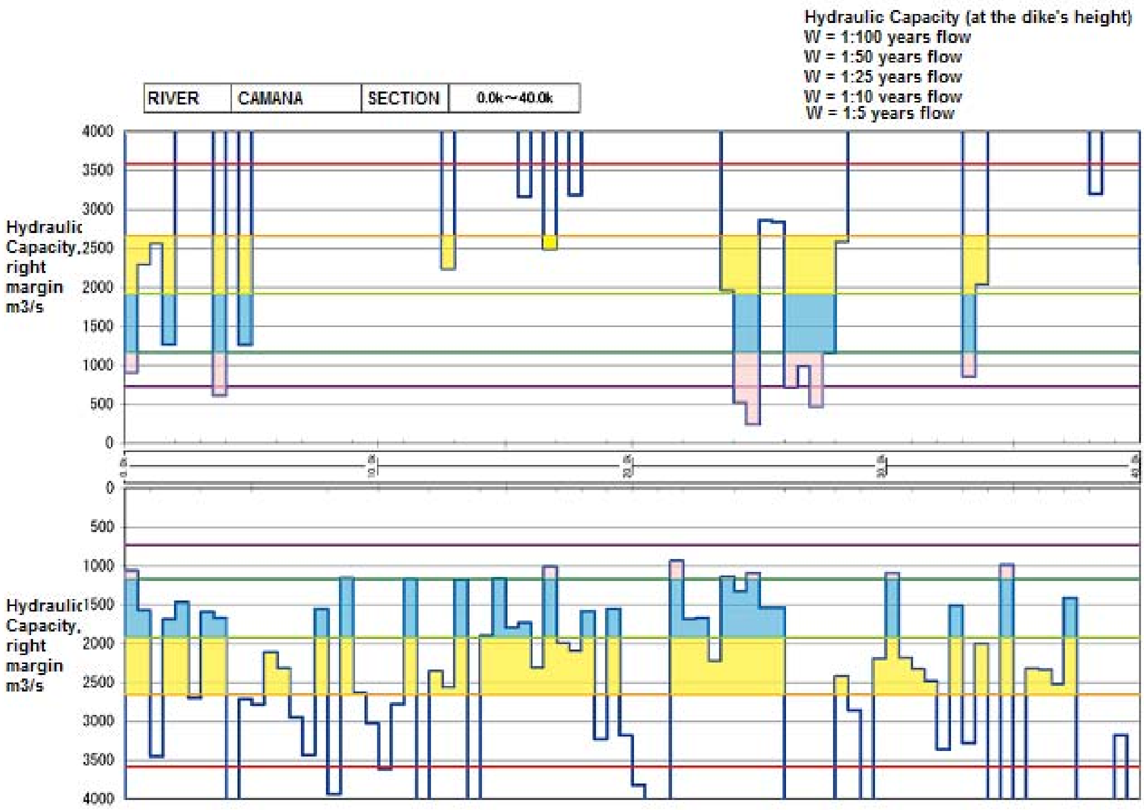


Figure 3.1.10-3(2) Current discharge capacity of Camana River

(4) Inundation area

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

Figure 3.1.10-4(1) Inundation area of Majes-Camana river

(50 year period floods)

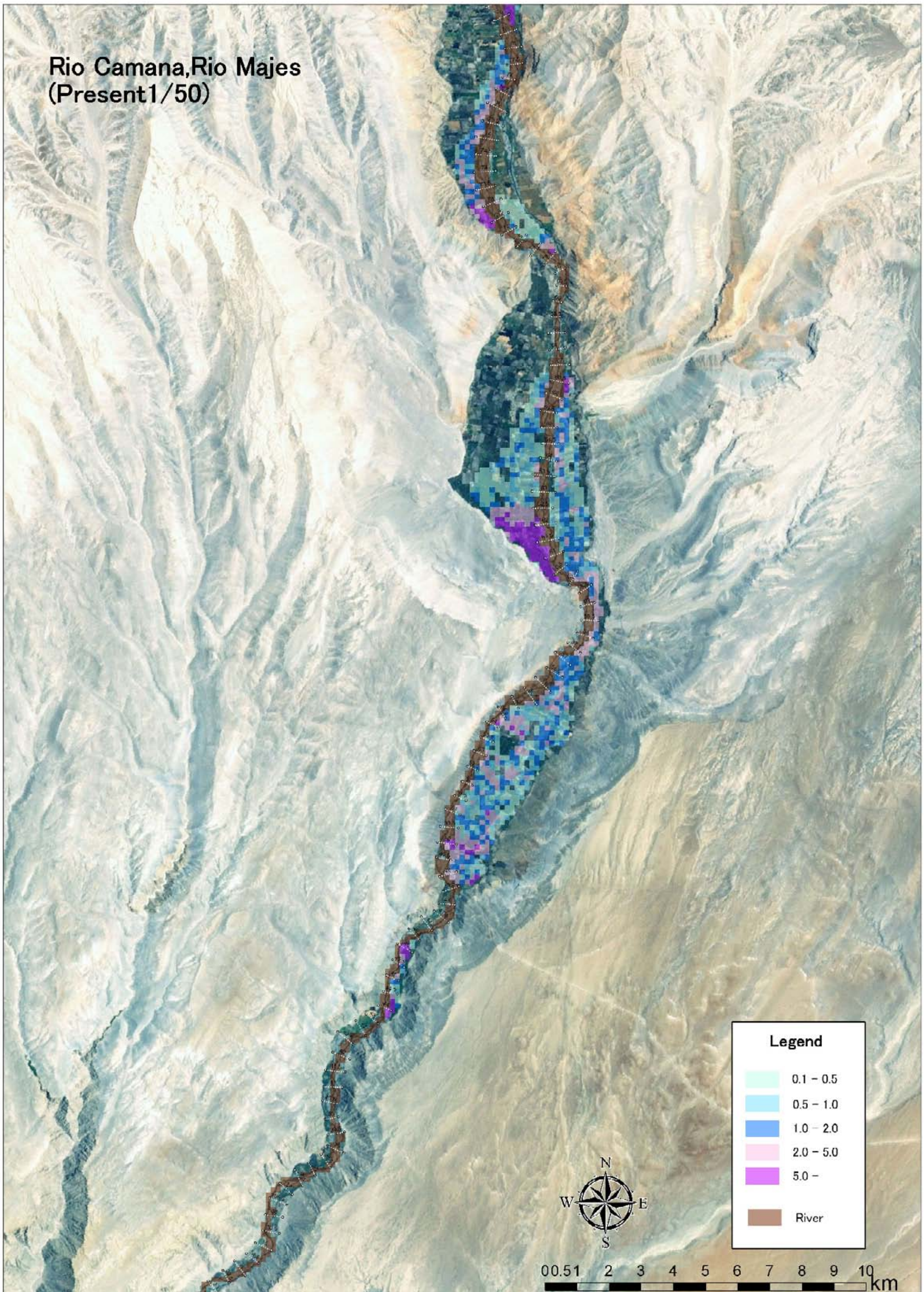


Figure 3.1.10-4(2) Inundation area of Majes-Camana river (50 year period floods) (2)

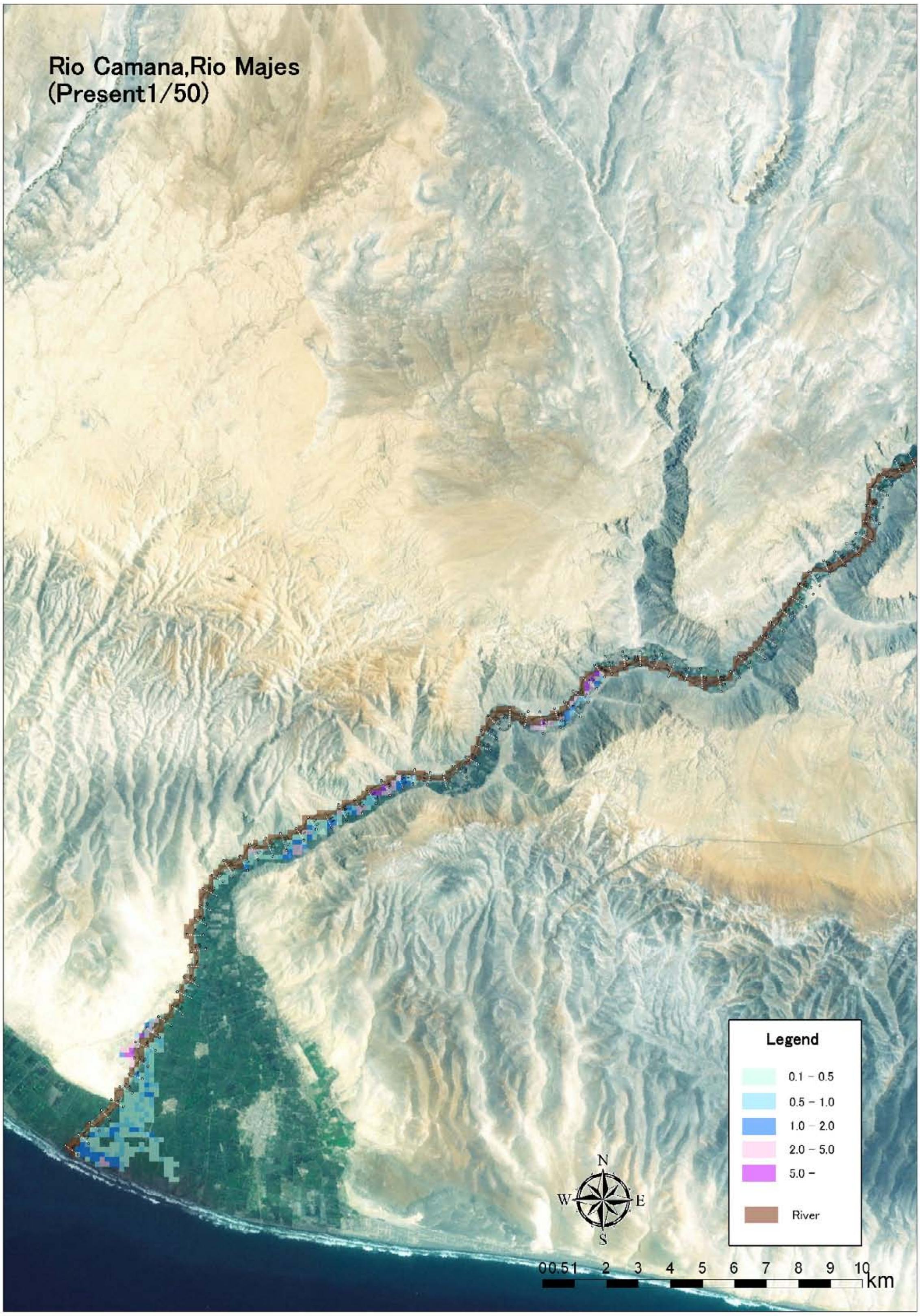


Figure 3.1.10-4(3) Inundation area of Majes-Camana river (50 year period floods) (3)

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

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

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

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 3.2.1-2 shows the direct and indirect causes of the main problem

Table 3.2.1-2 direct and indirect causes of the main problem

Direct cause	1. Excessive flood flow	2. Overflowing	3.Insufficient maintenance of control works	4. Insufficient communitarian activities for flood control
Indirect causes	1.1 Frequent occurrence of extraordinary weather (El Niño, etc..)	2. Lack of flood control works	3.1 Lack of maintenance knowledge and skills	4.1 Lack of knowledge and flood prevention techniques
	1.2 Extraordinary rains in the middle and upper basins	2.2 Lack of resources for the construction of works	3.2 Lack of training in maintenance	4.2 Lack of training in flood prevention
	1.3 Vegetation cover almost zero in the middle and upper basins	2.3 Lack of plans for flood control in basins	3.3 Lack of dikes and banks repair	4.3 Lack of early warning system
	1.4 Excessive sediment dragging from the upper and middle river levee	2.4 Lack of dikes	3.4 Lack of repair works and referral making	4.4 Lack of monitoring and collection of hydrological data
	1.5 Reduction of hydraulic capacity of rivers by altering slopes, etc.	2.5 Lack of bed channel width	3.5 Use of illegal bed for agricultural purposes	
		2.6 Accumulation of sediments in beds	3.6 Lack of maintenance budget	
		2.7 Lack of width at the point of the bridge construction		
		2.8 Elevation of the bed at the point of the bridge construction		
		2.9 Erosion of dikes and banks		
		2.10 Lack of capacity for the design of the works		

3.2.3 Problem Effects

(1) Main Problem

Valleys and local communities highly vulnerable to floods

(2) Direct and indirect effects

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

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

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

(3) Final effect

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

3.2.4 Causes and effects diagram

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

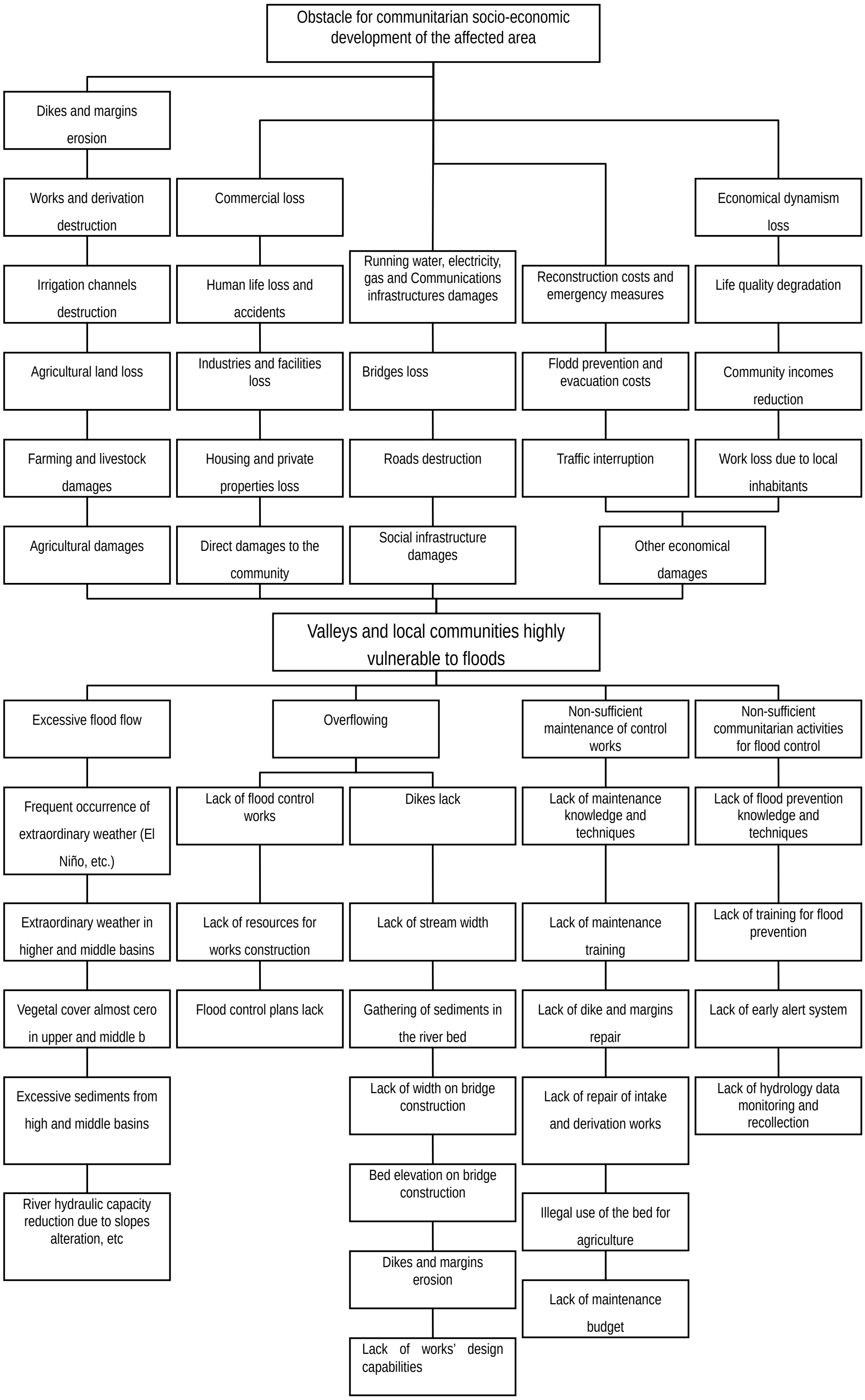


Figure 3.2.4-1 Causes and effects diagram

3.3 Objective of the Project

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

3.3.1 Solving measures for the main problem

(1) Main objective

Soothe the valleys and local community to flooding vulnerability.

(2) Direct and indirect measures

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

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

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

3.3.2 Expected impacts for the main's objective fulfillment

(1) Final Impact

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

(2) Direct and indirect impacts

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

Table 3.3.2-1 direct and indirect impacts

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

3.3.3 Measures - objectives – impacts Diagram

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

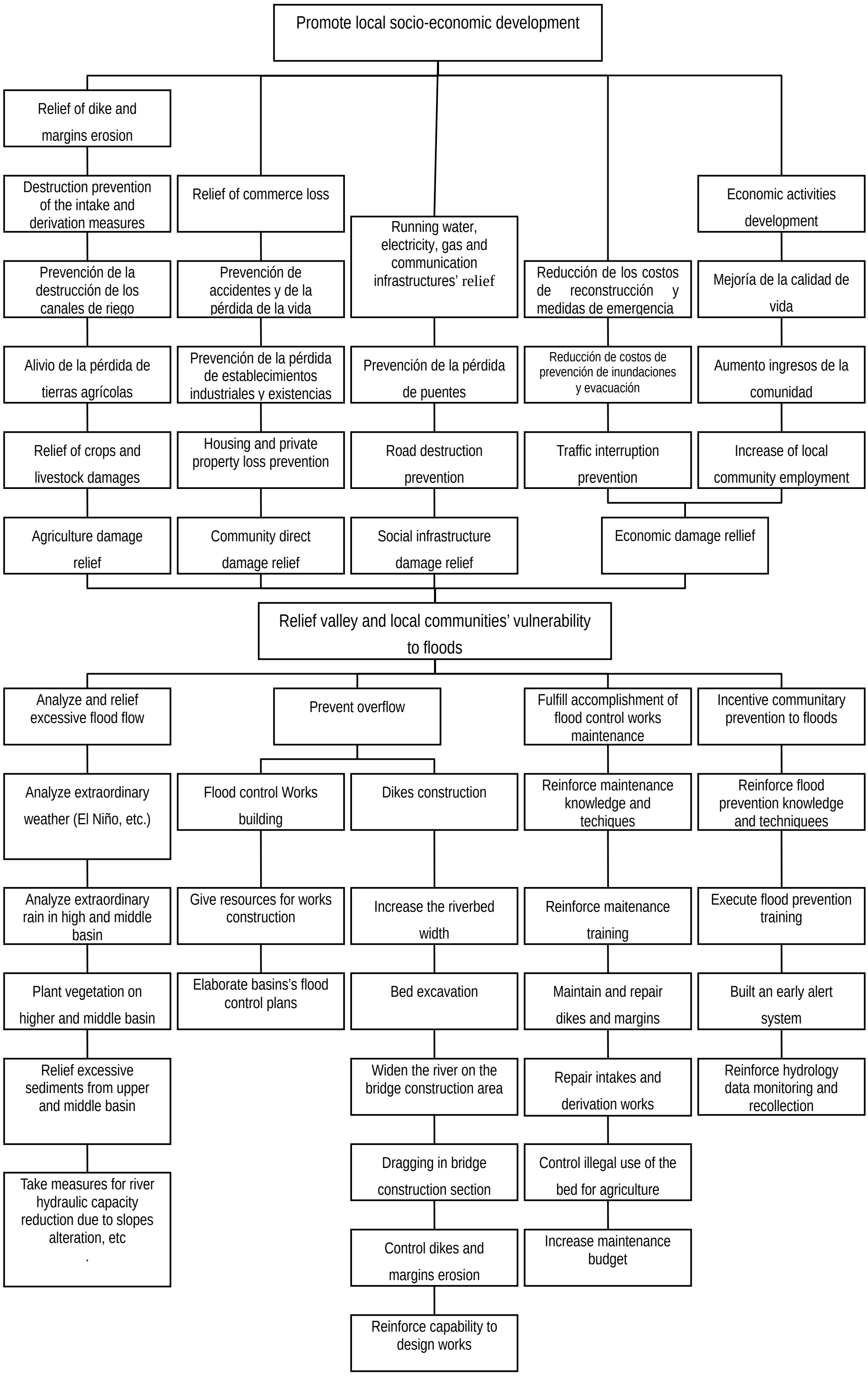


Figure 3.3.3-1 Measures - objectives – impacts diagram

4. FORMULATION AND EVALUATION

4.1 Definition of the Assessment Horizon of the Project

The Project's assessment horizon will be of 15 years, same as the one applied on the Program Profile Report.

4.2 Supply and Demand Analysis

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

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

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

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

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

Table 4.2-1 Watershed Demand and Supply

Basin	Present dike / ground height (supply)		Theoretical water level with a 50-year return period	Bordo libre dike	Dike height required (demand)	Diff. Demand/supply	
	Left	Right				Left	Right
	①	②	③	④	⑤=③+④	⑥=⑤-①	⑦=⑤-②
Majes-Camana River	401.90	405.19	399.43	1.20	400.63	1.21	0.88

Table 4.2-2 Demand and Supply according to the calculation

Distance (km)	Dike Height / current land (supply)		Theoretical water level with a return period of 50 years	Dike Freeboard	Required dike's height (demand)	Diff. demand/supply	
	Left bank	Right bank				Left bank	Right bank
	①	②	③	④	⑤ =③+④	⑥ =⑤-①	⑦ =⑤-②
0.0	5.26	4.99	4.26	1.20	5.46	0.20	0.47
0.5	6.25	6.05	7.87	1.20	9.07	2.82	3.03
1.0	8.01	8.70	9.00	1.20	10.20	2.20	1.51
1.5	11.64	11.22	11.46	1.20	12.66	1.03	1.44
2.0	13.01	12.62	13.83	1.20	15.03	2.01	2.41

2.5	15.09	22.64	16.21	1.20	17.41	2.33	0.00
3.0	18.47	23.25	18.41	1.20	19.61	1.14	0.00
3.5	20.47	23.68	21.60	1.20	22.80	2.33	0.00
4.0	22.57	21.29	24.18	1.20	25.38	2.81	4.09
4.5	25.45	26.89	28.55	1.20	29.75	4.30	2.86
5.0	28.79	27.41	29.28	1.20	30.48	1.69	3.07
5.5	31.35	38.06	31.09	1.20	32.29	0.94	0.00
6.0	32.90	51.69	33.33	1.20	34.53	1.63	0.00
6.5	35.90	46.14	36.20	1.20	37.40	1.50	0.00
7.0	37.81	43.39	37.80	1.20	39.00	1.19	0.00
7.5	41.14	45.63	40.65	1.20	41.85	0.71	0.00
8.0	43.87	49.52	44.85	1.20	46.05	2.18	0.00
8.5	47.06	50.55	46.56	1.20	47.76	0.70	0.00
9.0	48.70	58.23	50.02	1.20	51.22	2.52	0.00
9.5	52.00	57.35	51.99	1.20	53.19	1.19	0.00
10.0	55.01	60.22	56.33	1.20	57.53	2.52	0.00
10.5	58.19	60.00	60.66	1.20	61.86	3.67	1.86
11.0	60.14	60.96	61.08	1.20	62.28	2.14	1.32
11.5	62.71	71.89	63.29	1.20	64.49	1.78	0.00
12.0	67.26	71.79	66.17	1.20	67.37	0.11	0.00
12.5	69.14	71.54	69.35	1.20	70.55	1.41	0.00
13.0	71.82	71.53	73.27	1.20	74.47	2.65	2.94
13.5	73.31	89.35	77.82	1.20	79.02	5.71	0.00
14.0	77.69	84.03	79.39	1.20	80.59	2.90	0.00
14.5	78.61	94.88	80.04	1.20	81.24	2.63	0.00
15.0	82.06	90.00	82.76	1.20	83.96	1.90	0.00
15.5	83.91	94.56	84.47	1.20	85.67	1.76	0.00
16.0	87.18	88.81	88.44	1.20	89.64	2.46	0.83
16.5	90.33	99.09	90.58	1.20	91.78	1.45	0.00
17.0	91.77	93.73	93.92	1.20	95.12	3.35	1.39
17.5	95.34	101.83	95.91	1.20	97.11	1.77	0.00
18.0	98.31	99.56	98.93	1.20	100.13	1.82	0.57
18.5	100.52	107.63	101.84	1.20	103.04	2.52	0.00
19.0	104.47	112.23	104.09	1.20	105.29	0.82	0.00
19.5	106.02	116.45	107.45	1.20	108.65	2.63	0.00
20.0	109.64	118.45	109.15	1.20	110.35	0.70	0.00
20.5	111.77	120.01	111.15	1.20	112.35	0.58	0.00
21.0	116.33	116.11	114.30	1.20	115.50	0.00	0.00
21.5	121.18	123.21	117.68	1.20	118.88	0.00	0.00
22.0	119.60	126.53	120.62	1.20	121.82	2.22	0.00
22.5	123.59	130.43	124.72	1.20	125.92	2.33	0.00
23.0	125.50	150.14	126.50	1.20	127.70	2.20	0.00
23.5	128.40	131.49	128.75	1.20	129.95	1.55	0.00
24.0	130.06	130.94	131.68	1.20	132.88	2.82	1.94
24.5	133.45	132.02	135.07	1.20	136.27	2.82	4.25
25.0	137.05	134.85	139.29	1.20	140.49	3.44	5.64
25.5	139.43	141.44	141.12	1.20	142.32	2.89	0.88
26.0	140.95	142.25	142.13	1.20	143.33	2.38	1.08

26.5	146.60	142.12	144.14	1.20	145.34	0.00	3.22
27.0	167.92	146.57	147.99	1.20	149.19	0.00	2.62
27.5	165.14	147.71	150.66	1.20	151.86	0.00	4.15
28.0	157.32	152.67	155.19	1.20	156.39	0.00	3.72
28.5	155.64	155.76	155.94	1.20	157.14	1.50	1.38
29.0	158.95	162.66	158.75	1.20	159.95	1.00	0.00
29.5	162.56	182.70	161.21	1.20	162.41	0.00	0.00
30.0	164.97	172.07	165.42	1.20	166.62	1.65	0.00
30.5	167.68	173.08	169.28	1.20	170.48	2.80	0.00
31.0	170.61	182.03	171.02	1.20	172.22	1.61	0.00
31.5	173.60	180.56	173.86	1.20	175.06	1.46	0.00
32.0	177.87	185.81	178.25	1.20	179.45	1.58	0.00
32.5	181.11	182.27	180.41	1.20	181.61	0.50	0.00
33.0	180.74	183.57	181.88	1.20	183.08	2.34	0.00
33.5	185.23	183.68	184.86	1.20	186.06	0.83	2.38
34.0	187.81	187.85	188.42	1.20	189.62	1.81	1.77
34.5	204.28	197.86	192.73	1.20	193.93	0.00	0.00
35.0	193.16	199.85	194.37	1.20	195.57	2.41	0.00
35.5	204.46	213.40	198.32	1.20	199.52	0.00	0.00
36.0	199.68	203.21	199.82	1.20	201.02	1.34	0.00
36.5	202.82	220.00	203.04	1.20	204.24	1.42	0.00
37.0	205.50	213.29	205.60	1.20	206.80	1.30	0.00
37.5	208.96	224.00	209.78	1.20	210.98	2.02	0.00
38.0	222.38	225.00	214.08	1.20	215.28	0.00	0.00
38.5	232.41	216.82	216.42	1.20	217.62	0.00	0.80
39.0	225.78	224.00	220.59	1.20	221.79	0.00	0.00
39.5	222.90	224.90	222.59	1.20	223.79	0.89	0.00
40.0	231.24	254.46	227.05	1.20	228.25	0.00	0.00
40.5	238.75	229.19	229.55	1.20	230.75	0.00	1.56
41.0	243.35	232.04	232.29	1.20	233.49	0.00	1.45
41.5	244.83	235.47	236.38	1.20	237.58	0.00	2.11
42.0	250.73	239.16	239.64	1.20	240.84	0.00	1.68
42.5	255.17	244.44	243.29	1.20	244.49	0.00	0.05
43.0	259.78	246.46	247.32	1.20	248.52	0.00	2.06
43.5	260.99	249.74	251.27	1.20	252.47	0.00	2.73
44.0	254.07	255.56	254.58	1.20	255.78	1.71	0.22
44.5	256.54	355.37	257.93	1.20	259.13	2.58	0.00
45.0	260.61	413.49	261.38	1.20	262.58	1.97	0.00
45.5	263.51	369.98	264.29	1.20	265.49	1.98	0.00
46.0	266.25	315.14	267.09	1.20	268.29	2.04	0.00
46.5	269.88	270.01	270.11	1.20	271.31	1.43	1.30
47.0	275.60	274.95	274.85	1.20	276.05	0.45	1.10
47.5	289.11	286.44	277.15	1.20	278.35	0.00	0.00
48.0	286.18	312.30	280.65	1.20	281.85	0.00	0.00
48.5	283.73	291.87	285.08	1.20	286.28	2.55	0.00
49.0	287.36	292.03	288.27	1.20	289.47	2.11	0.00
49.5	290.36	292.12	291.58	1.20	292.78	2.42	0.66
50.0	295.18	298.86	296.58	1.20	297.78	2.60	0.00

50.5	299.70	307.87	301.11	1.20	302.31	2.61	0.00
51.0	305.12	310.49	304.75	1.20	305.95	0.83	0.00
51.5	308.74	309.00	308.60	1.20	309.80	1.06	0.80
52.0	312.36	312.50	312.59	1.20	313.79	1.43	1.29
52.5	313.91	347.19	316.41	1.20	317.61	3.69	0.00
53.0	319.46	324.98	319.00	1.20	320.20	0.74	0.00
53.5	322.86	324.29	322.40	1.20	323.60	0.74	0.00
54.0	325.34	339.40	326.95	1.20	328.15	2.81	0.00
54.5	329.86	346.99	331.71	1.20	332.91	3.05	0.00
55.0	332.90	372.91	333.24	1.20	334.44	1.54	0.00
55.5	336.67	369.23	337.83	1.20	339.03	2.36	0.00
56.0	344.01	388.32	343.71	1.20	344.91	0.90	0.00
56.5	348.44	371.67	347.35	1.20	348.55	0.10	0.00
57.0	353.00	356.86	351.82	1.20	353.02	0.01	0.00
57.5	357.06	360.00	356.44	1.20	357.64	0.58	0.00
58.0	362.04	369.90	360.06	1.20	361.26	0.00	0.00
58.5	365.00	366.31	365.47	1.20	366.67	1.67	0.37
59.0	370.06	390.29	369.36	1.20	370.56	0.50	0.00
59.5	374.33	371.96	373.78	1.20	374.98	0.65	3.01
60.0	378.14	374.96	377.08	1.20	378.28	0.13	3.32
60.5	382.86	381.01	382.15	1.20	383.35	0.49	2.34
61.0	385.73	387.67	385.88	1.20	387.08	1.35	0.00
61.5	389.13	390.16	390.92	1.20	392.12	3.00	1.96
62.0	395.20	395.05	396.15	1.20	397.35	2.14	2.30
62.5	402.87	400.16	400.78	1.20	401.98	0.00	1.82
63.0	406.88	405.88	405.13	1.20	406.33	0.00	0.45
63.5	411.27	411.54	411.52	1.20	412.72	1.45	1.18
64.0	416.36	416.12	415.60	1.20	416.80	0.44	0.68
64.5	420.47	420.33	420.31	1.20	421.51	1.04	1.18
65.0	422.49	425.54	424.98	1.20	426.18	3.68	0.63
65.5	429.42	428.00	428.42	1.20	429.62	0.20	1.62
66.0	437.95	432.88	433.71	1.20	434.91	0.00	2.03
66.5	437.32	439.27	439.56	1.20	440.76	3.44	1.49
67.0	445.23	444.37	444.65	1.20	445.85	0.63	1.48
67.5	449.17	449.58	449.11	1.20	450.31	1.14	0.74
68.0	454.82	454.48	453.78	1.20	454.98	0.16	0.51
68.5	457.23	459.54	458.19	1.20	459.39	2.16	0.00
69.0	461.75	463.52	461.17	1.20	462.37	0.62	0.00
69.5	466.00	465.64	466.76	1.20	467.96	1.95	2.32
70.0	475.66	469.12	470.59	1.20	471.79	0.00	2.67
70.5	476.00	475.57	475.38	1.20	476.58	0.58	1.01
71.0	480.07	480.00	480.20	1.20	481.40	1.33	1.40
71.5	484.80	484.00	484.65	1.20	485.85	1.05	1.85
72.0	487.93	494.51	488.85	1.20	490.05	2.12	0.00
72.5	492.57	492.89	494.18	1.20	495.38	2.82	2.49
73.0	497.47	496.99	498.13	1.20	499.33	1.86	2.33
73.5	504.05	504.44	504.69	1.20	505.89	1.84	1.45
74.0	508.89	509.79	510.50	1.20	511.70	2.81	1.91

74.5	515.17	514.14	514.48	1.20	515.68	0.52	1.55
75.0	520.15	520.23	519.38	1.20	520.58	0.43	0.35
75.5	524.58	524.75	524.23	1.20	525.43	0.85	0.67
76.0	528.22	529.44	528.72	1.20	529.92	1.70	0.49
76.5	531.64	534.26	533.01	1.20	534.21	2.57	0.00
77.0	535.15	535.13	537.47	1.20	538.67	3.52	3.55
77.5	540.28	542.37	541.29	1.20	542.49	2.22	0.12
78.0	545.08	546.72	547.02	1.20	548.22	3.15	1.50
78.5	552.44	551.73	552.29	1.20	553.49	1.05	1.76
79.0	557.05	556.80	556.82	1.20	558.02	0.98	1.22
79.5	562.51	562.79	561.58	1.20	562.78	0.27	0.00
80.0	563.91	567.45	565.45	1.20	566.65	2.73	0.00
80.5	571.02	572.31	570.74	1.20	571.94	0.93	0.00
81.0	574.60	574.68	575.96	1.20	577.16	2.56	2.48
81.5	581.23	581.25	581.78	1.20	582.98	1.76	1.73
82.0	587.36	585.34	587.25	1.20	588.45	1.09	3.11
82.5	593.38	607.08	592.59	1.20	593.79	0.41	0.00
83.0	598.15	595.22	596.35	1.20	597.55	0.00	2.34
83.5	603.56	601.15	602.55	1.20	603.75	0.19	2.60
84.0	606.51	607.41	606.72	1.20	607.92	1.41	0.51
84.5	609.11	610.58	610.80	1.20	612.00	2.89	1.42
85.0	622.61	615.37	615.33	1.20	616.53	0.00	1.16
85.5	628.43	620.06	620.78	1.20	621.98	0.00	1.92
86.0	645.54	627.56	627.88	1.20	629.08	0.00	1.52
86.5	632.65	633.82	631.44	1.20	632.64	0.00	0.00
87.0	635.86	636.22	635.60	1.20	636.80	0.94	0.58
87.5	641.45	639.17	639.84	1.20	641.04	0.00	1.87
88.0	644.21	650.70	644.88	1.20	646.08	1.87	0.00
88.5	657.62	650.10	652.00	1.20	653.20	0.00	3.10
89.0	667.85	656.55	656.84	1.20	658.04	0.00	1.49
89.5	668.63	660.78	660.48	1.20	661.68	0.00	0.90
90.0	673.44	664.19	664.26	1.20	665.46	0.00	1.27
90.5	697.69	670.28	668.61	1.20	669.81	0.00	0.00
91.0	686.00	671.51	672.09	1.20	673.29	0.00	1.78
91.5	685.08	675.39	677.11	1.20	678.31	0.00	2.92
92.0	682.72	695.65	683.08	1.20	684.28	1.56	0.00
92.5	687.29	685.90	687.24	1.20	688.44	1.15	2.54
93.0	696.78	693.52	691.40	1.20	692.60	0.00	0.00
93.5	697.53	698.07	696.20	1.20	697.40	0.00	0.00
94.0	704.83	723.65	701.45	1.20	702.65	0.00	0.00
94.5	717.41	715.23	705.35	1.20	706.55	0.00	0.00
95.0	714.48	711.75	707.79	1.20	708.99	0.00	0.00
95.5	709.48	710.99	711.90	1.20	713.10	3.62	2.11
96.0	713.23	720.86	715.03	1.20	716.23	3.00	0.00
96.5	718.39	724.80	719.89	1.20	721.09	2.70	0.00
97.0	724.98	723.32	723.54	1.20	724.74	0.00	1.42
97.5	726.65	730.79	728.63	1.20	729.83	3.18	0.00
98.0	731.07	735.05	732.51	1.20	733.71	2.64	0.00

98.5	744.51	735.62	736.96	1.20	738.16	0.00	2.54
99.0	748.48	740.07	742.15	1.20	743.35	0.00	3.28
99.5	746.53	746.62	747.23	1.20	748.43	1.90	1.81
100.0	765.13	752.28	751.97	1.20	753.17	0.00	0.89
100.5	757.25	757.09	758.02	1.20	759.22	1.97	2.13
101.0	773.81	762.97	763.84	1.20	765.04	0.00	2.07
101.5	772.00	770.41	771.41	1.20	772.61	0.61	2.20
102.0	787.47	774.78	775.79	1.20	776.99	0.00	2.21
102.5	789.63	788.67	780.50	1.20	781.70	0.00	0.00
103.0	797.97	785.87	785.38	1.20	786.58	0.00	0.71
103.5	790.00	788.37	790.71	1.20	791.91	1.91	3.54
104.0	794.00	792.84	794.60	1.20	795.80	1.80	2.96
104.5	807.88	799.11	799.42	1.20	800.62	0.00	1.51
105.0	813.04	803.88	804.74	1.20	805.94	0.00	2.06
105.5	817.72	811.80	811.40	1.20	812.60	0.00	0.80
106.0	821.32	822.80	819.76	1.20	820.96	0.00	0.00
106.5	836.00	838.53	824.77	1.20	825.97	0.00	0.00
107.0	838.79	865.15	829.33	1.20	830.53	0.00	0.00
107.5	833.74	837.90	834.59	1.20	835.79	2.05	0.00
108.0	839.44	840.38	840.27	1.20	841.47	2.03	1.09
108.5	856.86	850.08	846.01	1.20	847.21	0.00	0.00
109.0	864.52	849.96	850.89	1.20	852.09	0.00	2.13
109.5	872.07	859.31	857.34	1.20	858.54	0.00	0.00
110.0	866.43	865.82	864.47	1.20	865.67	0.00	0.00
110.5	881.45	872.36	871.32	1.20	872.52	0.00	0.16
111.0	881.73	878.24	878.10	1.20	879.30	0.00	1.06
111.5	949.26	892.01	887.60	1.20	888.80	0.00	0.00
112.0	912.40	904.94	894.99	1.20	896.19	0.00	0.00
112.5	904.46	911.05	895.00	1.20	896.20	0.00	0.00
113.0	907.55	912.94	901.88	1.20	903.08	0.00	0.00
113.5	916.04	920.44	904.26	1.20	905.46	0.00	0.00
114.0	923.28	921.43	911.74	1.20	912.94	0.00	0.00
114.5	929.36	925.09	916.79	1.20	917.99	0.00	0.00
115.0	929.96	929.64	918.22	1.20	919.42	0.00	0.00
115.5	933.64	931.67	922.65	1.20	923.85	0.00	0.00
Average	401.90	405.19	399.37	1.20	400.57	1.21	0.89

4.3 Technical Planning

4.3.1 Structural Measures

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

(1) Design flood discharge

1) Guideline for flood control in Peru

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

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

2) Maximum discharge in the past and design flood discharge

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

The maximum discharge in the past in Majes-Camana watershed is less than the flood discharge with return period of 50-year. However it seems that the flood discharge with return period of 50-year caused large damages.

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

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

Watershed	2-year	10-year	25-year	50-year	100-year	Max. in the Past
Majes-Camana	270	1,166	1,921	2,659	3,586	2,021

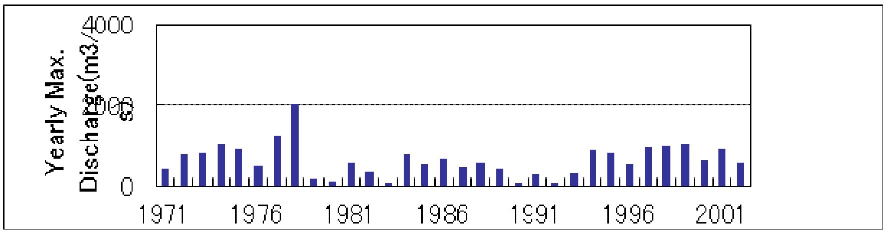


Figure- 4.3.1-1 Yearly Max. Discharge (Majes-Camana)

3) Relation among probable flood, Damage and inundation area

The relation among probable flood, Damage and inundation area in each watershed are shown in the Figure-4.3.1-2.

Based on the figures the following facts can be expressed.

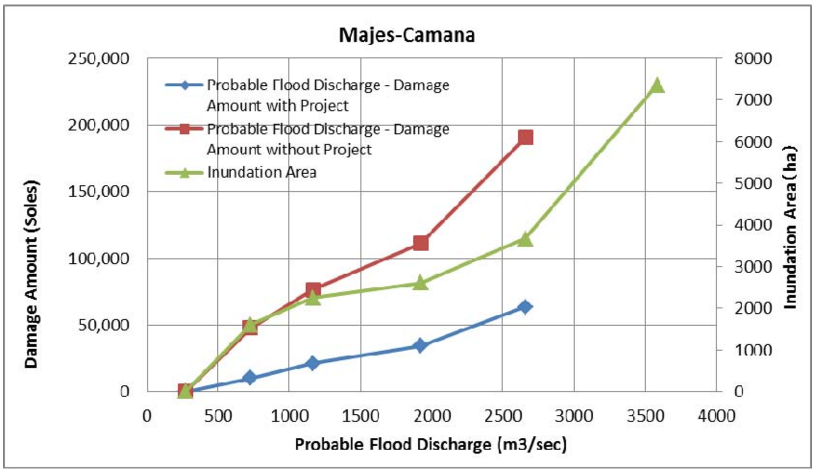
① The more increase probable flood discharge, the more increase inundation area (green line in the figure).

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

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

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

As shown in the above section, the design flood discharge with return period of 50-year is more than the maximum flood in the past, and absolute damage reduction amount in the design discharge is largest among the probable flood discharge less than with return period of 50-year, and economic viability of the design flood is confirmed.



Figure－4.3.1-2 Probable Flood Discharge, Damage Amount and Inundation Area (Majes-Camana river)

(2) Topographical survey

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

Table 4.3.1-2 Quantities of Topographical Survey

River	Topographical Uplift	Transverse Uplift
Majes - Camana	S = 1/2.500	S = 1/100, 100 m interval
	Ha	km
	193	21,3

(3) Selection of flood protection works with high priority

1) Basic Guidelines

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

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

Based on the river survey, field investigation, discharge capacity analysis of river channel, inundation analysis, and interviews to the local community (irrigation committee needs, local governments, historical flood damage, etc.) a comprehensive evaluation was made applying the five evaluation criteria listed above. After that we selected a total of seven (7) critical points (with the highest score in the assessment) that require flood protection measures.

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

Table 4.3.1-3 details evaluated aspects and assessment criteria.

Table 4.3.1-3 Assessment Aspects and Criteria

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

2) Selection results

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

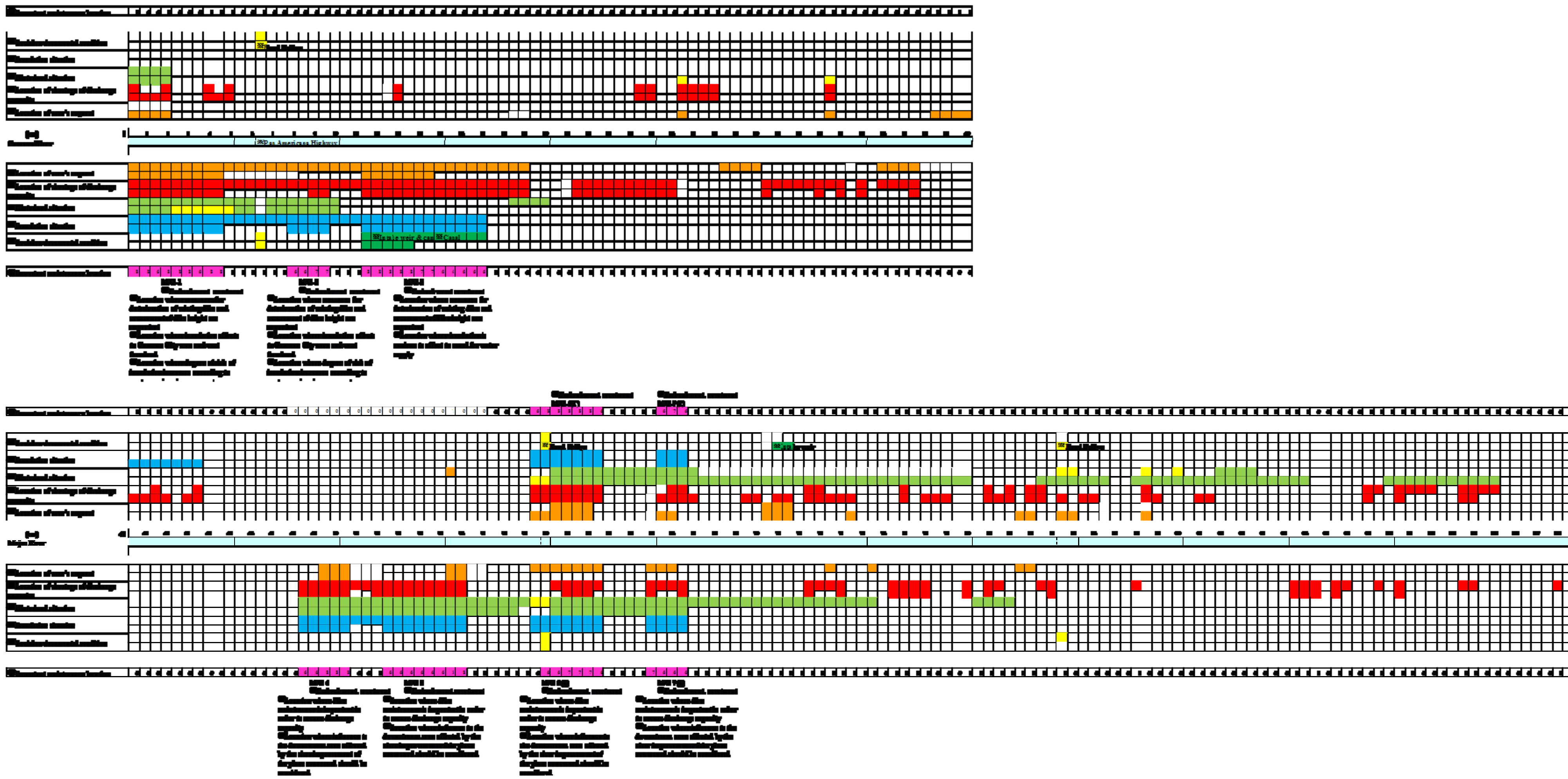


Figure 4.3.1-3 Selection results of prioritized flood protection works in Majes-Camana River

3) Basis of Selection

The existing dike in Camana river presents an advanced degree of obsolescence, and numerous eroded sections can be observed.
Currently, overflow occurs mainly in the upstream reach (Majes river), reducing the impact in this area. However, once this problem is solved in the upstream reach, impact would increase in this area, extending inundation area.
Likewise, at 13km there are a water supply intake to the urban area of Camana and a water channel along the river. Given that currently the left bank in the 12 km of the river is eroded and feared that the effect might strike the adjacent channel.
On the other hand, there are many sections without dike in Majes river so that damage by inundation and lost of farmland occur in every year.
Therefore in Camana river the rehabilitation and raising of existing dike is the most important in the left bank area which has large potential of damage, and in Majes river the embankment in the area without dike and with frequent flood damage is to be executed with priority.
The flood protection works in Majes river will affect the Camana river, therefore the order of the works should be carefully considered.

Table 4.3.1-4 Selected sections bases to execute works (Majes-Camana River)

No	Location	Basis of Selection
①	0.0km-4.5km (left bank)	In this section the existing dike is deteriorated and eroded sections are observed scattering here and there. At present inundation in this area is reduced due to inundation in upstream area (Majes river), however when the flood protection work in the upstream will progress, which will affect this area increasing inundation area. [Characteristics of the section] ● Section where it is important to solve the obsolescence issue in the existing dike and increase its height. ● Section where inundation in the left bank can affect the urban area of Camana as well as its adjoining vast arable lands. ● Section where inundation risk increases associated with the development of flood protection work in the upstream reach. [Elements to be protected] ○ Large arable lands extending in the left bank ○ Urban area of Camana city [Method of Protection] ▼It is characteristics of Camana river that once the flood discharge over the discharge with scale of 50-years, damage increases become serious so that the protection works are to be safe for the discharge with return period of 50-years. ▼Embankment with bank protection is to be executed in the section of insufficient dike height, utilizing the existing dikes.
②	7.5km-9.5km (left bank)	In this section the existing dike is deteriorated and eroded sections are observed scattering here and there. At present inundation in this area is reduced due to inundation in upstream area (Majes river), however when the flood protection work in the upstream will progress, which will affect this area increasing inundation area. [Characteristics of the section] ● Section where it is important to solve the obsolescence issue in the existing dike and increase its height. ● Section where inundation in the left bank can affect the urban area of Camana as well as its adjoining vast arable lands.

		● Section where inundation risk increases associated with the development of flood protection work in the upstream reach. [Elements to be protected] ○ Large arable lands extending in the left bank ○ Urban area of Camana city [Method of Protection] ▼It is characteristics of Camana river that once the flood discharge over the discharge with scale of 50-years, damage increases become serious so that the protection works are to be safe for the discharge with return period of 50-years. ▼Embankment with bank protection is to be executed in the section of insufficient dike height, utilizing the existing dikes.
③	11.0km-17.0km (left bank)	In this section the existing dike is deteriorated and eroded sections are observed scattering here and there. The intake for drinking water of Camana urban area is constructed at 13km and conveyance channel along river. The left bank at 12km is eroded and feared that the effect might strike the adjacent channel. [Characteristics of the section] ● Section where it is important to solve the obsolescence issue in the existing dike and increase its height. ●Section where inundation causes serious damage to the conveyance channel of drinking water. [Elements to be protected] ○ Channel (of drinking water service) in the left bank [Method of Protection] ▼At present inundation in this area is reduced due to inundation in upstream area (Majes river), however when the flood protection work in the upstream will progress, which will affect this area increasing damage in this area. The conveyance channel along the river will be also affected. In case that the channel is destroyed, the damage will be serious, therefore it will be safe in the flood with return period of 50-year. ▼Embankment with bank protection is to be executed to secure the discharge capacity in the section of insufficient dike height, utilizing the existing dikes.
④	48.0km-50.5km (left bank)	This is a section with most insufficient discharge capacity in the river that inundates easily with small flooding and causes big damages in accordance with increase of the flood discharge. [Characteristics of the section] ●Section where it is important to build a dike to keep necessary discharge capacity and to protect the secondary wide farmland in Majes area . [Elements to be protected] ○ Arable lands extending in the left bank (maximum area of inundation n) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ④and ⑤ can increase the effect

		of facilities.
⑤	52.0km-56.0km (left bank)	This is a section with most insufficient discharge capacity in the river that inundates easily with small flooding and causes big damages in accordance with increase of the flood discharge. The whole area was inundated in flooding in 1998 and damaged heavily. [Characteristics of the section] ●Section where it is important to build a dike to keep necessary discharge capacity and to protect the secondary wide farmland in Majes area . [Elements to be protected] ○ Arable lands extending in the left bank (secondary wide farmland in Majes area with the maximum area of inundation) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ④and ⑤ can increase the effect of facilities.
⑥	59.0km-62.5km (right bank) 59.5km-62.5km (left bank)	It is a narrow section where discharge capacity is insufficient, causing frequent flood damages in arable lands in the upstream section. There is a road bridge in the narrowness, and no dike in the adjacent area. [Characteristics of the section] ● Section where it is important to build a dike to keep necessary discharge capacity and to protect the maximum farmland in Majes area. [Elements to be protected] ○ Arable lands in both banks of the selected stretch (largest arable lands in Majes) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ⑥ and ⑦ can increase the effect of facilities.
⑦	65.0km-66.5km (right bank) 64.5km-66.5km (left bank)	This is a section with most insufficient discharge capacity in the river that inundates easily with small flooding and causes big damages in accordance with increase of the flood discharge. [Characteristics of the section] ● Section where it is important to build a dike to keep necessary discharge capacity and to protect the maximum farmland in Majes area. [Elements to be protected] ○ Arable lands in both banks of the selected stretch (largest arable lands in Majes) [Method of Protection] ▼Inundation occurs at the flood with return period of 5-year and the damage become heavily at the flood with return period of 50-year, so that the flood protection work is implemented for the latter flood flowing down safely. ▼The combination of protection work of ⑥ and ⑦ can increase the effect of facilities.

(4) Location of prioritized flood control works

In Figure 4.3.1-4 ~ Figure 4.3.1-5 the location of prioritized flood control works in indicated in each watershed and in the Table- 4.3.1-5 the summary of flood control works is indicated..

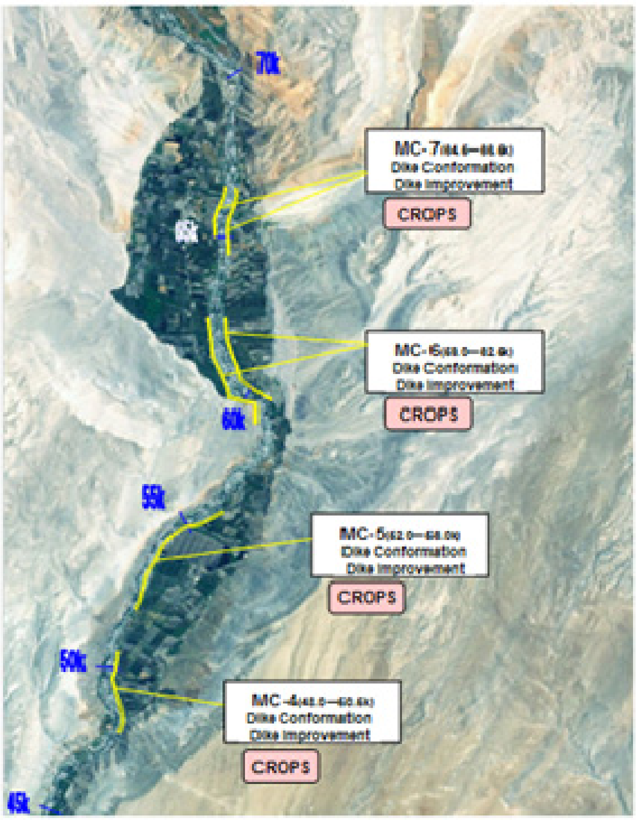


Figure 4.3.1-4 Prioritezed flood control works in Majes river

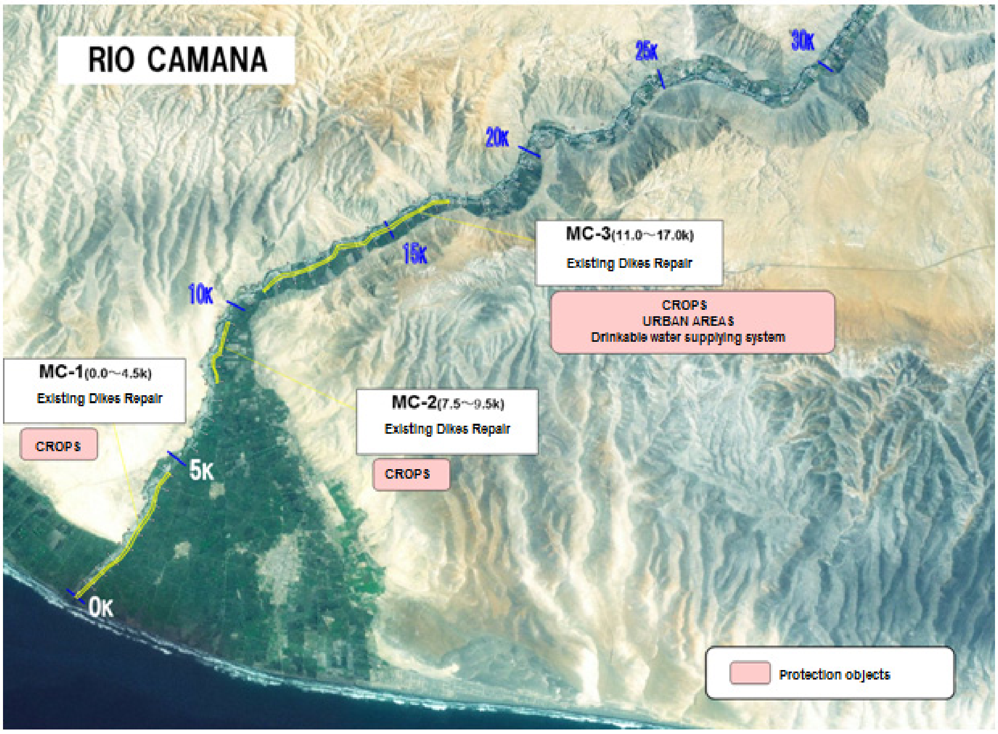


Figure 4.3.1-5 Prioritezed flood control works in Camana river

Table 4.3.1-5 Summary of Facilities

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Majes-Camana	MC 1	0.0k-4.5k	Inundation	Crop land (rice、others)	Dike(no dike section) Revetment	Top W;4.0m h;2.0m-3.0m Slope;1:3 L;4,500m	0.0km-4.5km (left bank)
	MC 2	7.5k-9.5k	Inundation			Top W;4.0m h;2.0m-3.0m Slope;1:3 L;2,000m	7.5km-9.5km (left bank)
	MC 3	11.0k-17.0k	Inundation			Top W;4.0m h;2.0m-3.0m Slope;1:3 L;6,000m	11.0k-17.0k(left bank)
	MC 4	48.0k-50.5k	Inundation			Top W;4.0m h;2.0m-3.0m Slope;1:3 L;2,500m	48.0km-50.5km (left bank)
	MC 5	52.0k-56.0k	Inundation			Top W;4.0m h;2.0m-3.0m Slope;1:3 L;4,o00m	52.0k-56.0k(left bank)
	MC 6	59.0k-62.5k 59.5k-62.5k	Inundation /erosion			Top W;4.0m h;2.0m-3.0m Slope;1:3 L;6,500m	59.0km-62.5km (left bank) 59.5km-62.5km. (right bank)
	MC 7	65.0k-66.5k 64.5k-66.5k	Inundation			Top W;4.0m h;2.0m-3.0m Slope;1:3 L;3,500m	65.0km.-66.5 km.(right bank) 64.5km.-66.5 km. (left bank)

(5) Standard section of the dike

1) Width of the crown

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

2) Dike structure

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

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

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

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

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

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

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

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

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

Therefore, the dike should have the following structure.

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

i) Infiltrate destruction caused by piping due to washing away fine material
ii) Sliding destruction of slope due to infiltrate pressure

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

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

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

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

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

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

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

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

3) Freeboard of the dike

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

Table 4.3.1-9 shows guidelines applied in Japan regarding freeboard. Although in Peru there is a norm on freeboard, it has been decided to apply the norms applied in Japan, considering that rivers in both countries are alike.

Table-4.3.1-6 Design discharge and freeboard

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

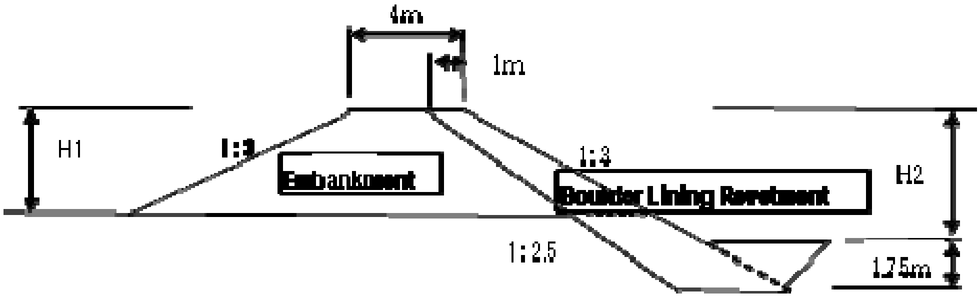


Figure 4.3.1-6 Standard dike section

4.3.2 Nonstructural measures

4.3.2.1 Reforestation and vegetation recovery

(1)Basic policies

The Reforestation and Vegetation Recovery Plan satisfying the goal of the present Project can be classified in: i) reforestation along river structures; and ii) reforestation in the high Watershed. The first one contributes directly to flood control and expresses its effect in short time. The second one demands a huge investment and an extended time, as detailed in the later section 4.12 “Medium and long term Plan”, 4.12.2 “Reforestation Plan and Vegetation Recovery”, what makes not feasible to implement it in the present Project. Therefore, the analysis is here focused only in option i).

(2) Reforestation plan along fluvial structures

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

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

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

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

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

Policies for the afforestation plan to be applied in constructions on the riverbanks are detailed below. Figures 4.3.2.1-1 and 4.3.2.1-2 show afforestation plan conceptual diagrams. There are two types of afforestation. In case A-type forestation cannot be applied in the Watershed of the Majes-Camana River, B-Type afforestation will do it. In the Watersheds, with exception of the before mentioned, A-Type afforestation will be used.

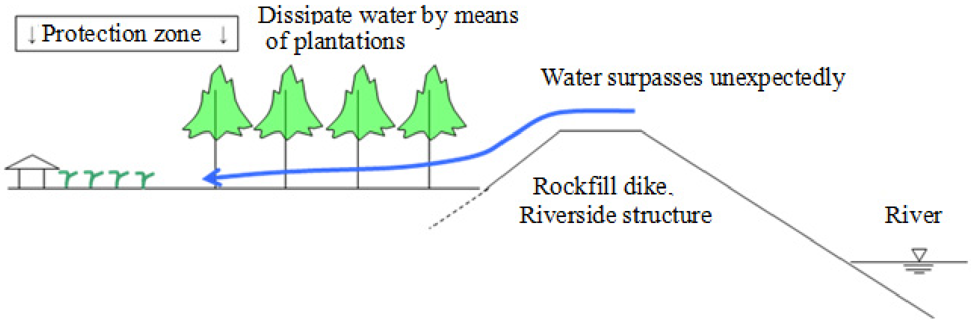


Figure 4.3.2.1-1 Conceptual Diagram Afforestation in the Riverside structures (A Type)
(Source: JICA Study Team)

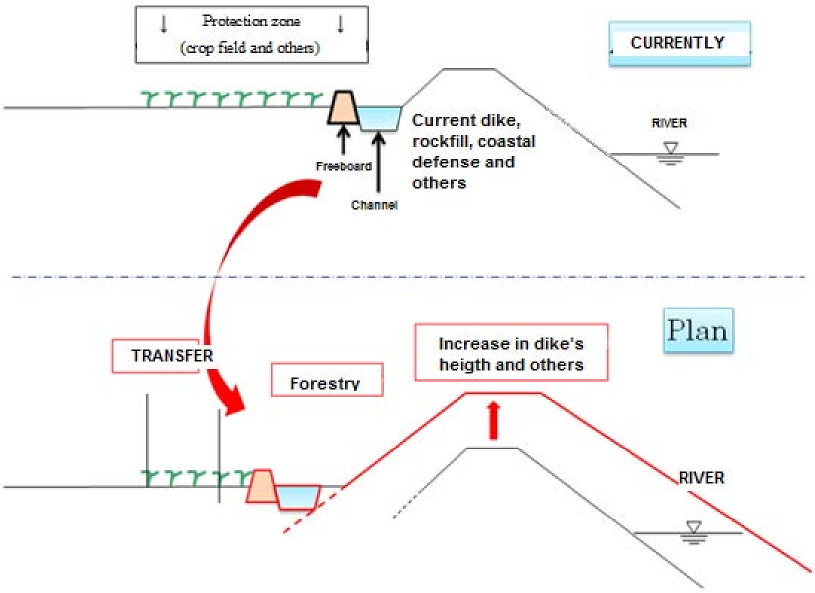


Figure 4.3.2.1-2 Conceptual Diagram Afforestation of riverside structures (B Type)
(Source: JICA Study Team)

In the Watershed of the Camana River, channels along the existing dikes have been built, and most of rice fields are covered with water. According to the interview to the Board of Users, land owners would not agree with A-Type afforestation (11-meter width afforestation) for it would reduce the arable area. Therefore afforestation is seen as a difficult issue. That is why in case the land cannot be acquired, B-Type afforestation is proposed as well as afforestation of channels for its conservation.

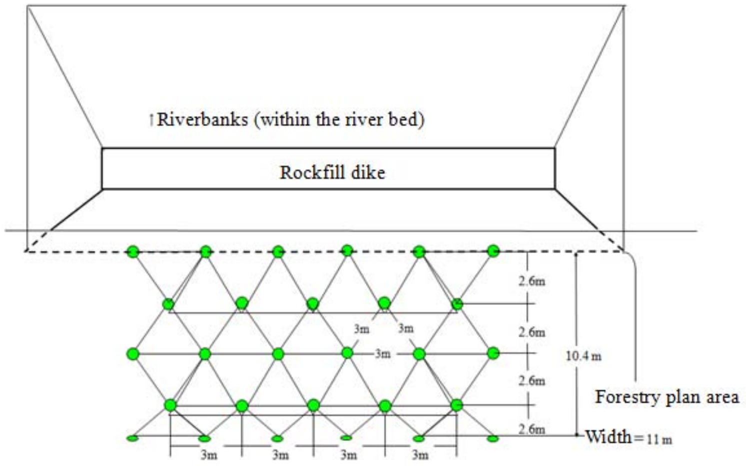
(3) Reforestation and Vegetation Recovery Plan along River Structures

This plan consists of conforming vegetation borders along river structures, serving as buffer zone in case for some reason water overflows the dike, etc. during water rise.

1) Structure (afforestation location)

i) A Type

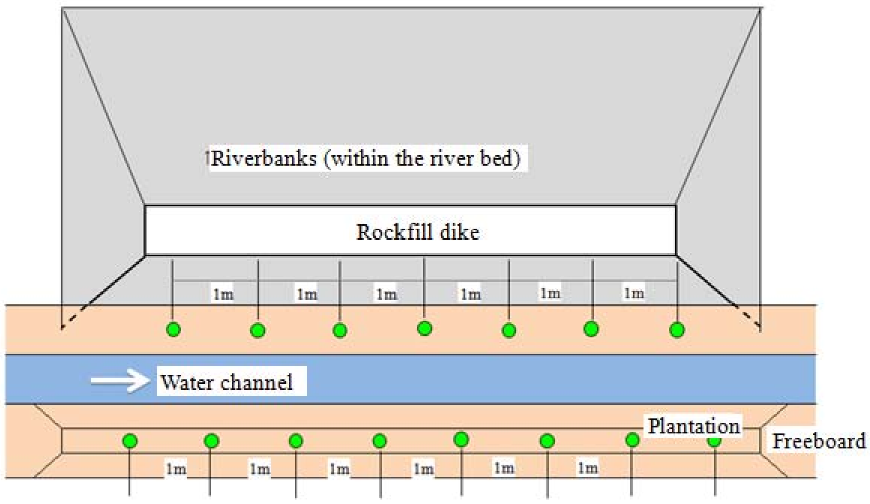
In Peru the most common pattern for afforestation is with equilateral triangles. This project also uses this model by planting trees with 3-meter intervals (Figure 4.3.2.1-3). If this method is used, the interval of trees vertical to the dike will be 2.6m and in the case of zigzag arrangement, the width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



(Source: JICA Study Team)

Figure 4.3.2.1-3 Conceptual Diagram Afforestation in the Riverside structures (A Type)

ii) B Type: in the current situation, afforestation is applied with a 1meter interval parallel to the channel. In this plan this afforestation will be applied. Figure 4.3.2.1-4 shows the location of the afforestation design plan.



(Source: JICA Survey)

Figure 4.3.2.1-4 Conceptual Diagram Afforestation in the Riverside structures (B type)

2) Species to be afforested

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

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

After making a land survey, a list of planted or indigenous species of each zone was firstly made. Then, a list of species whose plants would grow in seedbeds, according to interviews made to plant growers, was prepared. Priority was given to the aptitude of local conditions and to plant production precedents, leaving as second priority its usefulness and demand or if they were native species or not. Table 4.3.2.1-1 shows the assessment criterion.

Table 4.3.2.1-1 Assessment criterion for forest species selection

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

(Source: JICA Study Team)

Table-4.3.2.1-2 shows a list of selected species applying these assessment criterions. ◎ marks main species, ○ are those species that would be planted with a proportion of 30% to 50%. This proportion is considered to avoid irreversible damages such as plagues that can kill all the trees.

Table 4.3.2.1-2 Selection of forest species

Watershed	Forest species
Majes- Camana Watershed	Willow (◎), Casuarina (○)

In the Watershed of the Majes-Camana River the main afforestation specie is the Willow. This specie adapts very well in highly humid environments and there is experience in afforestation activities in the zone. This specie is generally afforested by the Users Board. However, the Willow and the Callacas are found between the seashore up to 1.5km, and still its growth is not optimal. This is due to the tide impact, for what it is proposed to replace the Willow with the Casuarina, given that the later one adapts better in salty zones. In the area there is abundance of Callacas, but they do not grow in plant nurseries. In the Watershed of the Majes- Camana River most of the fields are rice crop fields, therefore water level is high and the soil is clay soil. For this reason, the Eucalyptus is not apt for afforestation in this zone, since it may wither.

3) Volume of the Reforestation and Vegetation Recovery Plan

The afforestation plan has been selected as it is mentioned in the location and type of species plan, in the dikes and bank protection along the riverside. The width of the A-type afforestation is of 11 meters; in the case of the sedimentation well, afforestation occurs in places where river water does not pass through. In the case of B-type afforestation, it has been calculated to afforest two lines along the dike, with 1-meter interval.

Following Table 4.3.2.1-3 shows the construction estimating for the Afforestation and Recovery of Vegetation Cover Plan for Watersheds.

Table 4.3.2.1-3 Amount of Afforestation/Vegetation Recovery Plan (Riparian Afforestation)

N°	Location (bank)	Length	Width	Area	Quantity	Distribution according to the specie (unit)		
		(m)	(m)	(ha)	(unit)	Willow	Casuarina	Total
B Type								
Camana-1	Left	1.500	−	−	3.000	1.500	1.500	3.000
Camana-1	Left	3.000	−	−	6.000	6.000	−	6.000
Camana-2	Left	2.000	−	−	4.000	4.000	−	4.000
Camana-3	Left	6.000	−	−	12.000	12.000	−	12.000
A Type								
Majes-4	Left	2.500	11	2,8	8.288	8.288	−	8.288
Majes-5		4.000	11	4,4	13.024	13.024	−	13.024
Majes-6	Right	3.500	11	3,9	11.544	11.544	−	11.544
Majes-6		3.000	11	3,3	9.768	9.768	−	9.768
Majes-7	Right	1.500	11	1,7	5.032	5.032	−	5.032
Majes-7	Left	2.000	11	2,2	6.512	6.512	−	6.512
Camana-Majes River Total				18,3	79.168	79.168	1.500	79.168

(Source: JICA Study Team)

4) Areas subject to the Reforestation and Vegetation Recovery Plan

In areas subject to the Reforestation/Vegetation Recovery Plan along river structures, the structure arrangement is similar everywhere. See section 4.5.1.3(2).

5) Execution costs of the Reforestation and Vegetation Recovery Plan

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

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

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

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

i) Planting unitary cost
Planting unitary cost was defined as detailed in Table 4.3.2.1-4, based on information obtained through interviews to private providers. Given that planting prices and transportation cost varies per provider, an average Figure was applied.

Table 4.3.2.1-4 Unitary cost of plants

ii) Labor cost

iii) Reforestation execution cost
Work costs for the afforestation and vegetation cover recovery plan in the riverside structures are detailed in Table 4.3.2.1-5. The total cost of works is 504,745 Soles.

To carry out the afforestation plan a construction company is required for the execution of riverside structures. Like work construction cost, 88% of direct costs is allocated to indirect costs.

Table 4.3.2.1-5 Afforestation work cost (afforestation in riverside structures)

6) **Implementation process plan**

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

4.3.2.2 Sediment Control Plan

(1) Importance of the Sediment Control Plan

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

- Flood water overflows bank and inundates.
- Rivers have a steep slope of 1/30 to 1/300. The flow speed is high, as well as the sediment transport capacity.
- The accumulation of large quantities of sediment and the consequent elevation of the river bed aggravate flood damages.
- There is a great quantity of sediment accumulated on the river bed forming plural sandbar. The flow route and the flow collision point are unstable, causing route change and consequently, change of flow collision point.
- Riverside is highly erodible, causing a decrease of adjacent farming lands, destruction of regional roads, etc., for what they should be duly protected.
- Big stones and rocks cause damages and destruction of water intakes.

(2) Sediment Control Plan (structural measures)

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

Table 4.3.2.2-1 Basic guidelines of the Sediment Control Plan

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

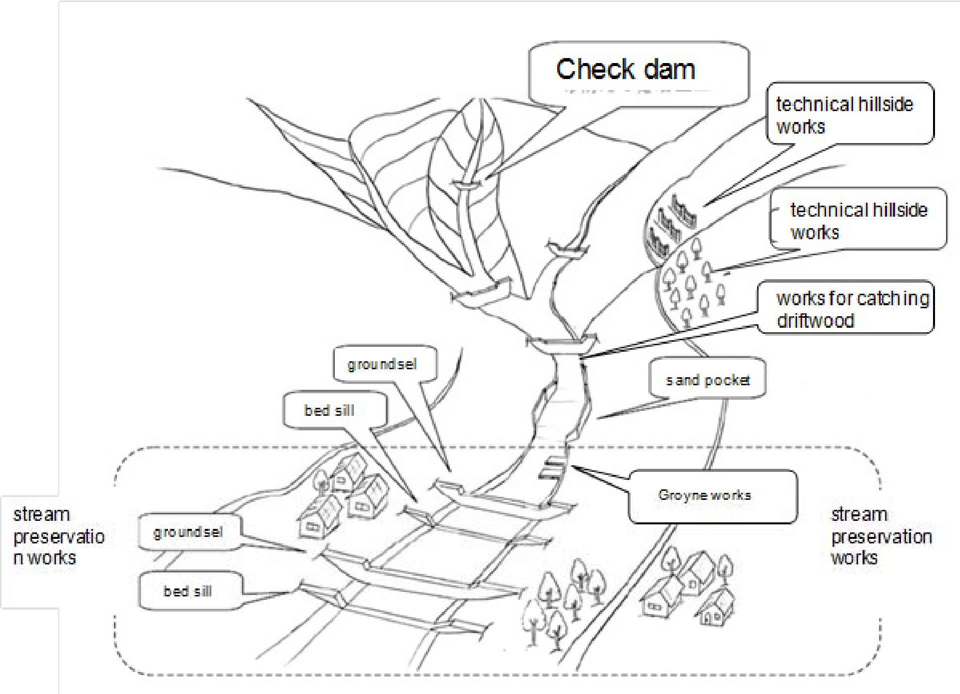


Figure 4.3.2.2-1 Sediment control works

1) Sediment control plan in the high Watershed
The later section 4.12 "Medium and long term Plan" 4.12.3 "Sediment Control Plan" details the sediment control plan covering the whole high Watershed. This plan will require an extremely long time with huge costs, what makes it quite not feasible. Therefore, it must be executed progressively within the medium and long term.

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

3) Riverbed fluctuation analysis results

- The analysis results of river bed fluctuation is as shown below. The average riverbed raising shows the average of raise in the objective section in future 50 years. The average bed height has been increasing, so basically it is concluded that this is the general trend. The total variation volume of the bed and sediment transport is augmenting in the Majes-Camana river.

Total volume of dragged sediment (in thousands of m^3)	20,956
Annual average of dragged sediment (in thousands of m^3)	419
Total volume of riverbed variation (in thousands of m^3)	5,316
Annual average of variation of riverbed height (m)	0.2

- Majes-Camana is the most susceptible to the accumulation of sediment. This tendency coincides to the field hearing results and actual riverbed conditions.
- One of the reasons why the Majes-Camana river discharges a relatively large amount of sediment is in the vast watershed area compared with other rivers, and the great magnitude of floods, what makes this river to transport large amounts of sediment downstream. While the variation of the bed (volume of sediment) is great too, looking at the average height of the bed, only 0.2 meters has changed in 50 years, and is therefore considered that the entry of sediments won't affect much the river downstream. Therefore, it is considered that it is not necessary to take a special sediment control measure. However the sediment disaster will happen suddenly and locally so that the required river channel maintenance work will be examined with monitoring of river bed sedimentation.

4.3.3 Technical Assistance

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

(1) Component objective

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

(2) Target area

The target area for the implementation of the present component is the Majes-Camana watershed.

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

(3) Target population

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

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

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

(4) Activities

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

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

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

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

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

	a-4) Workshop for flooding control plan preparation b-1) Community activity planning in consideration of ecological zoning b-2) Risk management b-3) Resource management c-1) Preparation of community disaster management plan c-2) Joint activity with local governments, users' association, etc.

Component 3: Basin Management for Anti – River Sedimentation Measures

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

(5) Direct cost and period

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

Table 4.3.3-1 Contents of technical assistance and direct cost

(6)Implementation Plan

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

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

- Experts in disaster management departments in each provincial government, ANA, AGRORURAL, INDECI, etc. as well as (international and local) consultants will be in charge of course instruction and facilitation.

4.4 Costs

4.4.1 Cost Estimate (at private prices)

(1) Project Costs Components

Project costs include the following:

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

(2) Work direct costs

In the Table 4.4.1-1 a summary of direct costs for structural measures is presented for the Majes-Camana River basin.

(3) Project Costs

The project cost is estimated in 97.2 million soles as shown in the Table 4.4.1-2. It includes reforestation and vegetation recovery costs and technical assistance. The annual operation and maintenance cost of completed works is approximately 0.5% of the constructin cost.

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

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

4.4.2 Cost Estimate (at social prices)

(1) Work direct costs

In the Table 4.4.2-1 a summary of direct costs for structural measures is presented for the

Majes-Camana River basin. The works' direct cost at private prices was turned into social prices applying the conversion factor.

(2) Project Costs

The project cost is estimated in 80.8 million soles as shown in Table 4.4.2-2. It includes reforestation and vegetation recovery costs, construction of early warning system and technical assistance, before converting from private prices.

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

Table 4.4.2-2 Project cost at social prices

4.5 Social Assessment

4.5.1 Private prices costs

(1) Benefits

Flood control benefits are flood loss reduction that would be achieved by the implementation of the Project and is determined by the difference between the amount of loss with and without Project. Specifically, in order to determine the benefits that will be achieved by the works' construction. First, the flood amount per flood loss of the different return periods (between 2 to 50 years) is calculated; assuming that the flood control works have a useful life of 50 years. To finish, determine the annual average amount of the loss reduction from the loss amount of different return periods. The Methodological Guideline for Protection and/or Flood Control Projects in agricultural or urban areas, 4.1.2p-105) establishes similar procedures.

Above find the description of the procedures to determine concrete benefits

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

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

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

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

1) Method of loss amount calculation

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

Table 4.5.1-1 Flood loss amount calculation variables

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

A. Direct loss

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

B. Indirect Loss

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

a. Dams damage

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

① Calculating the infrastructure cost

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

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

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

② Crop loss

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

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

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

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

b. Road infrastructure damage

Determine the loss due to traffic interruption.

Amount of loss = direct loss + indirect loss

Direct loss: road construction cost (construction, rehabilitation)

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

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

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

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

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

(s./1,000)

Case	t	Majes-Camana
Without Project	2	0
	5	47,669
	10	76,278
	25	111,113
	50	190,662
	Total	425,722
With Project	2	0
	5	10,021
	10	21,316
	25	34,254
	50	63,532
	Total	129,123

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

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

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

Table 4.5.1-3 Loss reduction annual average amount

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

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

Table 4.5.1-4 Annual average of loss reduction amount (Private prices)

流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damage - thousand of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project ②	軽減額 ③=①−② Mitigated Damage ③=①−②	区間平均被害額 ④ Average of damages	区間確率 ⑤ Incremental value of the probability	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	47,669	10,021	37,648	18,824	0.300	5,647	5,647
	10	0.100	76,278	21,316	54,962	46,305	0.100	4,631	10,278
	25	0.040	111,113	34,254	76,859	65,911	0.060	3,955	14,232
	50	0.020	190,662	63,532	127,130	101,994	0.020	2,040	16,272

(2) Social Assessment

1) Assessment's objective and indicators

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

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

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

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

2) Assumptions

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

i) Assessment Period

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

2012: Detailed Design

2013-2014: Construction

2013-2027: Assessment Period

ii) Standard Conversion Factor (SCF)

The standard conversion factor (SCF) is the relationship between socioeconomic prices established along the border and national private prices of all goods in a country's economy. It is used to convert goods and services prices purchased in the local market at affordable prices. In this Study the following SCF values were used:

Dams 0.804

Gabions 0.863

Intakes 0.863

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

iii) Other preliminary conditions

Price level: 2010

Social discount rate: 10%

Annual maintenance cost: 0.5% of construction cost

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

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

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

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

4.5.2 Costs at social prices

(1) Benefits

1) Estimated loss amount according to different return periods

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

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

(s./1,000)

Case	t	Majes-Camana
Without Project	2	0
	5	48,468
	10	78,194
	25	116,730
	50	206,459
	Total	449,851
With Project	2	0
	5	10,435
	10	21,738
	25	36,455
	50	70,838
	Total	139,466

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

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

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

s/1000

流域 Watershed	流量規模 Return Period	超過確率 Probability	被害額 (Total damage - thousands of S/.) 事業を実施しない場合① Without Project ①	事業を実施した場合② With Project	軽減額 ③=①－② Mitigated damages ③=①－②	区間平均被害額 ④ Damage Avergare	区間確率 ⑤ Probability incremental value	年平均被害額 ④×⑤ Average value of the damages flow	年平均被害額の累計＝年平均被害軽減期待額 Annual Medial Damage
Majes-Camana	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	48,468	10,435	38,033	19,016	0.300	5,705	5,705
	10	0.100	78,194	21,738	56,456	47,244	0.100	4,724	10,429
	25	0.040	116,730	36,455	80,275	68,366	0.060	4,102	14,531
	50	0.020	206,459	70,838	135,621	107,948	0.020	2,159	16,690

(2) Social Assessment

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

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

4.5.3 Social assessment conclusions

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

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

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

4.6 Sensitivity Analysis

(1) Objective

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

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

(2) Sensitivity Analysis

1) General description of the sensitivity analysis

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

Table 4.6-1 Sensitivity Analysis Methods

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

2) Description of the sensitivity analysis

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

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

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

3) Results of the sensitivity analysis

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

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

	Watershed	Variables	Base Case	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6
				Cost increase 5%	Cost increase 10%	Benefit reduction 5%	Benefit redcution 10%	Discount rate increase 5%	Discount rate increase 10%
Private prices	MAJES-CAMANA	IRR (%)	12%	11%	10%	11%	10%	12%	12%
		B/C	1,09	1,04	0.99	1.04	0.98	0.84	1.47
		NPV(s)	8,174,200	3,806,572	nagative 561,055	3,397,862	egative 1.378,475	gative 12,860,682	44,424,771
Social prices	MAJES-CAMANA	IRR (%)	16%	15%	14%	15%	14%	16%	16%
		B/C	1.35	1.28	1.23	1.28	1.21	1.04	1.82
		NPV(s)	25,359,998	21,728,954	18,097,910	20,460,954	15,561,910	2,658,312	63,876,226

(3) Assessment of the sensitivity analysis

The impact of socioeconomic conditions changes to the Project, has shown that in some cases (Case 2, Case 4 and Case 5) the Project does not show an economic impact regarding private prices costs, but it does show in the social prices costs, since a determined change in costs, benefits and discount rate does not affect much the IRR, C/B and NPV levels.

4.7 Sustainability Analysis

This project will be co-managed by the central government (through the DGIH), irrigation committees and regional governments. Also, the project cost will be covered with the respective contributions of the three parties. Usually the central government (in this case, the DGIH) takes the 80%, irrigation commissions 10% and regional governments 10%. However, the percentages of the contributions of these last two are decided through discussions between both parties. On the other hand, the operation and maintenance (O & M) of the completed works is assumed by the irrigation committee. So, the sustainability of the project depends on the profitability of the Project and the ability of the irrigation committees for O & M.

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

Table 4.7-1 Project Budget of the irrigation commissions

Rivers	Annual Budget				(In soles)
	2006	2007	2008	2009	2010
Majes-Camana River				1.959.302,60	1.864.113,30

(1) Profitability

The project in Majes-Camana river Watershed is sufficiently profitable and highly sustainable. The investment amount in this watershed is estimated in million soles at private prices. However, the C/B relation is 1.35, the internal return rate is high (approx. 16%), and the NPV is estimated in 25.43 million soles. These Figures show that the project's economic efficiency is very high.

(2) Cost of operation and maintenance

The annual cost of operation and maintenance required for the project, having as a base year 2008 is estimated at soles, corresponding to % of the project construction cost (83,228,000 soles). On the other hand, the average operating expenses in 2009 and 2010 of the irrigation commissions was 1,911,708 soles.
When considering that the annual operation and maintenance cost represents 22% of the annual irrigation commissions, the project would be sustainable enough according to the financial capacity of these committees to maintain and operate the constructed works.

4.8 Environmental Impact

4.8.1 Procedure of Environmental Impact Assessment

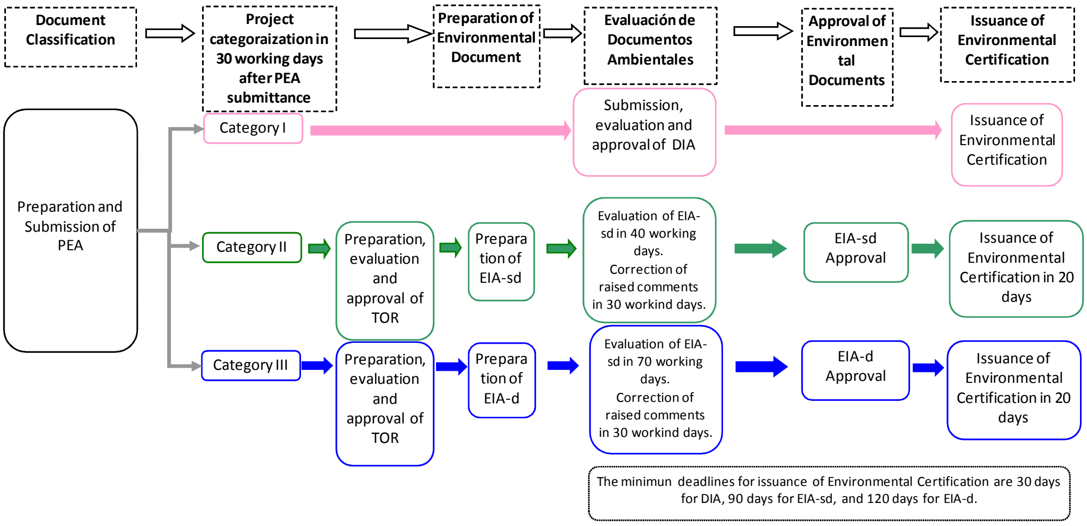
Projects are categorized in three scales, based on the significance level of the negative and positive impacts, and each sector has an independent competence on this categorization. The following table shows the environmental management instruments that are required for each category. The Project holder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

Table 4.8.1-1 Project Categorization and Environmental Management Instruments

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

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

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



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

Figure 4.8.1-1 Process to Obtain the Environmental Certification

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

The progress of the environmental impact study is as shown below.

The JICA Study Team subcontracted a local Consultant (CIDE Ingenieros S.A.), and a Preliminary Environmental Assessment (PEA) was carried out from September to October 2011for Majes-Camana river.

EAP for Majes- Camana was submitted to DGIH from JICA on December 20, 2012. DGIH submitted it on January 4, 2012.

EAP for 4 rivers except Yauca river was examined by DGAA, and DGAA issued their comments on EAP to DGIH. JICA Study Team revised EAP upon the comments and submitted them to DGAA on September 21, 2011. DGAA completed examination on the revised EAP and issued approval letter on 4 rivers in which DGAA classified 4 rivers into Category I. Therefore the additional environmental impact analysis for 4 rivers is not required.

Although EAP of the Majes-Camana river is still under examination of DGAA, the EAP of the river will be also classified into Category I because the flood prevention facilities in the river are similar to those of antecedent 4 rivers.

The positive and negative environmental impact associated with the implementation of this project was confirmed and evaluated, and the plan for prevention and mitigation measures are prepared by EAP results, field investigation and hearing by JICA Study Team.

The proposed works in this project include: the reparation of existing dikes, construction of new dikes, riverbed excavation, bank protection works and so on. Table 4.8.1-2 describes "Work Description" to be considered in the Environmental Impact section.

Table 4.8.1-2 Works Description

Basin	Location			Preservation Object	Counter Measure	Summary of Facility	Objective Section
Majes-Camana	MC 1	0.0k-4.5k	Inundation	Crop land (rice、others)	Dike (no dike section) Revetment	Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 4,500m	0.0km-4.5km (left bank)
	MC 2	7.5k-9.5k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 2,000m	7.5km-9.5km (left bank)
	MC 3	11.0k-17.0k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 6,000m	11.0k-17.0k(left bank)
	MC 4	48.0k-50.5k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 2,500m	48.0km-50.5km (left bank)
	MC 5	52.0k-56.0k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 4,o00m	52.0k-56.0k(left bank)
	MC 6	59.0k-62.5k 59.5k-62.5k	Inundation /erosion			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 6,500m	59.0km-62.5km (left bank) 59.5km-62.5km. (right bank)
	MC 7	65.0k-66.5k 64.5k-66.5k	Inundation			Top W; 4.0m h; 2.0m-3.0m Slope; 1:3 L; 3,500m	65.0km.-66.5 km.(right bank) 64.5km.-66.5 km. (left bank)

Source: JICA Study Team

4.8.2 Methodology

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

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

Table 4.8.2-1 Evaluation Criterion - Leopold Matrix

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

Source: Prepared based on PEAs of 6 Basins

Table 4.8.2-2 Impact Significance Degrees

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

Source: Prepared based on PEAs of 6 Basins

4.8.3 Identification, Description and Social Environmental Assessment

(1) Identification of social environmental impacts

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

Table 4.8.3-1 Impact Identification Matrix (Construction and Operation Stage) – Majes-Camana River

Construction Stage			Work	1-7	1-7	1-7	1-7	1-7	1-7	1-7	1-7	1-7		
Environment	Component	Environmental Factors	Activity	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Digging and movement of Land	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	Total Negative	Total Positive
Physique	Air	PM-10 (Particulate matter)			N	N		N	N		N	N	6	0
		Gas emissions			N	N	N	N	N		N	N	7	0
	Noise	Noise			N	N	N	N	N	N	N	N	8	0
	Soil	Soil fertility			N				N				2	0
		Land Use			N			N	N				3	0
	Water	Calidad del agua superficial					N	N		N			3	0
		Cantidad de agua superficial											0	0
	Physiography	Morfología fluvial						N					1	0
		Morfología terrestre			N	N			N				3	0
Biotic	Flora	Terrestrial flora			N				N				2	0
		Aquatic flora						N					1	0
	Fauna	Terrestrial fauna			N				N				2	0
		Aquatic fauna				N		N					2	0
Socio-economic	Esthetic	Visual landscape						N	N				2	0
	Social	Quality of life		P						N	N	N	3	1
		Vulnerability - Security											0	0
	Economic	PEA		P									0	1
		Current land use											0	0
Total				2	8	5	3	9	9	3	4	4	45	2
Percentage of positive and negative													96 %	4 %

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

Operation Stage												
Environment	Component	Environmental Factors	Works	Dike Point 1	Dike Point 2	Dike Point 3	Dike Point 4	Dike Point 5	Dike Point 6	Dike Point 7	Total Negative	Total Positive
Physique	Air	PM-10 (Particulate matter)									0	0
		Gas emissions									0	0
	Noise	Noise									0	0
	Soil	Soil fertility									0	0
		Land Use									0	0
	Water	Calidad del agua superficial									0	0
		Cantidad de agua superficial		P	P	P	P	P	P	P	0	7
	Physiography	Morfología fluvial		N	N	N	N	N	N	N	7	0
		Morfología terrestre		N	N	N	N	N	N	N	7	0
Biotic	Flora	Terrestrial flora									0	0
		Aquatic flora									0	0
	Fauna	Terrestrial fauna									0	0
		Aquatic fauna		N	N	N	N	N	N	N	7	0
Socio-economic	Esthetic	Visual landscape		P	P	P	P	P	P	P	0	7
	Social	Quality of life		P	P	P	P	P	P	P	0	7
		Vulnerability - Security		P	P	P	P	P	P	P	0	7
	Economic	PEA									0	0
		Current land use		P	P	P	P	P	P	P	0	7
Total				8	8	8	8	8	8	8	21	35
Percentage of positive and negative											38 %	63 %

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

On the Majes-Camana River basin, based on the impact identification results for the construction stage, a total number of 47 interactions have been found. 45 of these interactions (97 %) correspond to impacts that will be perceived as negative, and 2 (3 %) correspond to impacts that will be perceived as positive. In addition, 56 interactions have been found for the operation stage; 21 of these interactions (37.5%) correspond to impacts that will be perceived as negative, and 35 (62.5 %) correspond to impacts that will be perceived as positive.

(2) Environmental and Social Impact Assessments

Environmental and social impacts are assessed with the methodology that was explained in 4.8.2 Methodology. The following tables show the environmental and social assessment results for each basin, during the construction and operation stages.

Table 4.8.3-2 Environmental Impact Assessment Matrix – Majes-Camana River

			The Majes-Camaná River Basin									
			Construction Stage									Operation Stage
Medio	Componente	Acciones del proyecto	Labor Recruitment	Site preparation work (Clearing, land grading, Levelled)	Digging and refilling in riverside	Civil Work (Concreting)	I&O of stone pits and material production plants	DME I&O	Camps work I&O	Carriage Staff	Transportation of machinery, equipment, materials and supplies	MC1-MC7
		Puntos de Obras: / Factores Ambientales	MC1-MC7	MC1-MC7	MC1-MC7	MC1-MC7	MC1-MC7	MC1-MC7	MC1-MC7	MC1-MC7	MC1-MC7	
Physique	Air	PM-10 (Particulate matter)	0.0	-12.0	-12.0	0.0	-18.0	-18.0	0.0	-12.0	-12.0	0.0
		Gas emissions	0.0	-11.5	-11.5	-11.5	-11.5	-11.5	0.0	-11.5	-11.5	0.0
	Noise	Noise	0.0	-15.0	-12.0	-12.0	-15.0	-15.0	-15.0	-15.0	-15.0	0.0
	Soil	Soil fertility	0.0	-11.5	0.0	0.0	-14.2	-14.2	0.0	0.0	0.0	0.0
		Land Use	0.0	-14.2	0.0	0.0	-15.0	-15.0	0.0	0.0	0.0	0.0
	Water	Calidad del agua superficial	0.0	0.0	-12.0	0.0	-15.0	0.0	0.0	0.0	0.0	0.0
		Cantidad de agua superficial	0.0	0.0	0.0	-9.0	0.0	0.0	-15.0	0.0	0.0	26.0
	Physiography	Morfología fluvial	0.0	0.0	0.0	0.0	-23.0	0.0	0.0	0.0	0.0	-25.5
		Morfología terrestre	0.0	-33.0	-15.0	0.0	0.0	-28.0	0.0	0.0	0.0	-25.5
Biotic	Flora	Terrestrial flora	0.0	-28.0	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0
		Aquatic flora	0.0		-14.5	0.0	-14.5	0.0	0.0	0.0	0.0	0.0
	Fauna	Terrestrial fauna	0.0	-24.2	0.0	0.0	0.0	-22.5	0.0	0.0	0.0	0.0
		Aquatic fauna	0.0	0.0	-14.5	0.0	-15.0	0.0	0.0	0.0	0.0	-25.5
Socio-economic	Esthetic	Visual landscape	0.0	0.0	0.0	0.0	-12.0	-12.0	0.0	0.0	0.0	36.0
	Social	Quality of life	17.0	0.0	0.0	0.0	0.0	0.0	-17.5	-17.5	-17.5	36.0
		Vulnerability - Security	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0
	Economic	PEA	17.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Current land use	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.0

Grade of Positive Impacts		Grade of Negative Impacts	
0−15.0	Little significant	0−15.0	Little significant
15.1−28.0	Significant	15.1−28.0	Significant
28.1−	Very significant	28.1−	Very significant

Source: Prepared based on PEAs of 6 Basins

It must be pointed out that in the Majes-Camaná River basin 11 out of a total of 14 negative impacts have been quantified as significant, and 1 has been quantified as very significant, during the construction stage. Meanwhile, 3 significant negative impacts have been quantified as during the operation stage.

During the construction stage, the works site preparation component will significantly affect the land morphology. During the operation stage, river morphology and aquatic fauna will be significantly affected all the point, where the dikes will be built.

The Environmental Management Plan will be detailed in 3 Environmental Management Plans for Probable Impacts.

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

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

Most significant positive impacts are related to all works to be constructed along the river basins, and are directly related to improve the quality of the lives of the population around the area of influence, improve the “Current Use of land / soil”, improve the security conditions, and reduce vulnerability at social and environmental levels.

4.8.4 Socio-Environmental Management Plans

The objective of the Socio-Environmental Plans is to internalize both positive and negative significant and very significant environmental impacts that are related to the Project’s construction and operation stages, so that prevention and/or mitigation of significant and very significant negative impacts, preservation of environmental heritage, and Project sustainability are ensured.

During the construction stage, Projects of all the basin have set out the following measures: “Local Hiring Program”, “Works Sites Management and Control Program”, “Riverbed Diversion Program”, “Riverbank Excavation and Filling Management”, “Riverbed Excavations and Filling Management”, “Quarry Management”, “DME Management”, “Camp and Site Residence Standards”, and “Transportation Activity Management.” During the operation stages, Projects for the basin have considered the development of activities with regard to “Riverbed and Aquatic Fauna Management”. These activities should develop riverbed conditioning downstream the intervention points, for erosion probabilities to be reduced, and habitability conditions to be provided for aquatic fauna species. The following are measures related to those negative impacts to be mitigated or those positive impacts to be potentiated. Overall measures have been established for the basin, based on the impacts, as identified in the basin.

Table 4.8.4-1 Environmental Impact and Prevention/Mitigation Measures

<table>
<tr><th>Item</th><th>Impact</th><th>Counter Measures</th><th>Period</th></tr>
<tr><td rowspan="11">Natural environment</td><td rowspan="3">Water quality of surface water</td><td>Management of river diversion and coffering</td><td rowspan="11">Construction period</td></tr>
<tr><td>Management of bank excavation and banking</td></tr>
<tr><td>Management of riverbed excavation and back filling</td></tr>
<tr><td rowspan="3">River topography</td><td>Management of bank excavation and banking</td></tr>
<tr><td>Management of riverbed excavation and back filling</td></tr>
<tr><td>Management of quarry site</td></tr>
<tr><td rowspan="2">Other topography</td><td>Management of construction site</td></tr>
<tr><td>Management of large amount of excavated or dredged material</td></tr>
<tr><td rowspan="2">Dust</td><td>Management of construction site</td></tr>
<tr><td>Management of large amount of excavated and dredged material</td></tr>
<tr><td rowspan="5">Biological environment</td><td>Aquatic fauna</td><td>Management of riverbed excavation and back filling</td><td>O/M period</td></tr>
<tr><td rowspan="2">Terrestrial fauna</td><td>Management of construction site</td><td rowspan="8">Construction period</td></tr>
<tr><td>Management of large amount of excavated and dredged material</td></tr>
<tr><td rowspan="2">Terrestrial flora</td><td>Management of construction site</td></tr>
<tr><td>Management of large amount of excavated and dredged material</td></tr>
<tr><td rowspan="4">Social environment</td><td rowspan="3">Quality of life</td><td>Management of labor and construction office</td></tr>
<tr><td>Management of traffic of construction vehicle</td></tr>
<tr><td>Employment plan of local people</td></tr>
<tr><td>Population of economic activity</td><td>Employment plan of local people</td></tr>
</table>

Source: JICA Study Team

4.8.5 Monitoring and Control Plan

(1) Follow up and monitoring plan

The follow-up plan has to implement firmly the management of environmental plan. The monitoring plan is to be carried out to confirm that the construction activity fulfill the environmental standard such as Environmental Quality Standards (EQS) either or Maximum Permissible Limits (MPL). And the monitoring and control must be carried out under the responsibility of the project’s owner or a third party under the supervision of the owner.

· Construction stage

During the construction period of the projects to be done in the 4 watersheds, the Monitoring and Control Plan will be directed to the verification of the fulfillment measures designed as part of the environmental monitoring plan and the verification of the fulfillment of laws and regulation of the Peruvian Legislation. The following aspects will also be monitored:

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

Water quality and biodiversity parameters control shall be performed at downstream of these works must be monitored. In the following table the profile of this plan is shown.

Table 4.8.5-1 Monitoring to Water Quality and Biological Parameters

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country’s Standards
pH	pH			“National Standard for Water Quality” D.S. No. 002-2009 MINAM
TSS	mg/l			
BOD/COD	mg/l			
DO	mg/l			
Total Nitrogen	mg/l			
Heavy Metals	mg/l			
Temperature	^{o}C			
Biological Diversity indices: Shannon; Pielou; richness and abundance				

[Measurement Points]
-50 meters upstream the intervention points
-50 meters downstream the intervention points
-100 meters downstream the intervention points
[Frequency]
Quarterly
[Person in charge of Implementation]
DGIH-MINAG, or a third party under the project holder's supervision
Source: JICA Study Team

Air Quality:

During impact analysis, in the projects to be developed in the 4 watersheds no significant impacts will be seen in the activities related to hydraulic infrastructure works. However, the generation of dust and atmospheric contaminant emissions always affects the working area and the workers and inhabitants health. So, it is recommended to monitor air quality.

Table 4.8.5-2 Monitoring to Air Quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Peruvian Standards (D.S. No 074-2001-PCM)	Referred International Standards
SO^2				"National Standard for Air Quality" D.S. No.074-2001-PCM	National Ambient Air Quality Standards (NAAQS) (Updated in 2008)
NO^2					
CO					
O^3					
PM-10					
PM-2.5					

[Measurement Points]
*02 stations per monitoring point: Windward and downwind (upwind and against the wind direction)
-1 point at the working zones
-1 point at a quarry, away from the river (the largest and / or the closest point to a populated area)
-1 point at a D.M.E. (the largest and / or the closest point to a populated area)
[Frequency]
Quarterly
[Person in charge of the Implementation]
DGIH-MINAG, or a third party under the project holder's supervision
Source: JICA Study Team

Noise Quality

Likewise, it is proposed to perform a noise monitoring at the potential receptors located near the noise emission spots towards the working sites, in the next table 4.9.4-3, the terms are described.

Table 4.8.5-3 Monitoring to Noise Quality

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards
Noise level	LAeqT (dB(A))			National Environmental Quality Standards for noise (EQS) - S.N. N° 085-2003-PCM	-IEC 651/804 – International -IEC 61672- New Law: Replaces IECs 651/804 -ANSI S 1.4 – America

[Measurement Point]
Monitoring to acoustic contamination levels will be carried out at the potential receivers that are located around the noise emission points per work front.
01 point per potential receiver will be monitored.
[Frequency]
Every two months during construction phase
[Person in charge of the Implementation]
DGIH-MINAG, or a third party under the project holder's supervision
Source: JICA Study Team

· Operation Stages

Regarding works impact of all projects, it is mainly recommended to monitor biologic parameters and water quality as river topography and the habitat of aquatic life.

Table 4.8.5-4 Monitoring to Water Quality (Operation Stage)

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards
pH	pH			"National Standard for Water Quality" D.S. No. 002-2009 MINAM
TSS	mg/l			
BOD/COD	mg/l			
DO	mg/l			
Total Nitrogen	mg/l			
Heavy Metals	mg/l			
Temperature	^oC			
Biological Diversity indices: Shannon; Pielou; richness and abundance				

[Measurement Points]
-50 meters upstream the intervention points
-50 meters downstream the intervention points
-100 meters downstream the intervention points
[Frequency]
Quarterly in first two years of operation phase
[Person in charge of Implementation]
DGIH-MINAG, or a third party under the project holder's supervision

Source: JICA Study Team

(2) Closure or Abandon Plan

Closure or abandon plans have been made for each watershed. These will be executed at the end of construction activities and involves the removal of all temporary works and restoration of intervened and/or affected areas as a result of the works execution. The restoration includes the removal of contaminated soil, disposal of waste material, restoration of soil morphology and restoration with vegetation of intervened sites.

(3) Citizen Participation

Citizen participation plans have been made for each watershed, which must be executed before and during construction and when the works are completed. The recommended activities are:

• Before works: Organize workshops in the surrounding community‘s area near the project and let them know what benefits they will have. Informative materials in communities, which will explain the profile, lapse, objectives, benefits, etc. of the Project

• During works execution: Give out information on the construction progress. Responding complaints generated from the local community during works execution. For this, a consensus wants to be previously achieved with the community in order to determine how claims will be met

• When works are completed: Organize workshops to inform about works completion. Works delivery to the local community inviting local authorities for the transfer of goods, which means the work finished.

4.8.6 Cost for the environmental impact management

Next, direct costs of previously mentioned measures to mitigate environmental impacts in the Majes-Camana River Watershed are shown. In any case, it is necessary to determine in detail these measures' budget for each watershed in the detailed design stage.

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

4.8.7 Conclusions and Recommendations

(1) Conclusions

According to the Preliminary Environmental Appraisals to the basin, most impacts identified during the construction and operation stages were found out to be of little significance. Significant and very significant negative impacts can be controlled or mitigated, as long as suitable Environmental Management Plans are carried out. In addition, the Project will be implemented in the short term, as environmental conditions will be quickly restored. However, the execution of a follow – up and monitoring plan is important, and in the event that unexpected impacts are generated, immediate mitigation measures must be taken.

In addition, significant positive impacts are also present, especially during the operation stage. These positive impacts include: An enhanced security / safety and a decreased vulnerability at social and environmental levels; an improved quality of life among the population in the area of influence, and an improved "Current use of land / soil".

(2) Recommendations

1) We mainly recommend that the beginning of the construction activities coincides with the beginning of the dry seasons in the region (May to November) when the level of water is very low or the river dries up. Each river characteristics / features should be taken into account, that is, that the Majes-Camana Rivers are year - round rivers. At the same time, the crop season cycle in the areas of direct influence should be taken into account, so that traffic jams caused by the large trucks and farming machinery is prevented.

2) It is recommended that the Project holder (DGIH) should define the limit of river area

during detailed design stage, and identify the people who live within the river area illegally. Continually the DGIH should carry on the process of land acquisition based on the Land Acquisition Low, which are; Emission of Resolution for land acquisition by the State, Proposition of land cost and compensation for land owner, Agreement of the State and land owner, Payment, archaeological assessment certification.

3) DGIH has to promote the process to obtain the CIRA in the detail design stage. The process to be taken is i) Application form, ii) Copies of the location drawings and outline drawings, iii) voucher, iv) Archaeological Assessment Certificate.

4) The participation of the women in the workshops can be promoted through the existing women group such as Vaso de Leche.

Finally, the DGAA will submit the resolutions (Environmental Permissions) for the basin. The project will have been categorized as “Category I”, which means that the project is not required to carry out neither EIA-sd nor EIA-d, although the EAP report of Majes-Camana Basin is under examination by DGAA-MINAG.

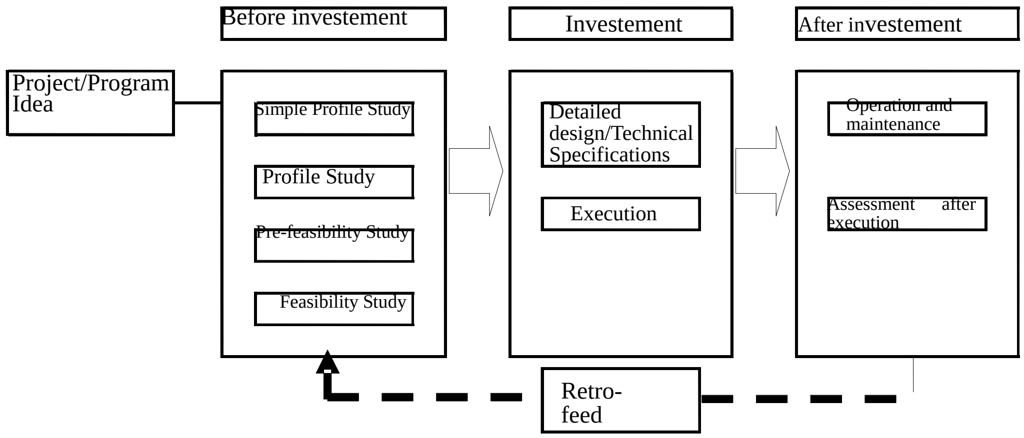
4.9 Execution Plan

The Project’s Execution Plan will review the preliminary schedule, which includes the following components. For pre-investment stage: ① full execution of pre-feasibility and feasibility studies to obtain SNIP’s approval in the pre-investment stage; for the investment stage: ② signing of loans (L/A), ③ consultant selection, ④ consulting services (detailed design and elaboration of technical specifications), ⑤ constructor selection and ⑥ work execution. For the post-investment stage: ⑦ Works’ completion and delivery to water users associations and beginning of the operation and maintenance stage.

(1) Review by the Public Investment National System (SNIP)
In Peru, the Public Investment National System (SNIP hereinafter) is under operation. This reviews the rationality and feasibility of public investment projects, and will be applied to this Project.

In SNIP, among previous studies to an investigation, it will be conducted in 3 stages: profile study (study on the project’s summary), pre-feasibility and feasibility. SNIP was created under Regulation N° 27293 (published on June 28, 2000) in order to achieve efficient use of public resources for public investment. It establishes principles, procedures, methods and technical regulations to be fulfilled by central/regional governments in public investment scheme plans and executed by them.

SNIP, as described below, is all public works projects which are forced to perform a 3-stage pre-investment study: profile study, pre-feasibility and feasibility, and have them approved. However, following the Regulation amendment in April 2011, the execution of pre-feasibility study of the intermediate stage was considered unnecessary; but in return, a study based on primary data during the profile study is requested. The required precision degree throughout all stages of the study has hardly changed before and after this modification.



(Source: DGPM HP)

Figure 4.9-1 SNIP Cycle Project

In order to carry out this Project, which is a project composed by several programs, pre-investment studies at investments' programs level are required to be performed and also have them approved.

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

		Economy and Finances Ministery (MEF)
UF (Formulator Units)	OPI	DGPM
① Perform profile, pre-feasibility and feasibility Studies ② Improve Studies regarding OPI and DGPM comments	① Assess each study ② Approve ③ Request DGPM to approve feasibility study / of the beginning of next stage	① Approve feasibility Studies on each stage

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

Figure 4.9-2 Related Institutions to SNIP

Due to the comments of examining authorities (OPI and DGPM) to FU, it will be necessary to prepare correspondent responses and improve the studies. Since these authorities officially admit applications after obtaining definitive answers, there are many cases in which they take several months from the completion of the study report until the completion of the study.
In this execution plan it is scheduled to present the pre-feasibility report in February 2011 and the feasibility report in April 2011.

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

(3) Procedure of the project's execution
After the documents are assessed by SNIP and a loan agreement between Japan (JICA) and the Peruvian counterpart is signed, a consultant will be selected. The consulting service includes the development of detailed design and technical specifications, the contractors' selection and the work's supervision. Table 4.9-1 presents the Project's overall schedule.

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

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

① River and re-forestation works along these works

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

② Capacity Building

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

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

Table 4.9-1 Implementation Plan

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

4.10 Institutions and Administration

Peruvian institutions regarding the Project's execution and administration are the Agriculture Ministry, Economy and Finance Ministry and Irrigation Commission, with the following roles for each institution:

Ministry of Agriculture (MINAG)

＊The Ministry of Agriculture (MINAG) is responsible for implementing programs and the Hydraulic Infrastructure General Direction (DGIH) is responsible for the technical administration of the programs. The Hydraulic Infrastructure General Direction (DGIH) is dedicated to the coordination, administration and supervision of investment programs.

＊ In investment stage, the PSI(Programa Subsectorial de Irrigaciones, Ministerio de Agricultura) is dedicated to calculate project costs, detail design and supervision of the works execution.

＊ The Planning and Investment Office (OPI) from the Agriculture Ministry is the one responsible for pre-feasibility and feasibility studies in the pre-investment stage of DGIH projects and requests approval of DGPI from the Economy and Finance Ministry (MEF).

＊ The General Administration Office of the Agriculture Ministry (OGA-MINAG) along with the Public Debt National Direction (DNEP) of the Economy and Finance Ministry is dedicated to financial management. It also manages the budget for procurement, commissioning works, contracting, etc. from the Agriculture Ministry.

* The Environmental Affairs General Direction (DGAA) is responsible for reviewing and approving the environmental impact assessment in the investment stage.

Economy and Finance Ministry (MEF)

* The DGPI approves feasibility studies. It also confirms and approves the conditions of loan contracts in yen. In the investment stage, it gives technical comments prior to the project execution.
* Financial management is in charge of DNEP from the Economy and Finance Ministry and OGA-MINAG.
* The Public Debt National Direction (DNEP) of the Economy and Finance Ministry administers expenses in the investment stage and post-investment operation.

Irrigation Commission

* Responsible for the operation and maintenance of facilities at the post-investment operation stage.

The relationship between the involved institutions in the Project's execution is shown in Figures 4.10-1 and 4.10-2.

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

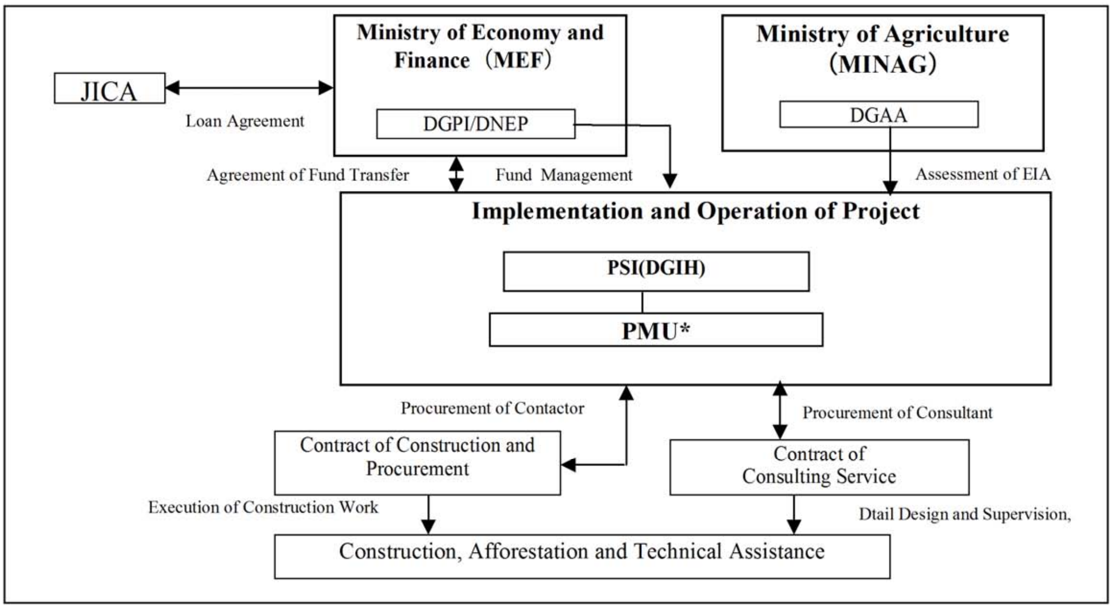


Figure 4.10-1 Related Agencies in Implementation Stage of Project

The main operations in the post-investment stage consist of operation and maintenance of the built works and the loan reimbursement. The O & M of the works will be assumed by the respective irrigation commission. Likewise, they should pay the construction costs in credits mode. Next, the relationship of different organizations involved in post-project implementation stage is detailed.

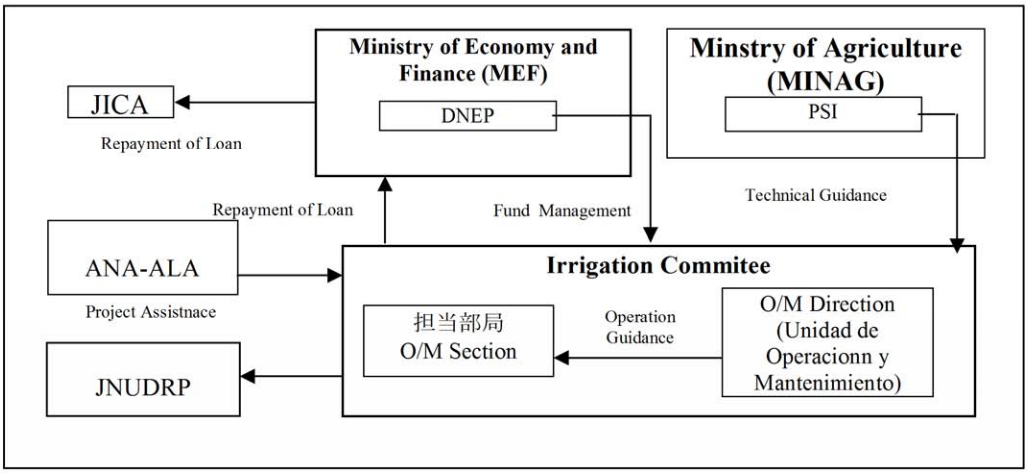


Figure 4.10-2 Related Agencies in Operation Stage of Project

(1) DGIH

1) Role and Functions

The Hydraulic Infrastructure General Direction is in charge of proposing public policies, strategies and plans aimed to promoting water infrastructure development, according with the Water Resources National Policy and the Environmental National Policy.

Water Infrastructure development includes studies, works, operation, maintenance and construction risk management, fit-out, improve and expand dams, intakes, river beds, irrigation channels, drains, meters, outlets, groundwater wells and modernize plot irrigation.

2) Main functions

a. Coordinate with the planning and budget office to develop water infrastructure and propose sectorial and management policies on infrastructure development. Monitor and assess the implementation of sectorial policies related to hydraulic infrastructure development

b. Propose government, region and provinces intervention regulations, as part of sectorial policies

c. Verify and prioritize hydraulic infrastructure needs

d. Promote and develop public investment projects at the hydraulic infrastructure profile level

e. Elaborate technical regulations to implement hydraulic infrastructure projects

f. Promote technological development of hydraulic infrastructure

g. Elaborate operation and maintenance technical standards for hydraulic infrastructure

(2) PSI

1) Function

The Irrigation Sub-sectorial Program (PSI) is responsible of executing investment projects. A respective management unit is formed for each project.

2) Main functions

a. Irrigation Sub-sectorial Program - PSI, under the Agriculture Ministry, is a body with administrative and financial autonomy. It assumes the responsibility of coordinating, managing and administering involved institutions in projects in order to meet goals and objectives proposed in investment projects

b. Also, it coordinates the disbursements of foreign cooperation agencies financing, such as JICA.

c. The Planning, Budget and Monitoring Office of PSI is responsible for hiring services, elaborating investment programs, as well as project execution plans. These Project preparation works are executed by hiring “in-house” consultants.

d. Likewise, it gathers contractors, makes a lease, executes works and implements supply projects, etc.

e. Contract management is leaded by the Planning, Budget and Monitoring Office

3) Budget

In Table 4.10-1 the PSI budget for 2011 is shown.

Table 4.10-1 PSI Budget (2011)

Programs / Projects / Activities	PIM (S/.)
JBIC Program (Loan Agreement EP-P31)	69.417.953
Program - PSI Sierra (Loan Agreement 7878-PE)	7.756.000
Direct management works	1.730.793
Southern Reconstruction Fund (FORSUR)	228.077
Crop Conversion Project (ARTRA)	132.866
Technified Irrigation Program (PRT)	1.851.330
Activity- 1.113819 small farmers...	783.000
PSI Management Program (Other expenses)	7.280.005
TOTAL	**89,180,024**

4) Organization

PSI is confirmed by 235employees, from which 14 are assigned for JBIC Projects and 29 technicians and assistants are working under them.

Table 4.10-2 PSI Payroll

Central Level	Data from May 31, 2011		
	CAS	**Servic. and Consult.**	**TOTAL**
Main Office	61	43	104
Zonal Office LIMA	12	24	36
Zonal Office AREQUIPA	14	12	26
Zonal Office CHICLAYO	17	13	30
Zonal Office TRUJILLO	13	26	39
TOTAL	**117**	**118**	**235**

In Figure 4.10-3, PSI organization is detailed:

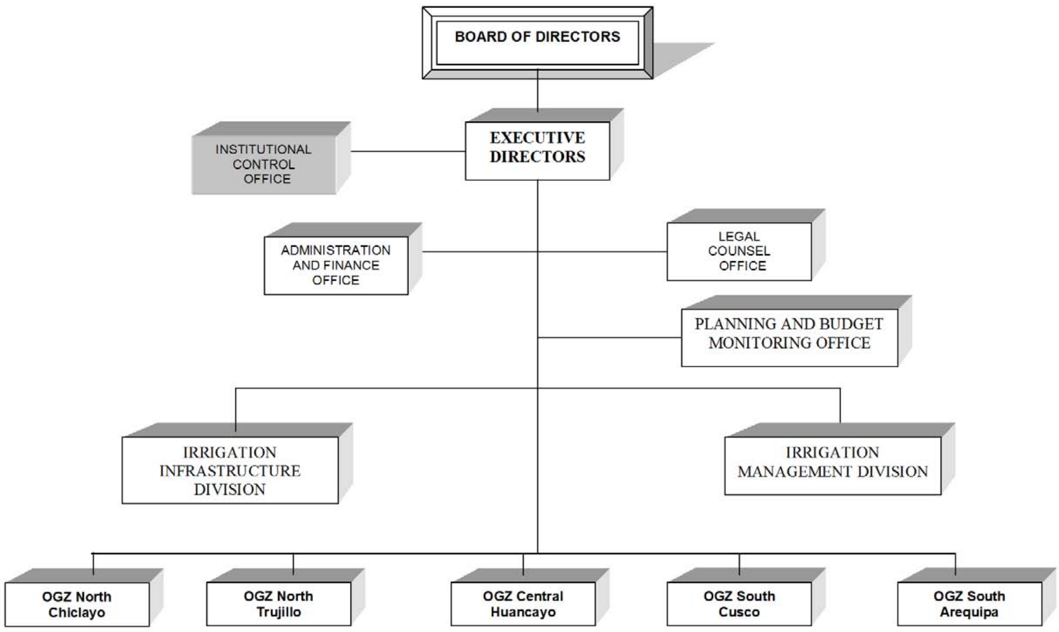


Figure 4.10-3 Organization of PSI

4.11 Logical framework of the eventually selected option

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

Table 4.11-1 Logical framework of the definite selected option

Narrative Summary	Verifying Indicators	Verifying Indicators Media	Preliminary Conditions
Superior Goal			
Promote socioeconomic local development and contribute in communities' social welfare.	Improve local productivity, generate more jobs, increase population's income and reduce poverty index	Published statistic data	Scio-economic and policy stability
Objectives			
Relief the high vulnerability of valleys and local continuity to floods	Types, quantity and distribution of flood control works, population and beneficiaries areas	Monitoring annual calendar works and financial plan, budget execution control	Ensure the necessary budget, active intervention from central and regional governments, municipalities, irrigation communities, local population, etc.
Expected results			
Reduction of areas and flooded areas, functional improvement of intakes, road destruction prevention, irrigation channels protection, bank erosion control and Poechos dike safety	Number of areas and flooded areas, water intake flow variation, road destruction frequency, bank erosion progress and watershed's downstream erosion.	Site visits, review of the flood control plan and flood control works reports and periodic monitoring of local inhabitants	Maintenance monitoring by regional governments, municipalities and local community, provide timely information to the superior organisms
Activities			

Component A: Structural Measures	Dikes rehabilitation, intake and bank protection works, road damages prevention, construction of 28 works, including dike's safety	Detailed design review, works reports, executed expenses	Ensure the works budget, detailed design/works execution/good quality works supervision
Component B: Non-Structural Measures			
B-1 Reforestation and vegetation recovery	Reforested area, coastal forest area	Works advance reports, periodic monitor by local community	Consultants support, NGO's, local community, gathering and cooperation of lower watershed community
Component C: Disaster prevention and capabilities development education	Number of seminars, trainings, workshops, etc	Progress reports, local governments and community monitoring	Predisposition of the parties to participate, consultants and NGO's assessments
Project's execution management			
Project's management	Detailed design, work start order, work operation and maintenance supervision	Design plans, work's execution plans, costs estimation, works specifications, works management reports and maintenance manuals	High level consultants and contractors selection, beneficiaries population participation in operation and maintenance

4.12 Middle and long term Plan

Up to this point, only flood control measures have been proposed and these must be executed most urgently, due to the limitations on the available budget for this Project. However, there are other measures that must be performed in the long term framework. In this section we will be talking about the middle and long term flood control plan.

4.12.1 Flood Control General Plan

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

In case of building a dam, assuming that this will reduce the flood peak (maximum flow) with a 50 year return period reaching an equivalent flow of 10 return years. It will be necessary to build a dam with a 48.6 million m3 capacity, which is quite an oversized number. Usually upstream of an alluvial area, there is a rough topography, and in order to build a dam with enough capacity, a very high dam need to be built, which implies investing a large amount (more than 10,000 million of yen in each dam). Also, it would take between three to five years to identify the dam site, perform geological survey, material assessment and conceptual design. The impact on the local environment is huge. So, it is considered inappropriate to include the dam analysis option in this Study.

Likewise, the option of building a retarding basin would be hardly viable for the same reasons already given for the dam, because it would be necessary to build a great capacity reservoir and it is difficult to find a suitable location because most of the flat lands along the river's downstream are being used for agricultural purposes. So, its analysis has been removed from this Study.

Therefore, we will focus our study in the construction of dams because it is the most viable option.

(1) Plan of the river

1) Discharge capacity

An estimation was done on the discharge capacity of the current flow of this river based on longitudinal and cross sectional survey of the river, which results are shown in the section 3.1.10, Figure 3.1.10-3 and Figure 3.1.10-4.

2) Inundation characteristics

The inundation analysis of Majes-Camana river was performed. In the section 3.1.10, Figure 3.1.10-5 and in Figure 3.1.10-6 the inundation condition for flood with probabilities of 50 years is shown.

It overflows at the vicinity of 5km from the river mouth, and the flood flow spreads greatly in the left-bank side. In middle stream and upstream areas, It overflows in lowland plain, and flood flow stagnates by the surrounded hills and mountains.

3) Design flood level and dike's standard section

The design flood level was determined in the flood water level with a return period of 50 years, and the dike's standard section will be determined as already mentioned in section 4.3.1, 5), 1). In the section 4.2, Table 4.2-2 and Table 4.2-3 the theoretical design flood level and the required height of the dike's crown is shown.

4) Dikes' Alignment

Considering the current conditions of existing dikes the alignment of the new dikes was defined. Basically, the broader possible river width was adopted to increase the discharge capacity and the retard effect. In Figure 4.12.1-1 the current channel and the setting alignment method of a section where the current channel has more width is explained schematically. In a normal section, the dike's crown has the same height to the flood water level with a return period of 50 years plus free board, while in the sections where the river has greater width, double dikes be constructed with inner consistent dike alignment and continuous with normal sections upstream and downstream. The crown height is equal to the flood water level with a return period of 50 years. The external dike's crown height is equal to flood water level with a return period of 50 years, so in case the river overflows the internal dike, the open gap between the two dikes will serve to store sediments and retarding water.

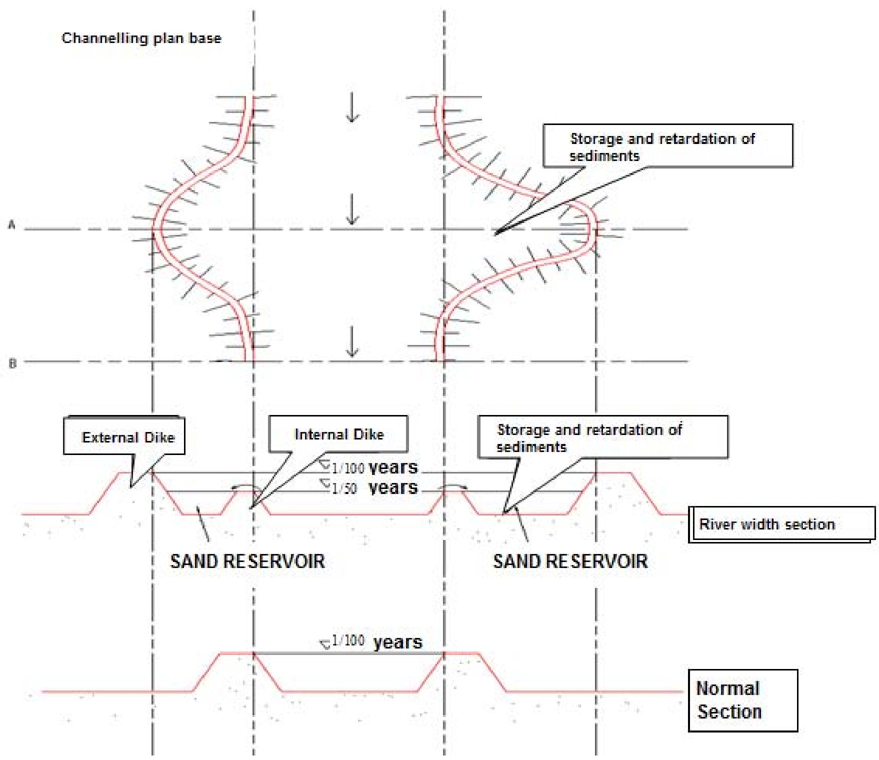
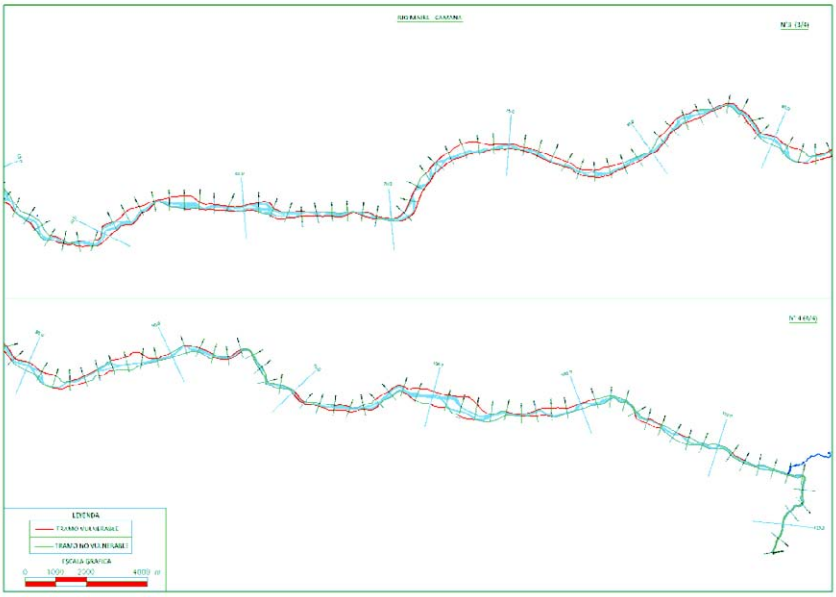


Figure 4.12.1-1 Definition of dike alignment

5) Plan and section of river

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

Majes River



Camana River

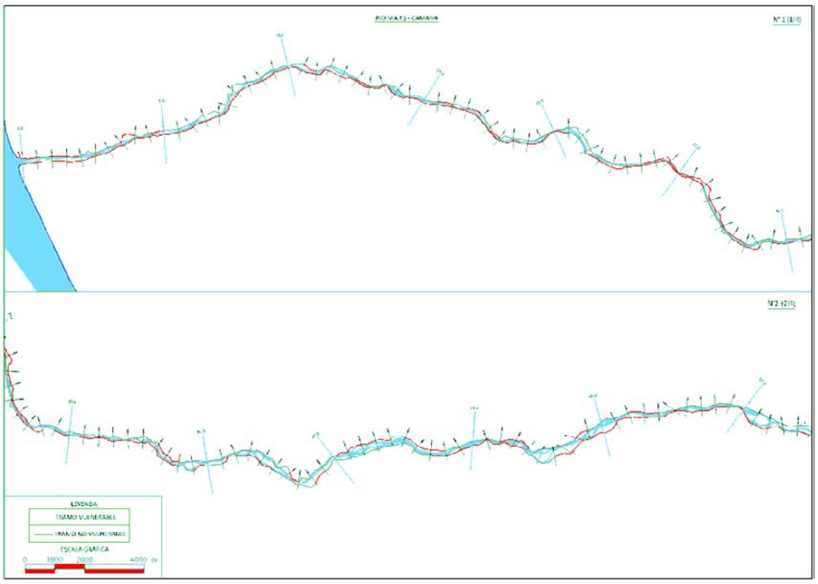


Figure 4.12.1-2 Plan of Majes-Camana River

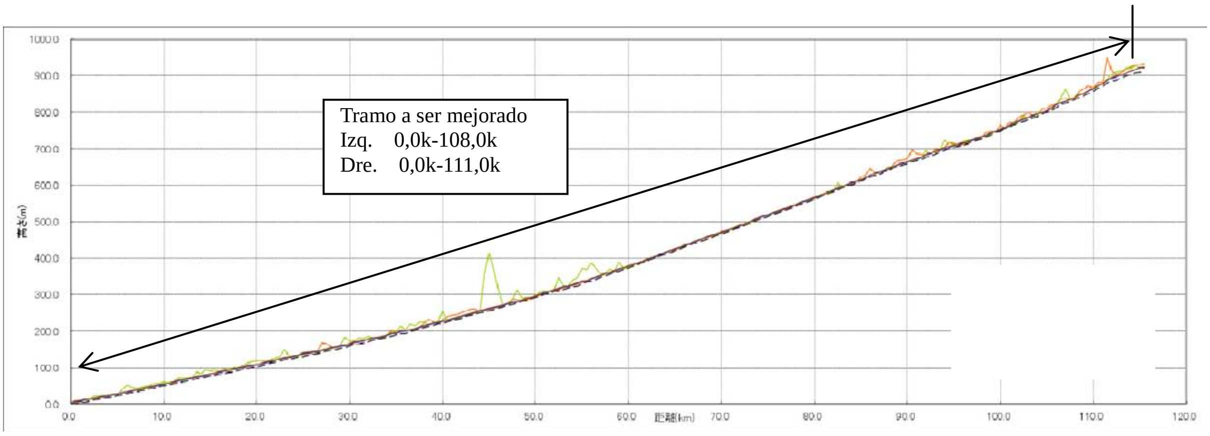


Figure 4.12.1-3 Majes-Camana River Longitudinal Profile

6) Dike's construction plan

Next, basic policies for the dike's construction plan on the Majes-Camana River are shown:

- Build dikes that allow flood flow safe passage with a return period of 50 years
- The dikes will be constructed in areas where overflowing water will enter the dike, according to the flood simulation
- The dikes will be placed in the sections above mentioned, where the design water level exceeds the existing dike's height or the ground level within the dike
- The dike's height is defined in the flood water level with a return period of 50 years plus the free board

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

Table 4.12.1-1 Dike's Construction Plan

River Name	Improvement Section		Shortage for Design Height (m)	Dike Plan	Dike Length (km)
Majes-Camana River	Left bank side	0.0k-108.0k	1.77	Dike h=2.0m Revetment h=3.0m	79.5
	Right bank side	0.0k-111.0k	1.81		56.5
	Total		1.79		136.0

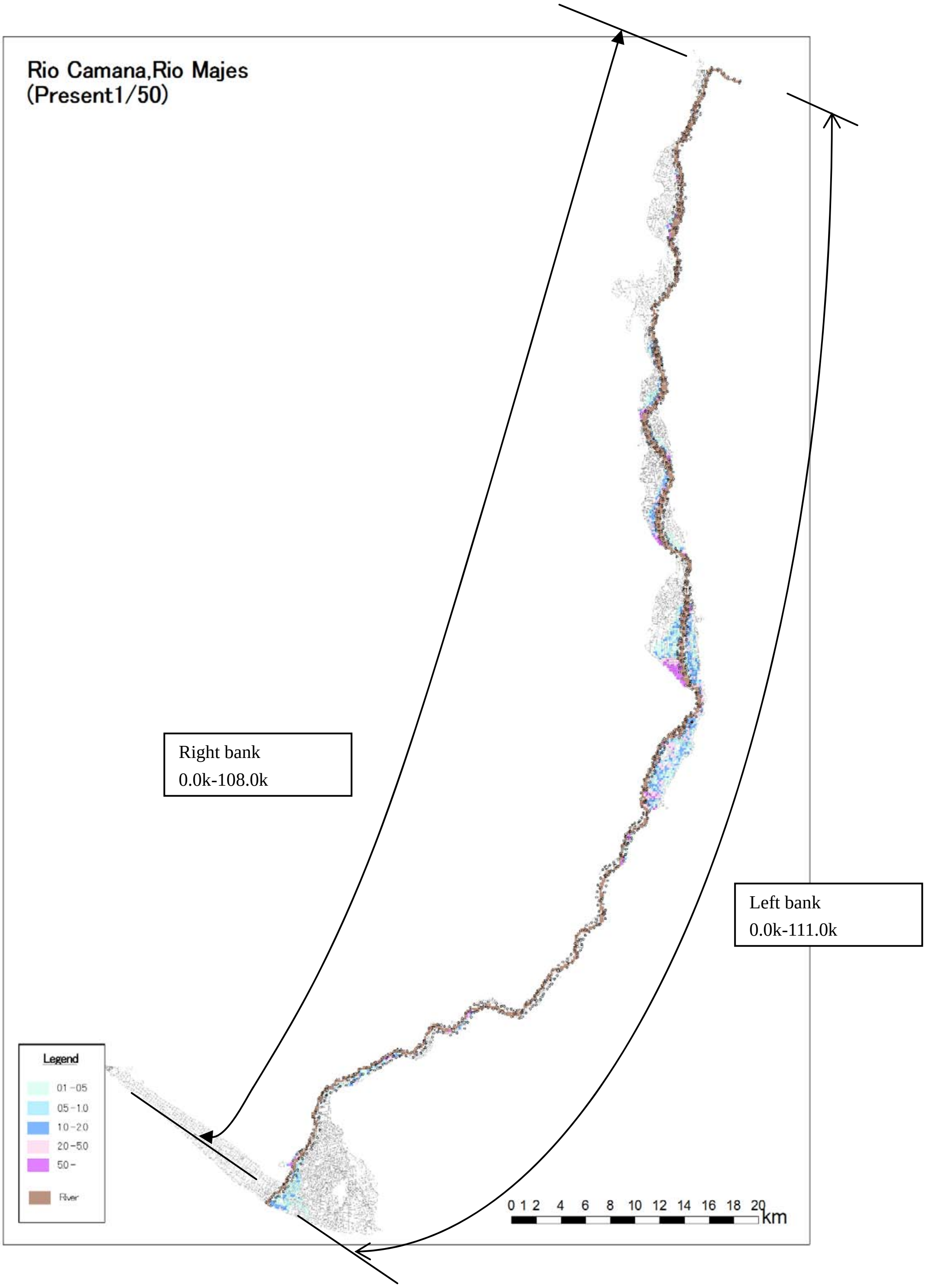


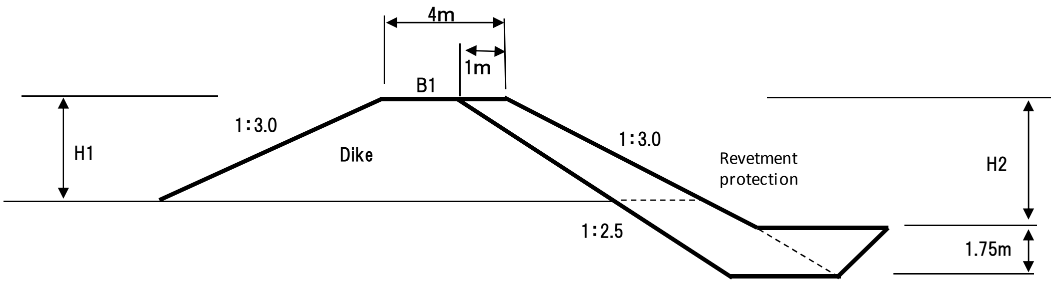
Figure 4.12.1-4 Layout of dike in Majes-Camana River

7) Project Cost

In Tables 4.12.1-2 and 4.12.1-3 works' direct costs in private prices and the Project's cost are shown. Also, the cost of the project in social prices is presented in Table 4.12.1-4.

Table 4.12.1-2 Works directs cost (at private prices)

Construction of dike					Revetment protection			
B1	H1	B2	A		B1	H2	B2	A
3.0	1.0	8.5	5.8		1.0	1.0	2.4	10.8
3.0	2.0	14.0	17.0		1.0	2.0	2.9	13.4
3.0	3.0	19.5	33.8		1.0	3.0	3.4	16.5
3.0	4.0	25.0	56.0		1.0	4.0	3.9	20.1
3.0	5.0	30.5	83.8		1.0	5.0	4.4	24.3
3.0	1.5	11.3	10.7		1.0	6.0	4.9	28.9
					1.0	1.5	2.6	12.0
					1.0	10.0	6.9	52.4



River Basin		Quantity	Unit	Unit Price (Sol)	Direct Construction Cost/ 1m (Sol)	Direct Construction Cost/ 1km (10^3 Soles)	Dike length (km)	Direct Construction cost (10^3 Soles)
Majes	Embankment	17.0	m3	10.0	170.0	170.0	136.0	23,120.0
Camana	Revetment	16.5	m3	100.0	1,650.0	1,650.0		224,400.0

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

(soles)

Nombre de la Cuenca	COSTOS A PRECIOS PRIVADOS – TOTAL 民間価格 – 洪水防御施設のみ											
	COSTO DIRECTO			COSTO INDIRECTO								INFRAESTRUCTURA HIDRAULICA Costo Total
	Costo Directo	Costo de Obras Temporales	Costo de Obras	Gastos Operativos	Utilidad	Costo Total Infraestructura	IGV	Costo Total Obra	Impacto Ambiental	Expediente Tecnico	Supervisión	
流域名	直接工事費計	共通仮設費	工事費	諸経費	利益	構造物工事費	税金	建設費	環境影響	詳細設計	施工管理費	構造物・事業費
	(1)	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)
MAJES-CAMANA	247,520,000	24,752,000	272,272,000	40,840,800	27,227,200	340,340,000	61,261,200	401,601,200	4,016,012	20,080,060	40,160,120	465,857,392

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

(soles)

	Direct Cost			Indirect Cost								Total Project Cost
	Direct Cost	Common Temporary Work Cost	Construction Cost	Overhead cost	Profit	Structure Construction Cost	Tax (IGV)	Construction Cost	Environment Cost	Detail Design Cost	Construction Supervision Cost	
流域名	直接工事費計	共通仮設費	工事費	諸経費	利益	構造物工事費	税金	建設費	環境影響	詳細設計	施工管理費	構造物・事業費
	(1)	(2) = 0.1 x (1)	(3) = (1) + (2)	(4) = 0.15 x (3)	(5) = 0.1 x (3)	(6) = (3)+(4)+(5)	(7) = 0.18 x (6)	(8) = (6)+(7)	(9)=0.01 x (8)	(10) = 0.05 x (8)	(11) = 0.1 x (8)	(12) = (8)+(9)+(10)+(11)
MAJES-CAMANA	199,006,080	19,900,608	218,906,688	32,836,003	21,890,669	273,633,360	49,254,005	322,887,365	3,228,874	16,144,368	32,288,736	374,549,343

2) Operation and Maintenance Plan

The operation and maintenance cost was calculated identifying the trend of the sedimentation and erosion bed based on the one-dimensional analysis results of the bed variation, and a long-term operation and maintenance plan was created.

The current river course has some narrow sections where there are bridges, farming works (intakes, etc.) and there is a tendency of sediment gathering upstream of these sections. Therefore, in this project there is a suggestion to increase the discharge capacity of these narrow sections in order to avoid as possible upstream and in the bed (main part) sedimentation, together with gathering sediments as much as possible when floods over a return period of 50 years occur.

1) Bed variation analysis

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

2) Sections that need maintenance

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

3) Operation and maintenance cost

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

Direct Work Cost

At private prices: 530,000 m^3 x 10 = 5,300,000 soles

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

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

River	Excavation extension		Maintenance method
Majes-Camana	Section 1	Section: km 12,0- km 13,0 EarthVolume: 70.000 m^3	It is a section where the bed can be considerably elevated with few sediment amount due to its narrowness. It is recommended to perform an annual periodic dredging to reduce its impact on the intake

	Section 2	Section: km100,0-km 101,0 EarthVolume: 460.000 m^3	It is a widen section, where great amounts of sediments gather. Periodic dredging of this section would also help to control the middle watershed's bed elevation. Is is an area where periodic dredging must be performed from the flood control's point of view

* Sediments volume that will gather in a 50 year period

Figure 4.12.1-5 Section that requires maintenance (Majes-Camana River)

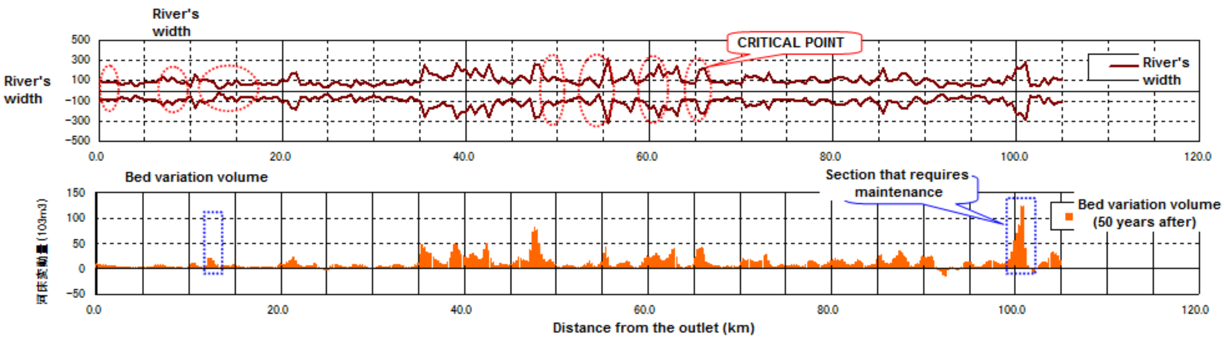


Table 4.12.1-6 Excavation Works cost for a 50 year bed (at private prices)

Watershed 流域名	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical FIle 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	Total Cost 事業費 (12) = (8)+(9)+(10)+(11)	Total Cost (13) = (12)/50
Majes-Camana	5,300	530	5,830	875	583	7,288	1,312	8,599	86	430	860	9,975	200

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

Watershed 流域名	Direct Cost 直接工事費計 (1)	Temporary works cost 共通仮設費 (2) = 0.1 x (1)	Works Cost 工事費 (3) = (1) + (2)	Operative Expenses 諸経費 (4) = 0.15 x (3)	Utility 利益 (5) = 0.1 x (3)	Total Cost of Infrastructure 構造物工事費 (6) = (3)+(4)+(5)	TAX 税金 (7) = 0.18 x (6)	Total work cost 建設費 (8) = (6)+(7)	Correction factor CF	Works Total cost (10) = 0.01*(8)	Environmental Impact 環境影響 (9)=0.01 x (8)	Technical FIle 詳細設計 (10) = 0.05 x (8)	Supervision 施工管理費 (11) = 0.1 x (8)	Total Cost 事業費 (12) = (8)+(9)+(10)+
Majes-Camana	5,300	530	5,830	875	583	7,288	1,312	8,599	0,804	6,914	69	345	691	8

(3) Social Assessment

1) Private prices cost

a) Damage amount

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

Table 4.12.1-8 Amount of damage for floods of different return periods

Damages in Thousand S/. 被害額（千ソーレス）	
Return period (t)	Majes-Camana
2	0
5	47.669
10	76.278
25	111.113
50	190.662

b) Damage reduction annual average

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

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

Table 4.12.1-3 shows the projects' cost. Also, the annual operation and maintenance (O & M) cost for dikes and bank protection works can be observed in the table. This is calculated from the 0.5% of the construction cost plus the bed excavation annual average cost indicated in Table 4.12.1-6.

d) Economic evaluation

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

Table 4.12.1-9 Damage Reduction Annual Average

流域 Basin	流量規模 Return period	超過確率 Probability	被害額（Total damage - miles de S/.）			区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ = Annual average damage reduction
			事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②				
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	47,669	0	47,669	23,834	0.300	7,150	7,150
	10	0.100	76,278	0	76,278	61,973	0.100	6,197	13,348
	25	0.040	111,113	0	111,113	93,696	0.060	5,622	18,969
	50	0.020	190,662	0	190,662	150,887	0.020	3,018	21,987

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

流域名	年平均被害軽減額 Accumulated Average Annual Benefit	評価期間被害軽減額(15年) Accumulated Average Annual Benefit (in 15 years)	事業費 Project's Cost	維持管理費 O&M Cost	C/B Cost/Benefit Relation	Net Present Value (NPV) NPV	Internal Rate of Return (IRR) IRR
Majes-Camana	285,833,001	129,076,518,	465,857,392	29,096,617	0.31	negative 291140628	none

2) Social prices cost

a) Damage amount

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

Table 4.12.1-11 Amount of damage for floods of different return periods

Damages in Thousand S/. 被害額（千ソーレス）	
Return Period (t)	Majes-Camana
2	0
5	48.468
10	78.194
25	116.730
50	206.459

b) Damage reduction annual average

Table 4.12.1-11 shows the damage reduction annual average of each watershed calculated with the data of Table 4.12.1-9.

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

Table 4.12.1-4 shows the projects' cost. Also, the annual operation and maintenance (O & M) cost for dikes and bank protection works can be observed in the table. This is calculated from the 0.5% of the construction cost, as well as the bed excavation annual average cost indicated in Table 4.12.1-7.

d) Economic evaluation

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

Table 4.12.1-12 Damage Reduction Annual Average

社会価格									
流域 Basin	流量規模 Return period	超過確率 Probability	被害額（Total damage – miles de S/.）			区間平均被害額 ④ Average damage	区間確率 ⑤ Section probability	年平均被害額 ④×⑤ Annual average damage ⑥	Accumulation of ⑥ ＝ Annual average damage reduction
			事業を実施しない場合① Without Project ①	事業を実施した場合② With project ②	軽減額 ③=①−② Damage reduction ③=①−②				
MAJES-CAMANA	1	1.000	0	0	0			0	0
	2	0.500	0	0	0	0	0.500	0	0
	5	0.200	48,468	0	48,468	24,234	0.300	7,270	7,270
	10	0.100	78,194	0	78,194	63,331	0.100	6,333	13,603
	25	0.040	116,730	0	116,730	97,462	0.060	5,848	19,451
	50	0.020	206,459	0	206,459	161,594	0.020	3,232	22,683

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

	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
Majes-Camana	294,878,168	133,161,136	374,549,343	23,393,680	0.39	-204,693,450	-

(4) Conclusions

The economic assessment result shows that the Project has negative economic impact in terms of cost on both private and social prices, in addition to that the required cost is extremely high (465.9 million soles), so that this Project is difficult to be adopted.

4.12.2 Reforestation and Recovery of Vegetation Plan

(1) Reforestation of the upper watershed

Long-term reforestation in all areas considered to be critical of the upper watershed is recommended. So, a detail analysis of this alternative will be explained next.

1) Basic Policies

Objectives: Improve the water source area's infiltration capacity, reduce surface soils water flow and at the same time, increase water flow in intermediate soils and ground-water level. Because of the above mentioned, water flow is interrupted in high flood season, this increases water resources in mountain areas, reduces and prevents floods increasing with it the amount and greater flow of ground-water level, reducing and preventing floods

Forestry area: means forestry in areas with planting possibilities around watersheds with water sources or in areas where forest area has decreased. Based on the Forestry Plan for Chincha River Watershed developed by AgroRural, areas that may have forestry projects executed relatively in short-term and with success probabilities have been selected

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

Maintenance after forestry: Maintenance is performed by the sow responsible in the community. For this, a payment system (Payment for Environmental Services) will be created by downstream beneficiaries

Observations: After each thinning the area will have to be reforested, keeping and preserving it in a long-term sustainable way. An incentive for community people living upstream of the watershed shall be designed.

The forest is preserved after keeping and reforesting it after thinning, this also helps in the support and prevention of floods. For this, it is necessary that local people are aware, encourage people downstream, promote and spread the importance of forests in Peru during the project's execution.

2) Selection of forestry area

In case of executing forestry upstream the watershed, as mentioned in "1) Basic Policies", the activities are executed by local people. In this case, the community will forest during their spare time from their agricultural activities. However, the community mostly lives in the highlands performing their farming and cattle activities in harsh natural conditions. Therefore, it is difficult to tell if they have the availability to perform forestry. So, finding comprehension and consensus of the inhabitants will take a long time.

3) Time required for the reforestation project

Since it is a small population, the workforce availability is reduced. So, the work that can be carried out during the day is limited, and the work efficiency would be very low. The JICA Study Team estimated the time required to reforest the entire area throughout the population in the areas within the reforestation plan, plant quantity, work efficiency, etc. According to this estimate, it will take 14 years to reforest approximately 40,000 hectares from the Chincha River Watershed. When estimating the required time for other watersheds, by simply applying this rate to the respective watershed area, we obtained that reforestation in Majes-Camana River Watershed will take 98 years.

4) Total reforestation volume in the upper watershed and project's period and cost

It has been estimated that the surface needed to be reforested in the Majes-Camana River Watershed, as well as the execution cost, having as reference Chincha River Watershed project reforestation data. According to this estimate, the area to be reforested is approximately a total of 307,000 hectares. The required period is 98 years, and the cost is calculated in 829 million soles. In other words, investing a great amount of time and money is required to reforest.

Table 4.12.2-1 Upstream Watershed Forest General Plan

Watershed	Forestry Area (ha) A	Required period for the project (years) B	Required budget (soles) C
Majes-Camana	307.210	98	829.200.856
Chincha Project Cost per hectare: ＝ 2.699,13 (soles /ha) (Calculation Example: Majes-Camana River Watershed) 307.210 / 44.075 x 14 = 98 (years) 307.210 x 2.699,13 = 829.200.856 (ha)			

(Source: JICA Study Team)

5) Conclusions

The objective of this project is to execute the most urgent works and give such a long period for reforestation which has an indirect effect with an impact that takes a long time to appear would not be consistent with the proposed objective for the Project. Considering that 98 years and invested 829 million soles are required, we can say that it is impractical to implement this alternative in this project and that it shall be timely executed within the framework of a long-term plan after finishing this project.

4.12.3 Sediment control plan

For the long-term sediment control plan, it is recommended to execute the necessary works in the upper watershed.

The Sediment Control Plan in the upper watershed will mainly consist in construction of sediment control dikes and bank protection works. In Figure 4.12.3-1 the sediment control works disposition proposed to be executed throughout the watershed is shown. The cost of Majes-Camana River works was estimated focusing on: a) covers the entire watershed, and b) covers only the priority areas, analyzing the disposition of works for each case. The results are shown in Table 4.12.3-1.

Due to the Majes-Camana River extension, the construction cost for every alternative would be too high in case of carrying-out the bank protection works, erosion control dikes, etc. Apart from requiring a considerably long time. This implies that the project will take a long time to show positive results. So, it is decided that it is impractical to execute this alternative within this project and should be timely executed within the framework of a long-term plan, after finishing this project.

Table 4.12.3-1 Upper watershed sediment control works execution estimated costs

Watershed	Approach	Bank Protection		Strip		Sediment control dike		Total works direct cost	Project Cost (Millions S/.)
		Vol. (km)	Direct Cost (Million S/.)	Vol. (units)	Direct Cost (Million S/.)	Vol. (units)	Direct Cost (Million S/.)		
Majes-Camana	All Watershed	264	S/.282	26	S/.1	123	S/.165	S/.448	S/.843
	Prioritized Section	264	S/.282	26	S/.1	81	S/.105	S/.388	S/.730

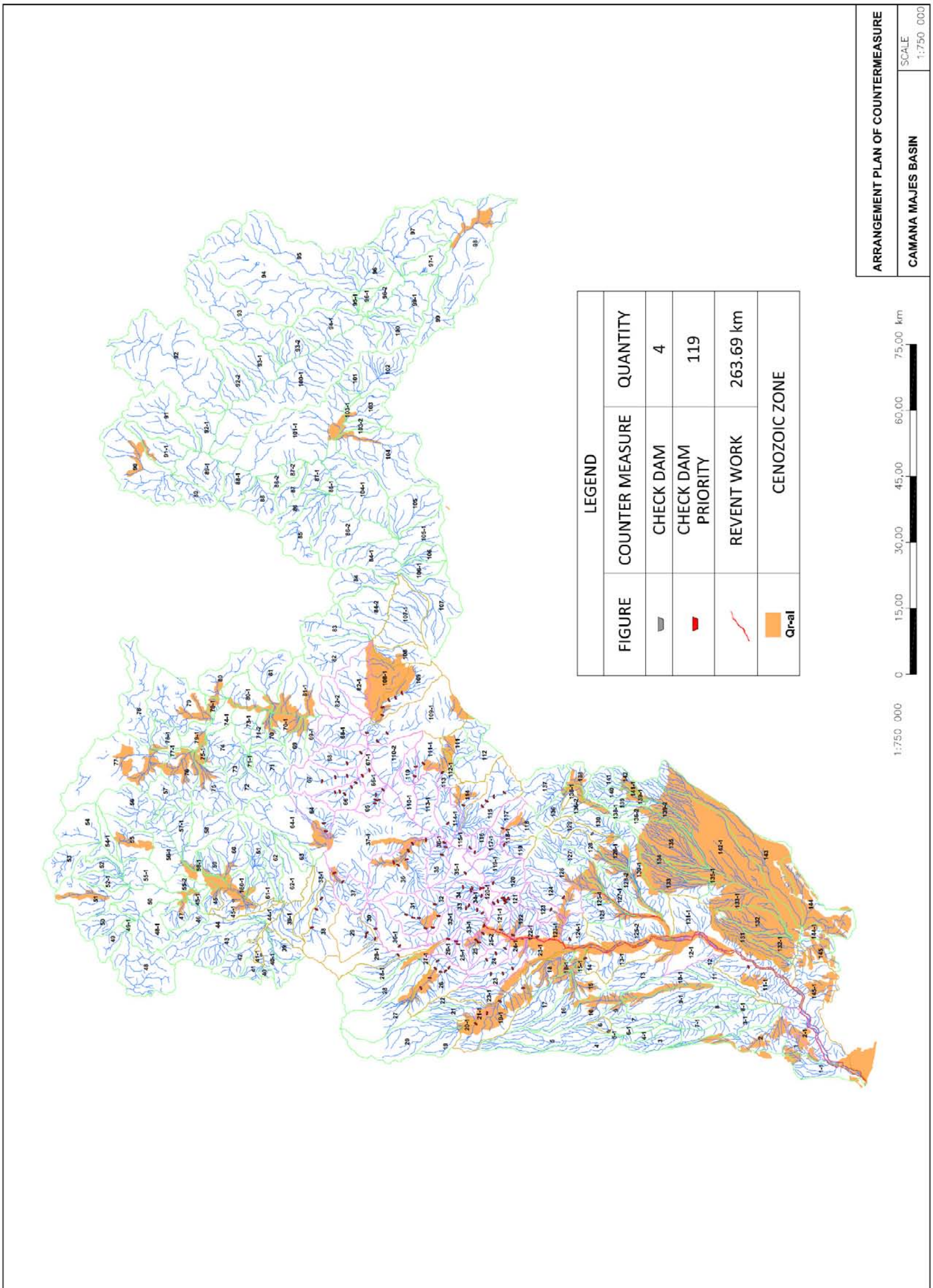


Figure 4.12.3-1 Sediment control works location Majes-Camana River Watershed

5. CONCLUSIONS

The selected alternative for flood control in this Study is structurally safe. Also, the social assessment showed a sufficiently high economic value. Its environmental impact is reduced. The implementation of this Project will contribute to relief the high vulnerability of valleys and local community to floods, and will also contribute to the local economic development. Therefore, we conclude to implement it as quickly as possible.