Ministry of Agriculture
Republic of Peru

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

FINAL REPORT
I-6 SUPPORTING REPORT

ANNEX-7 REFORESTATION AND VEGETATION PLAN
ANNEX-8 FACILITY PLAN AND DESIGN
ANNEX-9 CONSTRUCTION PLAN AND COST ESTIMATE
ANNEX-10 ECONOMIC EVALUATION AND ANALYSIS
ANNEX-11 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS/GENDER
ANNEX-12 TECHNICAL ASSISTANCE
ANNEX-13 STAKEHOLDER MEETING
ANNEX-14 IMPLEMENTATION PROGRAM OF LOAN PROJECT

March 2013

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

YACHIYO ENGINEERING CO., LTD.
NIPPON KOEI CO., LTD.
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Figure Study Area

ABBREVIATION

Abbreviation	Official Form or Meaning
ANA	Autoridad Nacional del Agua/National Water Authority
ALA	Autoridad Local del Agua/Local Water Authority
B/C	Costo Benefit Ratio/Benefit Cost Ratio
GDP	Gross Domestic Product/Gross Domestic Product
GIS	Geographic Information System/Geographic Information System
DGAA	Dirección General de Asuntos Ambientales/General Directorate of Environmental Affairs
DGFFS	Dirección General de Forestal y de Fauna Silvestre/Directorate General of Forest and Wildlife
DGIH	Dirección General de Infraestructura Hidráulica/ Directorate General for Water Infrastructure
DGPI (Paleo-DGPM)	Dirección General de Política de Inversiones/Directorate General of Investment Policy
DNEP	Dirección Nacional de Endeudamiento Público/National Directorate of Public Debt
DRA	Dirección Regional de Aguricultura/Regional Directorate Aguriculture
EIA	Evaluación de Impacto Ambiental/Environmental Impact Assessment
FAO	Agricultura y la Alimentación Organización de las Naciones Unidas/Food and Agriculture Organization of the United Nations
F/S	Estudio de factibilidad/Feasibility Study
GORE	Gobierno Regional/Regional Government
HEC-HMS	Centros de Ingeniería Hidrológica Sistema de Modelación Hidrológica Método /Hydrologic Engineering Centers Hydrologic Modeling System Method
HEC-RAS	Centros de Ingeniería Hidrológica del Río de Análisis del Sistema Método /Hydrologic Engineering Centers River Analysis System Method
IGN	Instituto Geográfico Nacional/National Geographic Institute
IGV	Impuesto General a Ventas/General Sales Tax
INDECI	Instituto Nacional de Defensa Civil/National Institute of Civil Defense
INEI	Instituto Nacional de Estadística/National Institute of Statistics
INGEMMET	Instituto Nacional Geológico Minero Metalúrgico/National Geological and Mining Metallurgical Institute
INRENA	Instituto Nacional de Recursos Naturales/Natural Resources Institute
IRR	Tasa Interna de Retorno (TIR)/Internal Rate of Return
JICA	Japonés de Cooperación Internacional /Japan International Cooperation Agency
JNUDRP	Junta Nacional de Usuarios de Distritos del Perú/National Board of Peru Districts Users
L/A	Convenio de Préstamo/Loan Agreement
MEF	Ministerio de Economía y Finanzas/Ministry of Economy and Finance
MINAG	Ministerio de Agricultura/Ministry of Agriculture
M/M	Acta de la reunion/Minutes of Meeting
NPV	Valor Actual Neto (VAN)/NET PRESENT VALUE

O&M	Operación y mantenimiento /Operation and maintenance
OGA	Oficina General de Administración/General Office of Administration
ONERRN	Oficina Nacional de Evaluación de Recursos Naturales/National Bureau of Natural Resource Evaluation
OPI (OPP)	Oficina de Programación e Inversiones/Programming and Investment Office (Oficina de Planificación e Prespuesto/Office of Planning and Budget)
PBI	Producto Bruto Interno/Gross Domestic Product
PE	Exp. Proyecto Especial (PE) Chira-Piura/ Exp. Special Project Chira-Piura
PES	Pago por Servicos Ambientales (PSA)/Payment for Environmental Services
PERFIL	PERFIL/PROFILE (Preparatory survey of project before investment)
Pre F/S	Estudio de Prefactibilidad /Pre-Feasibility Study
PERPEC	Programa de Encauzamiento de Ríos y protección de Estructura de Captación
PRONAMACHIS	Programa Nacional de Manejo de Cuencas Hidrográficas y Conservación de Suelos/ National Program of River Basin and Soil Conservation Management
PSI	Programa de Sub Sectorial de Irrigaciones/Program of Sub Irrigation Sector
SCF	Factor de conversión estándar/Standard conversion factor
SENAMHI	Servicio Nacional de Meteorología y Hidrología/ National Service of Meteorology and Hydrology
SNIP	Sistema Nacional de Inversión Pública/National Public Investment System
UF	Unidad formuladora/Formulator unit
VALLE	Valle/Valley
VAT	Impuesto al valor agregado/Value-added tax

THE PREPARATORY STUDY ON PROJECT OF THE PROTECTION
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IN THE REPUBLIC OF PERU
FEASIBILITY STUDY REPORT
SUPPORTING REPORT

Annex-7
Afforestation/Vegetation Recovery

TABLE OF CONTENTS

Pages

LIST OF TABLES

Pages

LIST OF FIGURES

Pages

CHAPTER 1 VEGETATION CONDITION

1.1 Vegetation in the Project Area

(1) Vegetation Classification

(a) Canete, Chincha, Pisco, Yauca River Basin

The latest vegetation study in Peru[1] was carried out in 2005 under the auspices of Food and Agriculture Organization of the United Nations (FAO) in cooperation of Department of Natural Resources, Ministry of Agriculture (INRENA[2]). This study was conducted based on the data of "vegetation maps 1995" and its expository text[3], which was drawn in 1995 by INRENA and the General Department of Forest. In 1970, the National Institution of Planning (Instituto Nacional de Planificacion) and the National Office of Natural Resource Evaluation (ONERN : Oficina Nacional de Evaluacion de Recursos Naturales) prepared "Assessment of natural resources and a list of its rational use in the coastal areas in Peru" which describes the natural conditions and charactaristics of vegetation in the coastal areas.

According to the vegetation maps in 1995, the river basins of Canete, Chincha, Pisco and Yauca cover whole areas ranging from the coastal line up to the Andes highland. The vegetation type is characterized by the elevation (refer to ***Table 1.1***). It can be said as follows: i) Vegetation cover is quite limited in the area between the coastal line up to about 2,500m above sea level (Cu, Dc in the maps). There are only several cactus and grass species in this area and these are the dominant vegetation in the area. Some shrubs scatter occasionally in the higher elevation part of this area. ii) Shrub forests can be found in the area between 2,500m and 3,500m, where precipitation condition is favorable for them. iii) Grasses becomes dominant in the areas higher than 3,500m above sea level. because the temperature is too low to grow for tree species. In these four (4) river basins, the maximum height of tree species is approx. 4m e that is found in shrub forests. Some tree species along rivers are grown taller but in an exceptional case.

Table 1.1 **Major Vegetation Zone in Canete, Chincha, Pisco and Yauca River Basins**

Symbol	Name of Zone	Elevation	Annual Rainfall	Major Vegetation
1)Cu	Agriculture lands in the coastal area	Coastal area	Almost zero	Agricultural lands in the coastal area
2)Dc	Desarts inthe coastal area	0 - 1,500m	Almost zero. There are some places with fog.	There are almost no vegetation, juts small areas covered with grasses can be found in the fog areas.
3)Ms	Dry-grass/shrub area	1,500 - 3,900m	120 - 220mm	Cactus and grasses

[1] Landsat-TM (data in 1999 and 2000) were used for the study.
[2] INRENA was disbanded and the it's functions were transferred to the General Department of forest & wildlife (Direction General Forestal Y de Fauna Silvesta).
[3] Landsat-MSS (data in 1988) were used for the study.

4)Msh	Semi-humidgrass/shrub area	In North & central area: 2,900 - 3,500m In Andes highland: 2,000 - 3,700m	220 - 1,000mm	Evergreen & Low trees which are not toller than 4m.
5)Mh	Humid grass/shrub area	Northern area: 2,500 - 3,400m Southern area: 3,000 - 3,900m	500 - 2,000mm	Evergreen trees, height is lower than 4m
6)Cp	Grass lands in Andes highland	Around 3,800m	(no description)	Poaceous grasses
7)Pj	Grass land	3,200 - 3,300m Central-southern area: up to 3,800m	In Southern rainless area: lower than 125mm Eastern Slopes: more than 4,000mm	Poaceous grasses
8)N	Snowpacked mountain	-	-	-

(Source: JICA Study Team based on the vegetation maps in 1995)

The vegetation zones are described below. The vegetation maps of four river basins are showen in ***Figure 1.1*** to ***1.4***.

(i) Cu: (Agricultural area in the coastal area): The agricultural lands extended along the rivers

(ii) Dc: (Desert area in the coastal area)

This vegetation zone covers 10.01 % (as 128,575 km^2) of the whole country. It can be found from Tumbes in the Northern area to Tacna in the Southern area. The elevation ranges from 0 m up to 1,500m above sea level. The climate characteristics in this zone are; i) Dry and hot in summer season (December to March) and ii) Foggy in winter season (May to September). "Lomas" is one of the vegetation types distributed occasionally in the areas between 700 and 1,000m above sea level. Some of tall grasses (several centimeters heights s) can be found not only in Lomas specifically in the Southern coastal area but only during the years in which there are lot of fogs. Taller trees are found only at riverside areas.

(iii) Ms (Dry grass/shrub)

This vegetation zone covers 2.18 % (as 28,026 km^2) of the country's total land area. This zone is found from western-low slopes of Tumbes inthe Northern area to Tacna in the Southern area. Elevation ranges up to 3,900 m above sea level in Tacna. In midland of Peru, the zone is found in the elevation range of higher than 1,500 m above sea level and it covers the middle range of the Western slopes of the Andes highland. The average yearly temperature ranges from 11 to 25 degrees Celsius, while annual rainfall isfrom 120 to 220mm. Exceptionally in Tacna Region, the average yearly temperature is lower than 6 degrees Celsius and the rainfall is less than 125mm. The variety of vegetation in this zone is limited only to cactus and grass species due to the inclement climate conditions. In the dry season, all shrubs drop their leaves for survival and all grasses disappear from the ground. However, they grow again once the rainy season gets started.

(iv) Msh (semi-dry grass/shrub)

This vegetation zone covers approx. 2.91 % (as 37,278 km^2) of the land area of the country follows to dry grass/shrub zones. It is located between 2,900 m and 3,500 m above sea level in the Northern and central area, and between 2,000 m and 3,700 m on the Andes highland. The average yearly temperature ranges from 9 to 18 degrees Celsius, and the annual rainfall is from 220 to 1,000 mm. The major shrub species is evergreen and its height is not taller than 4m in general.

(v) Mh (humid grass/shrub area)

This vegetation zone covers 3.17 % (as 40,777km^2) of the country's land area. It is found between 2,500 and 3,400 m above sea level in the Northern area, between 3,000 and 3,900 m in the Central-Southern area of Peru. This means that this zone is located in the middle between semi-dry grass/shrub vegetation area and the Andes highland. The average yearly temperature ranges from 6 to 14 degrees Celsius, the average yearly rainfall is from 500 to 2,000 mm; while in some areas it reaches 4,000 mm exceptionally. The most of the vegetation in this zone are evergreen with high tolerance against dry climate and low temperature. The height of trees is approx.. less than 4m. Small patches of forests are formed on such places where inaccessible for humans

(vi) Cp (pasture grass land in the Andes highland)

It covers 1.89 % (as 24,249km^2) of the country's land area, and is located at 3,800m above sea level of the central-southern area of Peru, and at the fringelike of the Andes highland. The principle vegetation of this zone is gramineous species. Cyperaceous, juncaceous and papilionaceous species are also found in the zone.

(vii) Pj (Grass land)

This zone is located in low temperature highlands in the Andes Cordilleras. The elevation of the zone ranges from 3,200 to 3,300m above sea level. The zone is also found in the area up to 3,800m exceptionally in Central-Southern region. The southern areas of this zone is dryer than the northern or central area, the yearly average rainfall is less than 125mm in some places. While, there are some places in the east side of the zone in which annual rainfall reaches 4,000mm. The yearly average temperature is 1.5 to 6 degrees Celsius. Talares is a representative vegetation type composed of grasses and shrubs in the southern areas. such as in Arequipa Region. However, degradation of vegetation is notable in this zone because of the overuse as fuel.

(viii) N: Snowcapped mountain

(b) Kamana/Majes River Basin

According to the vegetation maps in 1995, the vegetation types in the Kamana/Majes River Basin are almost same as the one in four river basins described above. Three differences points of the major vegetation types in Kamana/Majes River Basin and the four river basins described above are; i) Cu (Agricultural area in the coastal area) is not found in Kamana/Majes River Basin, ii) Lomas can be found n Kamana/Majes, and iii) Bf(humid grassland) can be found in Kamana/Majes.

The vegetation types which can be found in Kamana/majes River Basin but not in the previous four river basins are describe below. The vegetation maps in Kamana/Majes River Basin are shown in ***Figure 1.5***.

(i) Lo (Lomas)

This type ranges from 0m up to 1,000m above sea level, is located along to the South-North coastal line between Peru to Chili. This quite characteristic vegetation type appears because of fogs from the sea in the winter season (May to September). The dominant vegetation species are *Tillandsia spp.* (Ananas family), tara (*Caesalpinea spinosa*), *Ismene amancae* (Lycoris radiate family, Spider lily genus), *Haageocereus spp.* (Cactus daily), *Oxalis spp.* (Sorrel Family) and *Solanum spp.* (Nightshade family). The desert area in Peru covers approx. 11% of the country's land area, is extended approx. 2,000km between the South-North, and the area is approx. 14,000km2. However, any information of area of Lomas can not be found during this study.

(ii) Bf (Humid grassland)

This type ranges from 3,900m up to 4,800m above sea level. The topography of this type is almost flat with occasionally depressions. There is surface water from spring sourced by the glacier and it makes high ground water level, therefore, the surface water can not infiltrate into the ground. This condition keeps the area wet. The dominant vegetation in the type are; champa (*Distichia muscoides*), sillu - sillu (*Alchemilla pinnata*), libro-libro (*Alchemilla diplophylla*), chillihua (*Festuca dolichophylla*), crespillos (*Calamagrostis curvula*), tajlla (*Lilecopsis andina*), sora (*Calamagrostis eminens*), and ojho pilli (*Hipochoeris stenocephala*). These are low height grasses, and sometimes used for fodder of camel family (as llama, alpaca, vicuna and guanaco).

(c) Chira River Basin

In accordance with the vegetation maps and the description in 1995, the xerophile forest is major in this zone as different with the other four river basins. There are three types of xerophile forest as, i) savanna xerophile (Bas a), ii) terrace xerophile forest (Bs co), and iii) mountainous xerophile forest (Bs mo). These forest types have characteristics by the elevation (please see ***Table 1.2***). The major plant species in this zone is Algarrobo (*Prospis pallida*). Toll trees and shrubs are mixed in Algarrobo forest. The tree species in the terrace xerophile forest and the mountainous xerophile forest is almost same; deciduous tree species. And the height of the trees is about 12m. There are some evergreen trees with more than 10cm diameters along the rivers, because the groundwater level there is high. It is difficult to recover the vegetation naturally in the xerophile forests in case of being destroyed once. The vegetation of the mountainous humid forest type has rich in plant species and the height of the most of trees is less than 10m.

Table 1.2 **List of Major Vegetation in Chira River Basin**

Symbol	Name of Zone	Elevation	Annual Rainfall	Major Vegetation
1)Bs sa	Savanna xerophile forest	0 to 500m	160 to 240mm	Algarrobo forest (evergreen tree forest) . Deciduous trees & shrubs/grasses can be found in high elevation areas.
2)Bs co	Terrace xerophile forest	400 to 700m	230 to 1,000mm	Almost same situation as mountainous xerophile forest
3)Bs mo	Montainus xerophile forest	500 to 1,200m	230 to 1,000m	Evergreen tree is major. The average height of high layer trees in the forest is about 12m.
4)Bh mo	Mountainous humid forest	Up to 3,200m (in the areas of Amazon highland to the Northern areas in Peru) Up to 3,800m (in the central southern areas in Peru)	Fogs are common in this zone, there are some mist forests.	The high layer tree measure about 10m in height, palm trees measure 2 to 4m. There are grasses too, and the vegetation is rich in this type.
In addition to above, as described fore, there are the desert area (Dc and Cu), semi-humid shrub forest (Msh), and humid shrub forest (Mh) in this river basin.				

(Source: JICA Study Team based on the vegetation maps in 1995 (INRENA))

The each zone is described as below. The vegetation map in Chira River basin is attached in ***Figure 1.6***.

(i) Bs sa (Savanna xerophile forest)

This zone covers 1.89% of the whole country (as 24,307km^2). It is found in the coastal plain and valley, mainly in the Northern areas; Region of Lambayeque, Piura, and Tumbes under about 500m above sea level. The annual average temperature is 21 to 25 degree in Celsius. The annual rainfall is 160 to 240mm, but in some places it is under 10mm per year. In addition, the savanna xerophile forests are distributed in the middle area of the Andes Range.

The major tree species of the savanna xerophile forest zone is Algarrobo (*Prosopis pallida*), which is evergreen tree. And the other two species in same genus are found in Piura/ Lambayeque Region. These tree species can grow 8 to 12m in height along the rivers or irrigation channels where the water condition is rich. Also, grasses under the trees are grow well in that places. The toll tree species as Zapote, Faique, and Palo verde and shrubs (Bichayo, Cun cun) that are living with Algarrobo in Algarrobo forests are found too.

The savanna xerophile forests have been got deforestation/degradation of forests by over-logging for fuel (firewood, charcoal) and wood box production.

(ii) Bs co (Terrace xerophile forest

This zone covers 0.12% of the whole country (as 1,514km^2). It is found in the hills/terraces,

which are located 400 to 700m above sea level, in Piura and Tumbes Region of the Northern area of Peru. The annual average temperature is 17 to 25 degree Celsius. The annual rainfall is 230 to 1,000mm.

(iii) Bs mo (mountainous xerophile forest)

This zone covers 0.82% of the whole country (as 10,524km2). It is found in Region; La Libertad, Lambayeque, Piura, and Tumbes of the Northern area of Peru. It is located at the western side of the Andes Range, and the elevation is 500 to 1,200m above sea level. The annual average of the temperature is 17 to 25 degree Celsius, the annual rainfall is 230 to 1,000mm per year.

The height of trees in the terrace xerophile and the mountainous xerophile is about 12m, but in a valley or along the rivers the trees with more than 20m in height can be found exceptionally. The zone is composed with the deciduous trees as, Pasallo, Ceibo, Palo santo, Hualtaco, Guayaca, Porotillo, Polo polo, and Huarahumo (*Tecoma weberbaueriana*). The trees with 10cm of diameters along the river, where the water condition is rich, can be founded. Also the number of tree is about 100/ha sp in the zone. Also, some of evergreen shrubs as Sapote, Charan, Almendro, Palo blamco, Angolo, Ebano, Analque (*coccoloba sp.*), and Huasimo compose the forest.

(iv) Bh mo (mountainous humid forest)

This zone covers 11.71% of the whole country (as 150,517.63km2). It is located in the eastern slope of the Andes highland (between the grass lands and humid shrubs). The elevation of this zone is up to 3,200m in the place between Amazon highland and the northern area of Peru, up to 3,800m in the place of central and southern areas of Peru. It is located in the mountainous area where the geography is very precipitous. The fog rises commonly at the upper place of this zone and the forest which is known and described as the mist forest is developed. The air plans, which lives on the other trees or bed rock, climbers, lichens, mosses, fiddlehead fern, and the other grasses grow thickly in this vegetation zone.

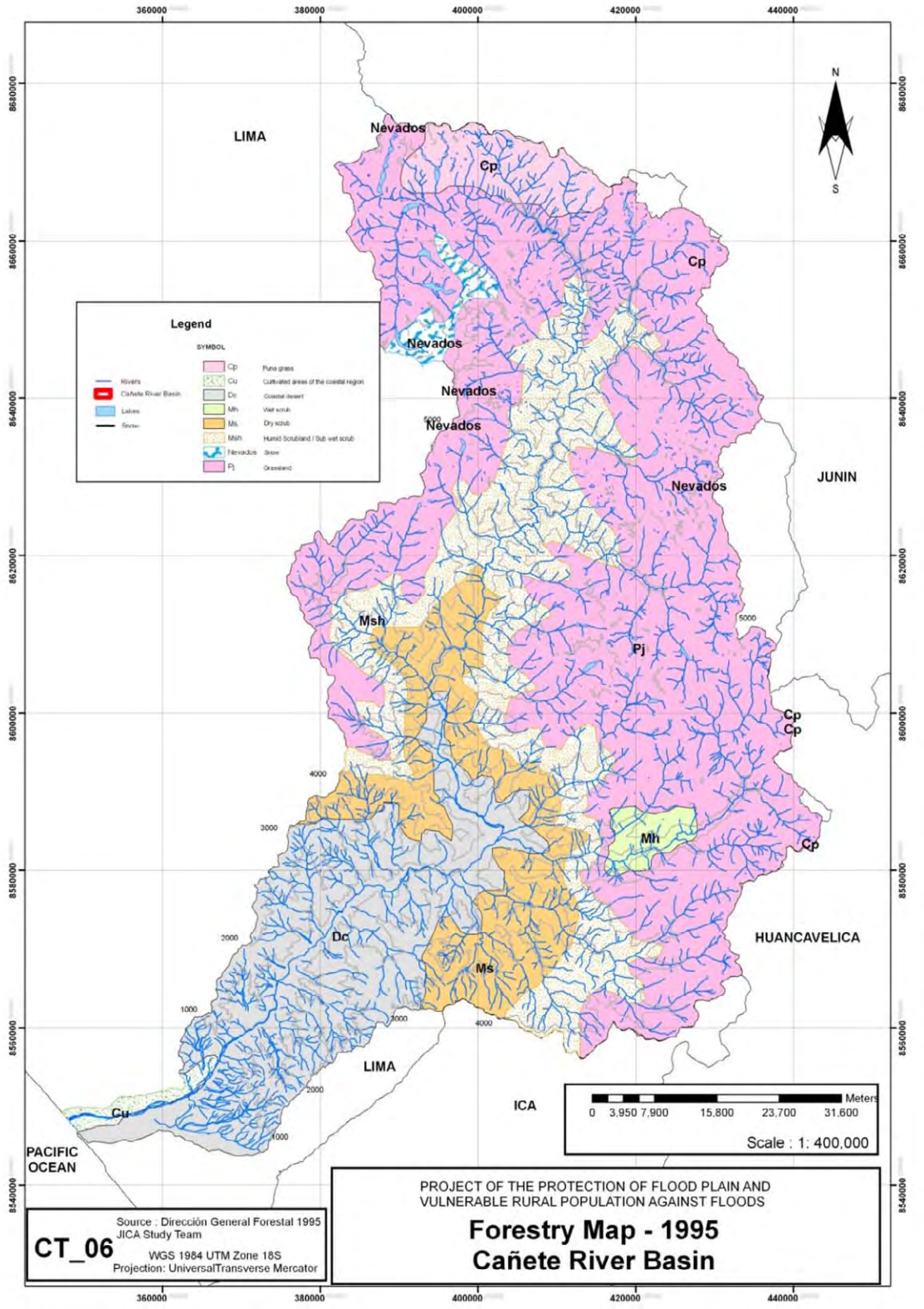


Figure 1.1 **Vegetation Map (Canete River Basin)**

(Source: JICA Study Team based on the research by INRENA, 1995)

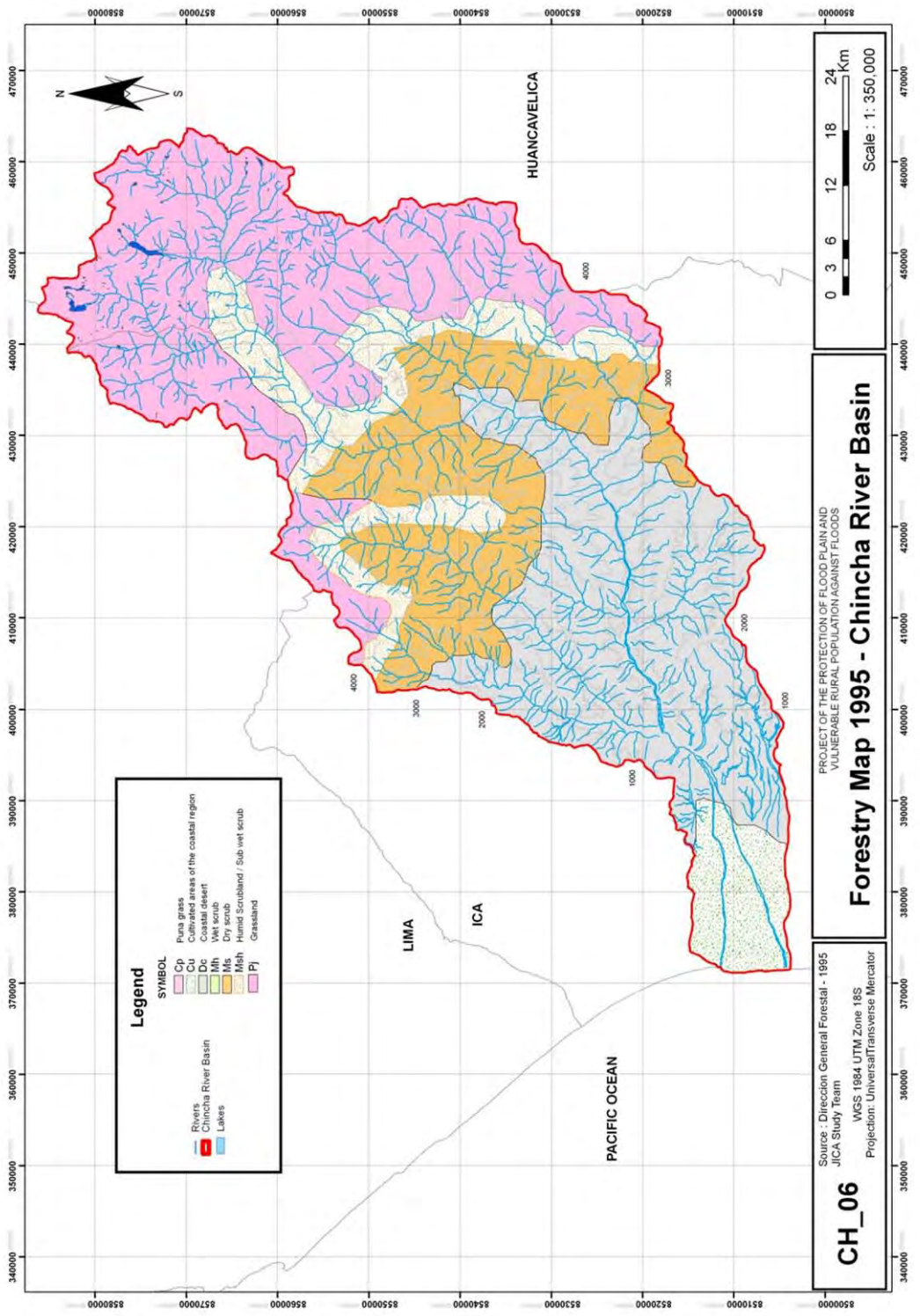


Figure 1.2 **Vegetation Map (Chincha River Basin)**

(Source: JICA Study Team based on the research by INRENA, 1995)

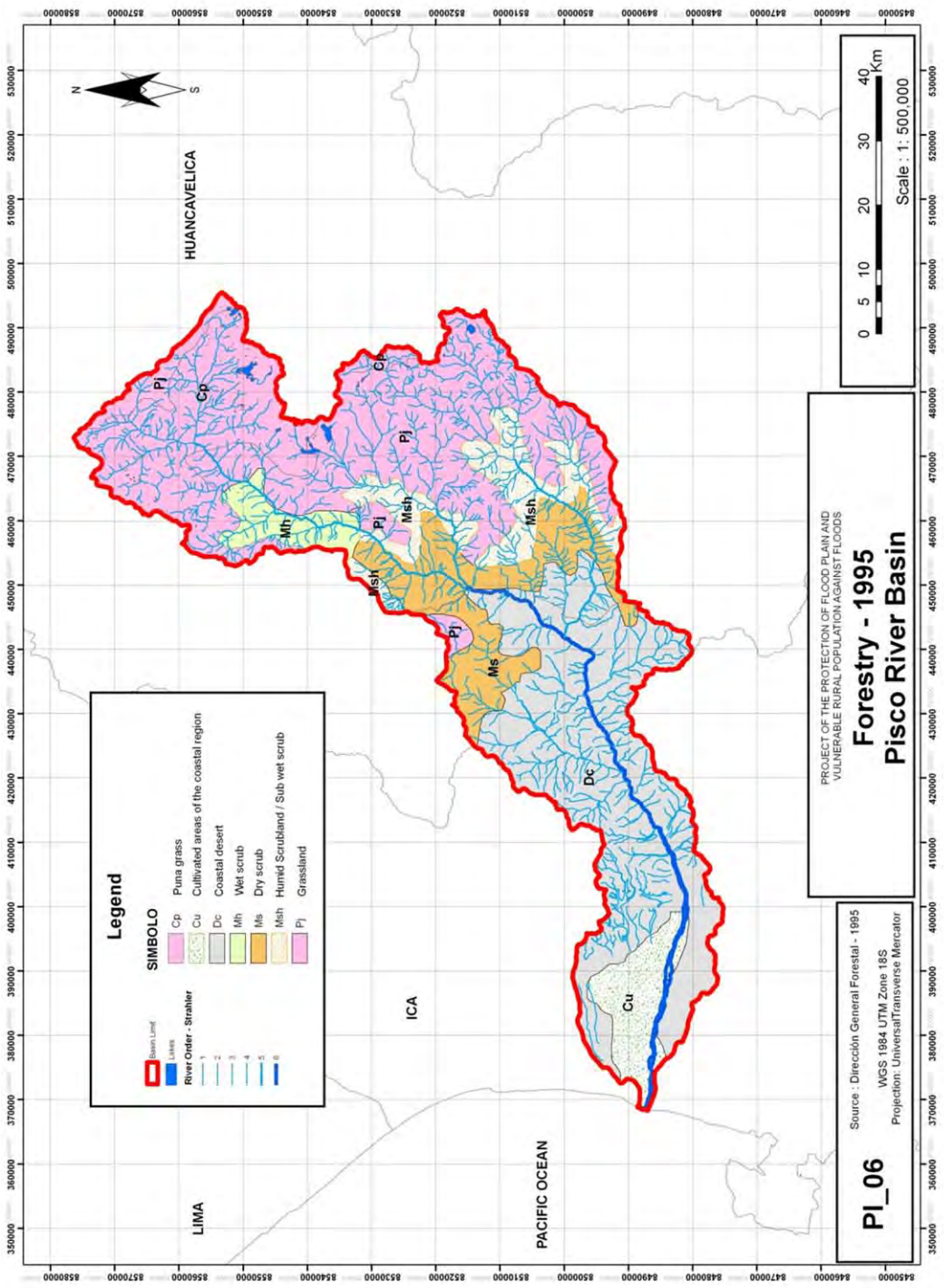


Figure 1.3 **Vegetation Map (Pisco River Basin)**

(Source: JICA Study Team based on the research by INRENA, 1995)

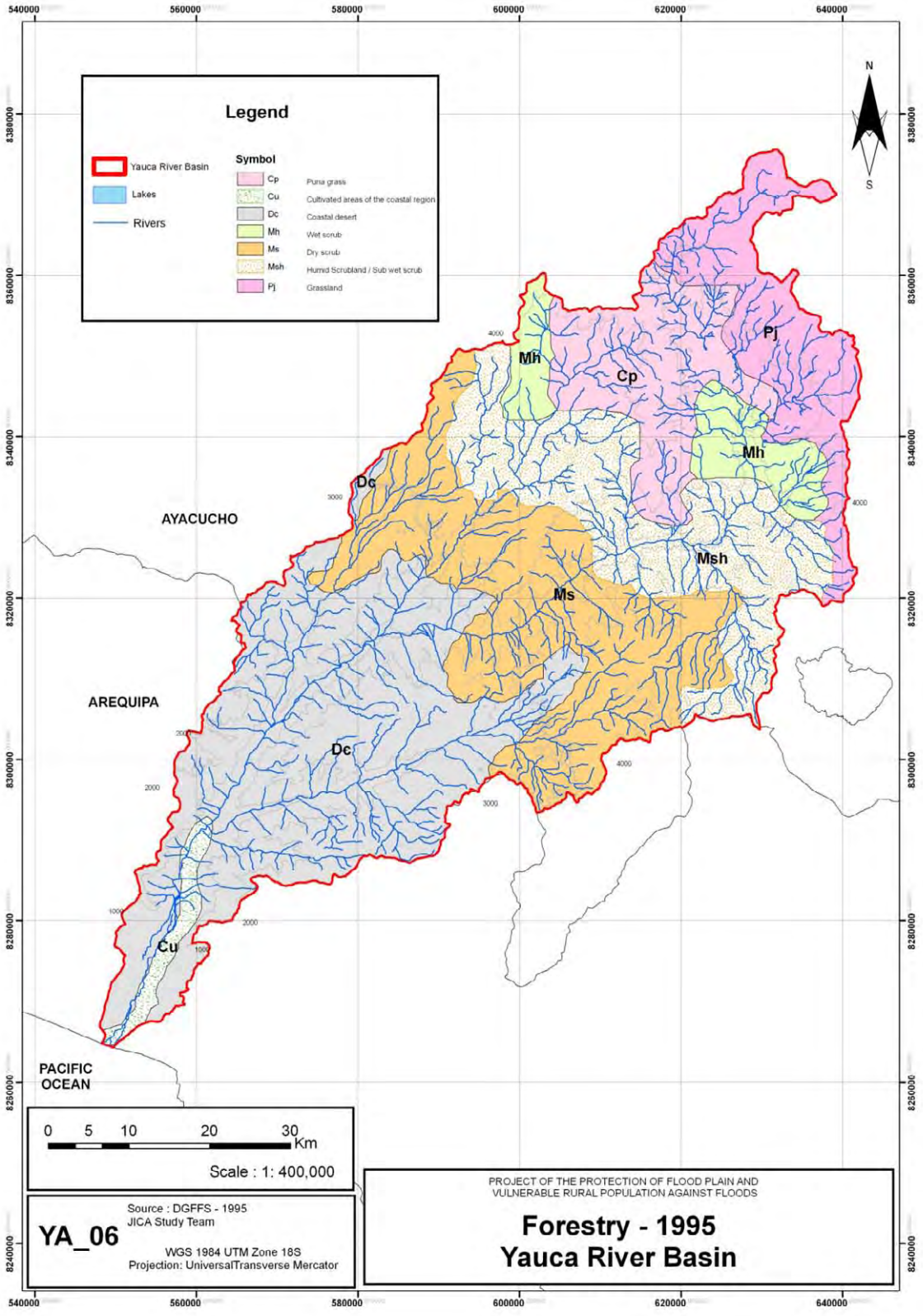


Figure 1.4 **Vegetation Map (Yauca River Basin)**

(Source: JICA Study Team based on the research by INRENA, 1995)

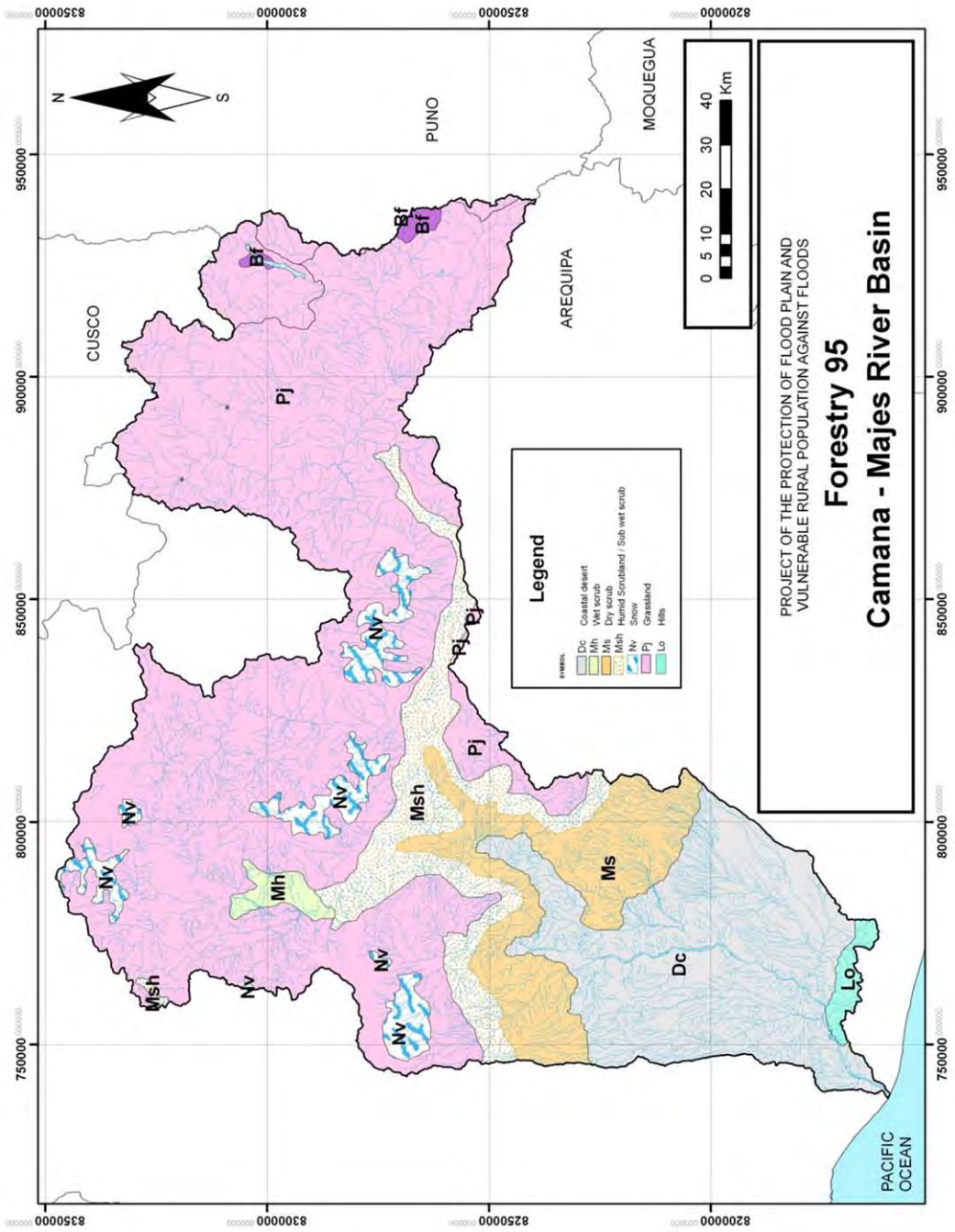


Figure 1.5 **Vegetation Map (Camana-Majes River Basin)**

(Source: JICA Study Team based on the research by INRENA, 1995)

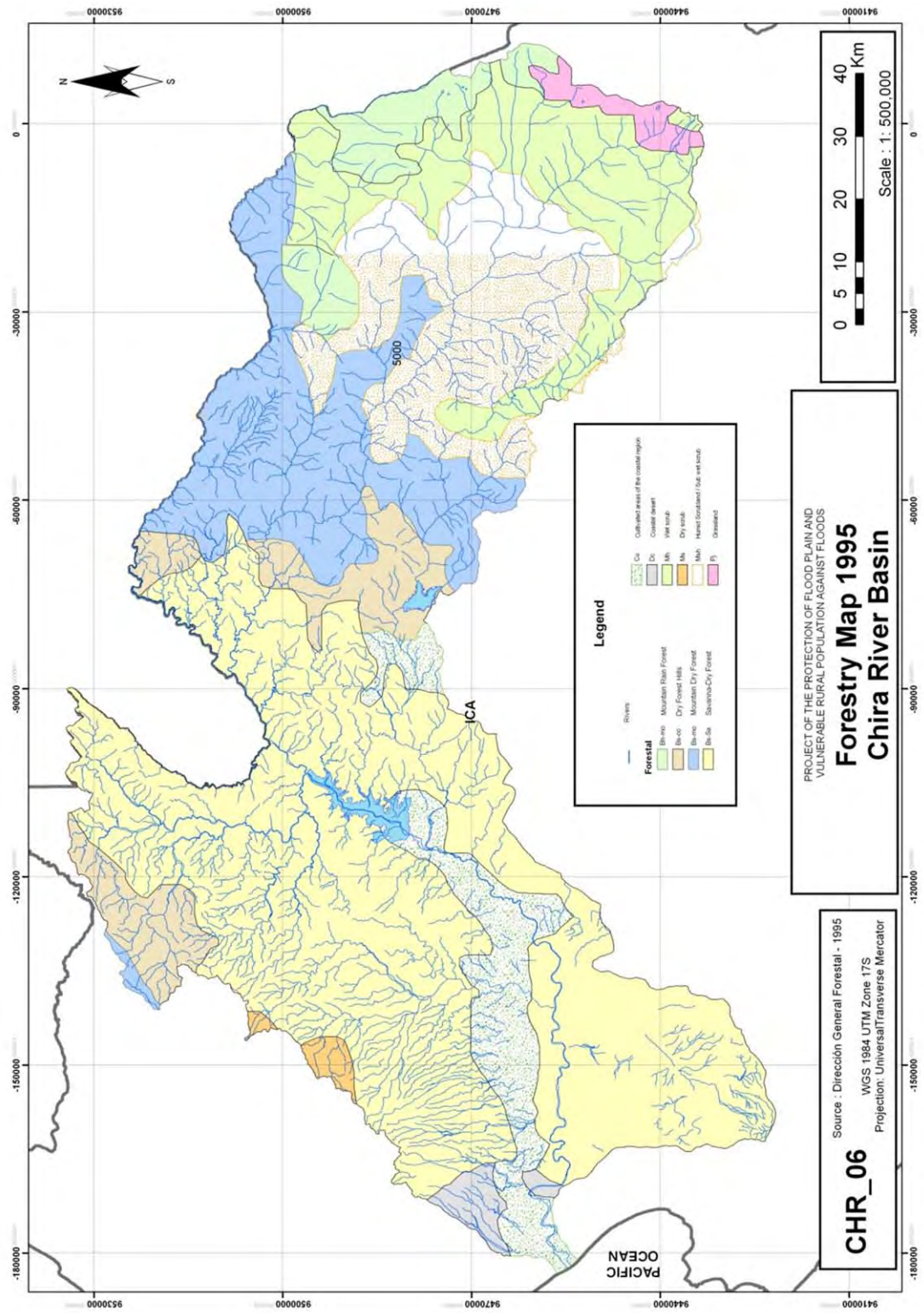


Figure 1.6 **Vegetation Map (Chira River Basin)**

(Source: JICA Study Team based on the research by INRENA, 1995

(2) Vegetation Area and Distribution

(a) Canete, Chincha, Pisco, Yauca River Basin

The results of the research by INRENA in 1995 was transported into the GIS data which was developed by the JICA Study Team. The area of each vegetation zone and its area ratio compared with the each river basin were measured by the GIS data. (Please refer to ***Table 1.3***).

Table 1.3 **Areas of Vegetation Zones of Each River Basin (Canete, Chincha, Pisco, and Yauca)**

R. Basin	Vegetation Zone								
	Cu	Dc	Ms	Msh	Mh	Cp	Pj	N	Total
(Area of vegetation zone : km^2): A									
Pisco	217.88	1,354.39	469.99	381.55	140.01	672.59	1,035.68	0.00	4,272.09
Chincha	169.98	1,010.29	642.53	365.18	0.00	854.74	261.17	0.00	3,303.89
Canete	61.35	1,072.18	626.23	1,024.77	70.39	187.39	2,956.65	66.78	6,065.74
Yauca	69.48	1,433.26	990.99	730.67	234.49	428.64	435.04	0.00	4,322.57
Total	518.69	4,870.12	2,729.74	2,502.17	444.89	2,143.36	4,688.54	66.78	17,964.29
(Area ratio to river basin area: %): B									
Pisco	5.1	31.7	11.0	8.9	3.3	15.7	24.2	0.0	99.9
Chincha	5.1	30.6	19.4	11.1	0.0	25.9	7.9	0.0	100.0
Canete	1.0	17.7	10.3	16.9	1.2	3.1	48.7	1.1	100.0
Yauca	1.6	33.2	22.9	16.9	5.4	9.9	10.1	0.0	100.0
Total	2.9	27.1	15.2	13.9	2.5	11.9	26.1	0.4	399.9

Note1: R. Basin = River Basin
Note2: B = A/ total river basin area
(Source: JICA Study Team based on the study by INRENA 1995)

The some of vegetation zones are merged as i) desert zone in the coastal area (Cu, Dc), ii) grass/cactus zone (Ms), iii) shrub zone (Msh, Mh), iv) Grass zone (Cp, Pj), and v) snow capped mountain zone (N). The areas of merged zones and the area ratios to the river basins are shown in ***Table 1.4***. Viewing broadly the Table, the condition of area and area ratio to the total area of each river basin can be summarized as follows. 1) the desert zone covers about 30% of the river basin area, 2) the grass/cactus zone covers about 10 to 20 %, 3) the grass zone covers 30 to 50 %, and 4) the shrub zone covers 10 to 20 % only. Generally, the shrub vegetation can be found in the hard situation for the plants as where the closed forest can not form themselves. However, in these river basins, even that shrub forest covers less area. In this point of view, it can be described that the natural condition for the high trees are sever in Vanete, Chincha, Pisco, and Yauca River Basins. Some of the most difficult conditions for the trees are probably less rainfall, poor soil, and steep slope.

Table 1.4 **Area Ratio of the Vegetation Zones to the River Basin Area (Canete, Chicnah, Pisco, Yauca River Basin)**

R. Basin	Vegetation Zone					
	Desert (Cu, Dc)	Grass/Cactus (Ms)	Shrub Forest (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
(Area ratio of vegetation zone to river basin area: %)						
Pisco	36.8	11.0	12.2	40.0	0.0	100.0
Chincha	35.7	19.4	11.1	33.8	0.0	100.0
Canete	18.7	10.3	18.1	51.8	1.1	100.0
Yauca	34.8	22.9	22.3	20.0	0.0	100.0
Total	30.0	15.2	16.4	38.0	0.4	100.0

Note1: R. Basin = River Basin
Note2: S.C.M = Snow capped mountain
(Source: JICA Study Team based on the study by INRENA 1995)

(b) Camana – Majes River Basin

As same as the description of (a) above, the results of the research by INRENA 1995 was transported into the GIS data. The area of vegetation zones of the vegetation zone and its area ratio to the river basin area were measured by the GIS system. (Please refer to ***Table 1.5***).

Table 1.5 **Area of Vegetation Zones of Camana-Majes River Basin**

Classification	Vegetation Zone								
	Lo	Dc	Ms	Msh	Mh	Bf	Nv	Pj	計
Vegetation zne area(km^2)	104.54	3108.12	1570.08	1334.76	155.20	66.16	641.44	10069.21	17,049.51
Ratio of above to river basin area (%)	0.6	18.2	9.2	7.8	0.9	0.4	3.8	59.1	100.0

(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.6 shows summarized results of ***Table 1.5***. The characters of Cama-Majes River Basin are; 1) the shrub zone covers about 9%, 2) grass zone covers about 60%, the shrub zone covers only a little and the grass zone covers a lot. The upper stream of Majes River Basin is almost located in about 4,000 m elevation from sea level, and the grass zone covers most of the area.

Table 1.6 **Area Ratio of the Vegetation Zones to Camana - Majes River Basin Area**

Classification	Desert (Lo,Dc)	Grass & cactus (Ms)	Shrub (Msh, Mh)	Grassland in high altitude (Bf, Pj)	C.C.M (N)	Total
Vegetation zne area (km^2)	3,212.66	1,570.08	1,489.96	10,135.37	641.44	17,049.51
Ratio of above to river basin area (%)	18.8	9.2	8.7	59.4	3.8	99.9

Note: S.C.M = Snow capped mountain
(Source: JICA Study Team based on the study by INRENA 1995)

Figure 1.7 shows comparison of the area ratios of the vegetation zones in 5 river basins (Canete, Chincha, Pisco, Yauca and Camana-Majes River Basin). The area ratio of the shrub zone, which is composed by forest vegetation, in Canete and the other three river basins are about 13 to 24%. It is not much, but the ratio in Camana-Majes River basin is much less as about 9%.

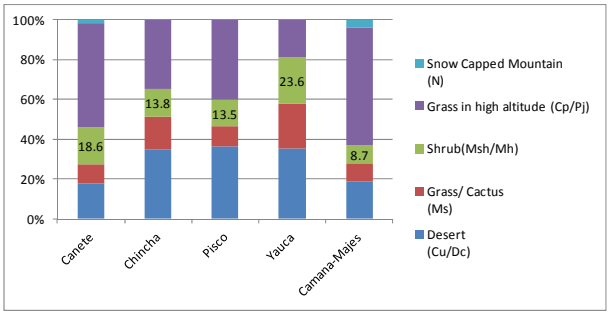


Figure 1.7 **Comparison of Area Ratio in 5 River Basins**
(Source: JICA Study Team based on the study by INRENA 1995)

(c) Chira River Basin

As same as the description of (a) above, the results of the research by INRENA 1995 was transported into the GIS data. The area of vegetation zones of the vegetation zone and its area ratio

to the river basin area were measured by the GIS system. (Please refer to ***Table 1.7***).

Table 1.7 **Area of Vegetation Zone (Chira River Basin)**

	Vegetation Zone											
	Cu	Dc	Ms	Msh	Mh	Bs-sa	Bs-co	Bs-mo	Bh-mo	C-A*	Pj	Total
(Area of vegetation zone: Km^2)												
U.	714.92	105.81	59.34	142.28	139.47	2,668.16	185.40	222.87	0.00	0.00	0.00	4,238.25
L.	31.70	0.00	0.00	1,205.16	1,021.28	1,889.54	473.16	1,164.53	401.54	90.25	112.57	6,389.73
Total	746.62	105.81	59.34	1,347.44	1,160.75	4,557.70	658.56	1,387.40	401.54	90.25	112.57	10,627.98
(Area ratio of vegetation zone to ribr basin area: %)												
U.	16.9	2.5	1.4	3.4	3.3	63.0	4.4	5.3	0.0	0.0	0.0	100.2
L.	0.5	0.0	0.0	18.9	16.0	29.6	7.4	18.2	6.3	1.4	1.8	100.1
Total	7.0	1.0	0.6	12.7	10.9	42.9	6.2	13.1	3.8	0.8	1.1	100.1

Note1: U. = Upper side of the river basin
Note2: L. = Lower side of the river basin
Note 3: C-A = C-A＝Cuerpo Agua (water body in territorial area)
(Source: JICA Study Team based on the study by INRENA 1995)

Some of zones are merged as i) Desert (Cu, Dc), ii) Grass/cactus (Ms), iii) Shrub forest (Msh, Mh), iv) Xerophile forest (Bs-sa, Bs-co, Bs-mo), v) Mountainous mist forest (Bh-mo), vi) Water body in territorial area (C-A), and vii) Grass (Pj). ***Table 1.8*** shows the area ratio of the merged vegetation zones to the area of the river basins.

Table 1.8 **Area Ratio of Merged Zone to River Basin Area (Chira River Basin)**

Classification	Merged Vegetation Zone							
	Desert (Cu, Dc)	Grass /Cactus(Ms)	Shrub forest (Msh, Mh)	Xerophile F. (Bs-sa,-co,-mo)	M. mist forest (Bh-mo)	W.b (C-A)	Grass (Pj)	Total
(Area ratio of the merged zone to river basin area: %)								
U.	19.4	1.4	6.6	72.6	0.0	0.0	0.0	100.0
L.	0.5	0.0	34.8	55.2	6.3	1.4	1.8	100.0
Total	8.0	0.6	23.6	62.1	3.8	0.8	1.1	100.0

Note 1: C-A = Cuerpo Agua (Ater body in the territorial area)
Note 2: W. b = Water body
(Source: JICA Study Team based on the study by INRENA 1995)

Compared with Canete, Chincha, Pisco and Yauca River Basins, there are two differences between those 4 river basins and Chira River basin as follows, i) the desert zone covers only about 10% of the river basin area, ii) grass/cactus zone covers less than 1%. The ratio of the area of shrub forest zone is almost same (about 20%). The biggest difference from the other four river basins is the area ratio of the xerophile forest; it covers almost 60% of the river basin area. This is the vegetation feature of Chira River Basin.

(3) Feature of Vegetation

(a) Elevation and Vegetation

1) Canete, Chincha, Pisco, Yauca River Basin

The areas of the vegetation zones in Canete River Basin and the other three basins are shown in ***Table 1.9***, the area ratios of the vegetation areas to the river basins are shown in ***Table 1.10***.

The major vegetation zone classified by the elevation shows almost same in four river basins as follows. i) the desert zone covers almost 100% between 0 to 2,000m above sea level, ii) the area

ratio of the desert, grass/cactus, shrub forest is about 4:4:2 between 2,000 to 3,00m above sea level. The woody vegetation covers a few areas only, iii) the area ratio of the shrub forest becomes 40 to 60% over 3,000m above sea level, iv) the grass zone (Pj) covers almost 100% over 4,000m above sea level.

Table 1.9 **Vegetation Zone Area in each Elevation (Canete and the other 3 river basins)**

(Unit: km^2)

Name of R. Basin	Elevation Classification (m)	Vegetation Zone					
		Desert (Cu, Dc)	Grass/cactus (Ms)	S. Forest (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
Canete	0 - 1000	370.15					370.15
	1001 - 2000	479.96	46.16	2.59			528.71
	2001 - 3000	235.05	324.03	121.35			680.43
	3001 - 4000	6.57	202.89	631.98	139.26		980.70
	4001 - 5000		2.93	370.15	2,982.87	64.62	3,420.57
	5001<			0.03	54.62	30.53	85.18
	Total	1,091.73	576.01	1,126.10	3,176.75	95.15	6,065.74
Chincha	0 - 1000	435.60					435.60
	1001 - 2000	431.33					431.33
	2001 - 3000	263.68	220.40	50.20			534.28
	3001 - 4000	25.20	307.72	373.23	176.24		882.39
	4001 - 5000		18.50	32.15	968.97		1,019.62
	5001<				0.67		0.67
	Total	1,155.81	546.62	455.58	1,145.88		3,303.89
Pisco	0 - 1000	683.34					683.34
	1001 - 2000	498.22	10.09				508.31
	2001 - 3000	351.56	217.32	37.17	0.03		606.08
	3001 - 4000	32.12	189.61	357.31	137.88		716.92
	4001 - 5000		1.98	180.97	1,565.10		1,748.05
	5001<				9.39		9.39
	Total	1,565.24	419.00	575.45	1,712.40		4,272.09
Yauca	0 - 1000	332.79					332.79
	1001 - 2000	449.96	89.52	36.13			575.61
	2001 - 3000	683.75	328.65	256.58	37.90		1,306.88
	3001 - 4000	49.65	540.20	680.49	234.46		1,504.80
	4001 - 5000		21.75	47.24	533.29		602.28
	5001<				0.21		0.21
	Total	1,516.15	980.12	1,020.44	805.86		4,322.57

Note 1: R. Basin = River Basin, S. Forest = Shrub Forest, S.C.M = Snow Capped Mountain

(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.10 **Area Ratio of Vegetation Zone in each Elevation (Canete & Other 3 River Basins)**

(Unit: %)

R.Basin	Elevation (m)	Vegetation Zone

		Desert (Cu, Dc)	Grass/cactus (Ms)	S.Forest (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
Canete	0 - 1000	100.0					100.0
	1001 - 2000	90.8	8.7	0.5			100.0
	2001 - 3000	34.5	47.6	17.8			99.9
	3001 - 4000	0.7	20.7	64.4	14.2		100.0
	4001 - 5000		0.1	10.8	87.2	1.9	100.0
	Above 5001				64.1	35.8	99.9
Chincha	0 - 1000	100.0					100.0
	1001 - 2000	100.0	1.5				101.5
	2001 - 3000	49.4	41.3	9.4			100.1
	3001 - 4000	2.9	34.9	42.3	20.0		100.1
	4001 - 5000		1.8	3.2	95.0		100.0
	Above 5001				100.0		100.0
Pisco	0 - 1000	100.0					100.0
	1001 - 2000	98.0	2.0				100.0
	2001 - 3000	58.0	35.9	6.1			100.0
	3001 - 4000	4.5	26.4	49.8	19.2		99.9
	4001 - 5000		0.1	10.4	89.5		100.0
	Above 5001				100.0		100.0
Yauca	0 - 1000	100.0					100.0
	1001 - 2000	78.2	15.6	6.3			100.1
	2001 - 3000	52.3	25.1	19.6	2.9		99.9
	3001 - 4000	3.3	35.9	45.2	15.6		100.0
	4001 - 5000		3.6	7.8	88.5		99.9
	Above 5001				100.0		100.0

Note 1: R. Basin = River Basin, S. Forest = Shrub Forest, S.C.M = Snow Capped Mountain

(Source: JICA Study Team based on the study by INRENA 1995)

The shrub zone (Msh, Mh) in Canete and the other 3 river basins ranges between 3,000m to 4,000m. in Canete and Pisco River Basins, the shrub zone covers about 30% of the area above 3,000m (***Table 1.11***)

Table 1.11 **Area Ratio of Shrub Zone (Ms, Msh) by altitude (Canete and the other 3 River Basins)**

(Unit: %)

R.Basin	Altitude Classification						Total
	0 – 1000m	1001 - 2000m	2001 - 3000m	3001 - 4000m	4001 - 5000m	> 5000m	
Canete	0.0	0.2	10.8	56.1	32.9	0.0	100
Chincha	0.0	0.0	11.0	81.9	7.1	0.0	100
Oisco	0.0	0.0	6.5	62.1	31.4	0.0	100
Yauca	0.0	3.5	25.1	66.7	4.6	0.0	100

(Source: JICA Study Team based on the study by INRENA 1995)

2) Camana – Majes River Basin

The areas of the vegetation zones in Camana – Majes River Basins shown in ***Table 1.12***, the area ratios of the vegetation areas to the river basin is shown in ***Table 1.13***. The relation between

vegetation distribution and altitude is shown in ***Appendix 7 Figure 1.5***.

The prior vegetation is summarized as below; i)the desert covers most of the area up to 2,000m elevation above sea level, ii) the ratio of area of the desert :grass/ cactus: shrub from 2,000m up to 3,000m is 1:5:2. The ratio of tree vegetation is quite low, iii) the grass land in high altitude covers about 50% of the area above 3,000m elevation, iv) most of the area above 4,000m elevation is covered by the grass land in high altitude, and v) the Snow capped mountain covers about 15% of the area above 5,000m elevation.

Table 1.12 **Area of Vegetation Zone in each Elevation (Camana – Majes River Basin)**

(Unit: km^2)

Elevation (m)	Vegatation Zone					
	Desrt (Lo,Dc)	Grass/Cactus (Ms)	Shrub (Msh, Mh)	Grass (Bf, Pj)	S.C.M (N)	Total
0 - 1000	1,019.83	20.73	-	-	-	1,040.56
1001 - 2000	1,944.01	580.07	70.93	21.67	2.09	2,616.68
2001 - 3000	165.33	613.51	243.61	241.58	13.51	1,277.54
3001 - 4000	80.50	304.99	606.10	1,090.26	223.79	2,305.64
4001-5000	2.99	50.78	510.33	8,292.15	315.31	9,171.56
> 5000	-	-	58.99	489.71	86.74	635.44
Total	3,212.66	1,570.08	1,489.96	1,0135.37	641.44	16,408.07

S.C.M = Snow Capped Mountain

(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.13 **Area Ratio of Vegetation Zone in each Elevation (Camana – Majes River Basin)**

(Unit: %)

Elevation (m)	Vegetation Zone					
	Desrt (Lo,Dc)	Grass/Cactus (Ms)	Shrub (Msh, Mh)	Grass (Bf, Pj)	S.C.M (N)	Total
0 - 1000	98.0	2.0				100.0
1001 - 2000	74.2	22.2	2.7	0.8	0.1	100.0
2001 - 3000	12.9	48.0	19.1	18.9	1.1	100.0
3001 - 4000	3.5	13.2	26.3	47.3	9.7	100.0
4001 - 5000		0.6	5.6	90.4	3.4	100.0
> 5000			9.3	77.1	13.7	100.1

S.C.M = Snow Capped Mountain

(Source: JICA Study Team based on the study by INRENA 1995)

The area ratio of shrub in Camana-Majes River Basin between 3,000 to 4,000m elevation is about 40%, about 34% between 4,000 to 5,000m, and 74% between 3,000 to 5,000m elevation.

Table 1.14 **Area and Area Ratio of Shrub Zone in each Elevation (Camana – Majes River Basin)**

(Unit: %)

Elevation (m)

0 - 1000m	1001 - 2000m	2001 - 3000m	3001 - 4000m	4001 - 5000m	5000m 超	計
Area (km^2)						
0.0	70.93	243.61	606.1	510.33	58.99	1,489.96
Area Ratio (%)						
0.0	4.8	16.4	40.7	34.3	4.0	100.0

(Source: JICA Study Team based on the study by INRENA 1995)

(Comparison between Camana-Majes River Basin and Canete River Basion and the other 3 river basins): The area ration of shrub zone in Camana-Majes River basin and Canete River Basin and the other 3 river basins is shown in ***Figure 1.8***. Most of the shrub area ranges between 3,000 up to 5,000m elevation. It is mutual between these 5 river basins.

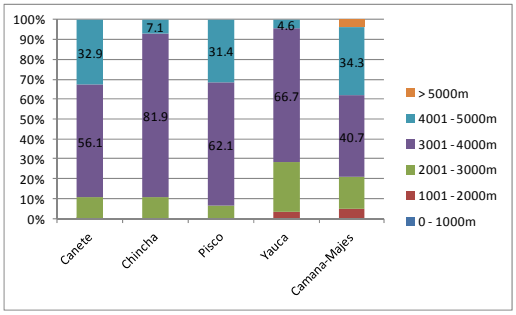


Figure 1.8 **Comparison of Area Ratio of Shrub by Elevation in 5 River Basins**
(Source: JICA Study Team based on the study by INRENA 1995)

3) Chira River Basin

The area and area ratio of the vegetation zones in each elevation classification in Chira River Basin are shown in ***Table 1.15*** and ***Table 1.16***. The major vegetation zones in each elevation class in the Chira River Basin are as follows. i) the xerophile forest is the most popular between 0 to 1,000m above sea level, ii) the shrub forest covers about 50% between 1,000 to 4,000m above sea level, iii) the xerophile forest covers about 30% between 1,000 to 3,000m above sea level, iv) the grass zone covers 100% above 4,0000m above sea level. The most different point from the situation in Canete and the other 3 river basins is that the shrub forest covers many areas even in the low elevation area.

The relation between vegetation zones coverage and elevation classification in Chira River Basin is shown in ***Appendix 7 Figure 1.6***.

Table 1.15 **Vegetation Area in each Elevation Class (Chira River Basin)**

(Unit: km^2)

R.Basin	Elevation (m)	Vegetation Zone							
		Desert (Cu, Dc)	G/C (Ms)	X.F. (Bs)	M. H. F (Bh)	S.F. (Msh,	Water body	Gras (Pj)	Total

						Mh)			
Lower Area	0 - 1000	819.58	80.24	2,926.37					3,826.19
	1001 - 2000			113.63	15.54	95.46			224.63
	2001 - 3000				33.06	49.03			82.09
	3001 - 4000				61.03	153.94			214.97
	4001 - 5000								
	Total	819.58	80.24	3,040.00	109.63	298.43			4,347.88
Upper Area	0 - 1000	6.44		3,117.14		25.57	93.71		3,242.86
	1001 - 2000			447.37	414.04	1,085.74			1,947.15
	2001 - 3000			294.60	476.09	887.85		13.37	1,671.91
	3001 - 4000				86.83	133.47		102.41	322.71
	4001 - 5000							0.22	0.22
	Total	6.44		3,859.11	976.96	2,132.63	93.71	116.00	7,184.85
Total Area	0 - 1000	826.02	80.24	6,043.51		25.57	93.71		7,069.05
	1001 - 2000			561.00	429.58	1,181.20			2,171.78
	2001 - 3000			294.60	509.15	936.88		13.37	1,754.00
	3001 - 4000				147.86	287.41		102.41	537.68
	4001 - 5000							0.22	0.22
	Total	826.02	80.24	6,899.11	1,086.59	2,431.06	93.71	116.00	11,532.73

Note: G/C = Grass/Cactus, X.F. = Xerophile Forest, M. H. F = Mountainous Humid Forest, S.F. = Shrub Forest
(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.16 **Area Ratio of Vegetation Zones in each Elevation Classification (Chira River Basin)**

(Unit: %)

R.Basin	Elevation (m)	Desert (Cu, Dc)	G/C (Ms)	X.F. (Bs)	M. H. F (Bh)	S.F. (Msh, Mh)	Water body	Gras (Pj)	Total
All	0 - 1,000	11.7	1.1	85.5		0.4	1.3		100.0
	1001 - 2000			25.8	19.8	54.4			100.0
	2001 - 3000			16.8	29.0	53.4		0.8	100.0
	3001 - 4000				27.5	53.5		19.0	100.0
	4001 - 5000							100.0	100.0

Note: G/C = Grass/Cactus, X.F. = Xerophile Forest, M. H. F = Mountainous Humid Forest, S.F. = Shrub Forest
(Source: JICA Study Team based on the study by INRENA 1995)

(b) Slope Angle and Vegetation

1) Canete, Chincha, Pisco, Yauca River Basin

The areas and area ratios of the vegetation zones are shown in ***Table 1.17*** and ***1.18***.

Table1.18 shows the followings.

The area ratio of the grass zone in the steep slope classification (more than 35%) in Canete is about 40%, but that in Chincha and Pisco River Basins are about 20%, about 10% in Yauca River basin. The most of the grass zone is distributed above 4,000m above sea level. Therefore, it can be said as the high elevation area in Canete has been dissected much. Compared to Canete River Basin, in the other 3 river basins the high elevation area is flat. Even these are linkages as above, the impact by the elevation, as same as the condition of rainfall and temperature, is much bigger than the slope angle to the vegetation distribution.

While, the area ratio of the shrub zone of the steep slope area (more than 35%) is about 60 to 80%

in the 4 river basins except Yauca River Basin. It is necessary to consider the countermeasures against erosion in these 4 river basins (see ***Table 1.19***). The relation between slope angles and vegetation in each river basin is shown in ***Appendix 7 Figure 2.1*** to ***2.4***.

Table 1.17 **Vegetation Areas in Slope Angle Classifications (Canete and the other 3 River Basins)**

(Unit: km^2)

Name of R.Basin	S.A. Class (%)	Vegetation Zone					
		Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
Canete	0 - 2	15.77	0.65	0.49	8.63	0.13	25.67
	2 - 15	130.00	12.38	41.45	477.25	8.90	669.98
	15 - 35	198.88	75.08	195.09	1,209.38	30.89	1,709.32
	35<	747.08	487.90	889.07	1,481.49	55.23	3,660.77
	Total	1,091.73	576.01	1,126.10	3,176.75	95.15	6,065.74
Chincha	0 – 2	74.50	1.49	1.80	12.83		90.62
	2 – 15	170.78	10.97	34.99	282.94		499.68
	15 - 35	210.50	97.99	150.59	560.69		1,019.77
	35<	699.81	436.30	268.20	289.51		1,693.82
	Total	1,155.59	546.75	455.58	1,145.97	0.00	3,303.89
Pisco	0 – 2	133.17	0.79	5.88	33.46		173.30
	2 – 15	411.99	22.79	58.57	455.03		948.38
	15 - 35	290.82	100.36	194.65	832.96		1,418.79
	35<	729.26	295.06	316.35	390.95		1,731.62
	Total	1,565.24	419.00	575.45	1,712.40	0.00	4,272.09
Yauca	0 – 2	32.23	11.75	24.14	10.89		79.01
	2 – 15	387.97	265.08	299.27	237.66		1,189.98
	15 - 35	376.69	359.11	451.42	405.23		1,592.45
	35<	719.26	344.18	245.61	152.08		1,461.13
	Total	1,516.15	980.12	1,020.44	805.86	0.00	4,322.57

Note 1:R. Basin = River Basin, S.A. = Slope Angle
Note 2: G/C = Grass/Cactus, S.F. = Shrub Forest, S.C.M. = Snow Capped Mountain
(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.18 **Area Ratio of Vegetation in each Slope Angle Classification (Canete, Chincha, Pisco and Yauca River Basin)**

Name of R.Basin	S.A. Class (%)	Vegetation Zone					
		Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
Canete	0 - 2	61.4	2.5	1.9	33.6	0.5	99.9
	2 - 15	19.4	1.8	6.2	71.2	1.3	99.9
	15 - 35	11.6	4.4	11.4	70.8	1.8	100.0
	35<	20.4	13.3	24.3	40.5	1.5	100.0
Chincha	0 - 2	82.2	1.6	2.0	14.2		100.0
	2 - 15	34.2	2.2	7.0	56.6		100.0
	15 - 35	20.6	9.6	14.8	55.0		100.0
	35<	41.3	25.8	15.8	17.1		100.0
Pisco	0 - 2	76.8	0.5	3.4	19.3		100.0
	2 - 15	43.4	2.4	6.2	48.0		100.0
	15 - 35	20.5	7.1	13.7	58.7		100.0
	35<	42.1	17.0	18.3	22.6		100.0
Yauca	0 - 2	40.8	14.9	30.6	13.8		100.1

Name of R.Basin	S.A. Class (%)	Vegetation Zone					
		Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
	2 - 15	32.6	22.3	25.1	20.0		100.0
	15 - 35	23.7	22.6	28.3	25.4		100.0
	35<	49.2	23.6	16.8	10.4		100.0

Note 1: R. Basin = River Basin, S.A. = Slope Angle
Note 2: G/C = Grass/Cactus, S.F. = Shrub Forest, S.C.M. = Snow Capped Mountain
(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.19 **Relation between Slope Angles and Area Ratio of Shrub (Canete River Basin and the other 3 River Basins)**

(Unit: %)

River Basin	Slope Angle Classification			
	0 - 2%	2 - 15%	15 - 35%	> 35%
Canete	0.0	3.7	17.3	79.0
Chincha	0.4	7.7	33.1	58.9
Pisco	1.0	10.2	33.8	55.0
Yauca	2.4	29.3	44.2	24.1

(Source: JICA Study Team based on the study by INRENA 1995)

2) Camana – Majes River Basin

The areas and area ratios of the vegetation zones are shown in ***Table 1.20*** and ***1.21***. The relation between slope angle and vegetation is shown in ***Appendix 7 Figure 2.5***.

The area ratio of grass in high elevation is much high (as about 85%). However, the ratio of desert is less than 1 %. It is difficult for tree vegetation to grow in the high elevation area due to low temperature. And, the shrub zone covers only 12% of its whole area in more than 35% slope angle (see ***Table 1.23***). The steep slope is vulnerable against erosion, therefore, vegetation recovery is required. However, in this river basin, vegetation recovery in the steep slope areas, where counter measures against erosion is required, is difficult and the vegetation recovery may not able to be effective.

Table 1.20 **Vegetation Areas in Slope Angle Classifications (Camana – Majes River Basin)**

(Unit: km^2)

S.A. Class (%)	Vegetation Zone					Total
	Desert (Lo,Dc)	Grass/Cactus (Ms)	Shrub (Msh, Mh)	Grass (Bf, Pj)	S.C.M (N)	
0 - 2	655.27	35.26	64.66	114.56		869.75
2 - 15	1762.87	852.64	663.9	2721.91	209.22	6210.54

15 - 35	766.94	415.25	576.51	3478.38	215.89	5452.97
> 35	27.58	266.93	184.89	3820.52	216.33	4516.25
Total	3212.66	1570.08	1489.96	10135.37	641.44	17049.51

Note: S.A. = Slope Angle, S.C.M. = Snow Capped Mountain
(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.21 **Area Ratio of Vegetation in each Slope Angle classification (Camana-Majes River Basin)**

(Unit: %)

S.A. Class (%)	Vegetation Zone					Total
	Desert (Lo,Dc)	Grass/Cactus (Ms)	Shrub (Msh, Mh)	Grass (Bf, Pj)	S.C.M (N)	
0 - 2	75.3	4.1	7.4	13.2	0.0	100.0
2 - 15	28.4	13.7	10.7	43.8	3.4	100.0
15 - 35	14.1	7.6	10.6	63.8	4.0	100.1
> 35	0.6	5.9	4.1	84.6	4.8	100.0

Note: S.A. = Slope Angle, S.C.M. = Snow Capped Mountain
(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.22 **Area and Area Ratio of Shrub (Msh, Mh) in Camana – Majes River Basin**

Slope Angle Classification				
0 - 2%	2 - 15%	15 - 35%	> 35%	Total
Area(km^2)				
64.66	663.9	576.51	184.89	1,489.96
Area ratio (%)				
4.3	44.6	38.7	12.4	100.0

(Source: JICA Study Team based on the study by INRENA 1995)

(Comparison between Camana-Majes River Basin and Canete River Basin and the other 3 river basins): the shrub zone ranges in the steep slope area (more than 35%) (area ratio is 50 to 80%) in Canete, Chincha and Pisco river Basin. While, the ratio in Camana-Majes River Basin is much lower (as about 12%).

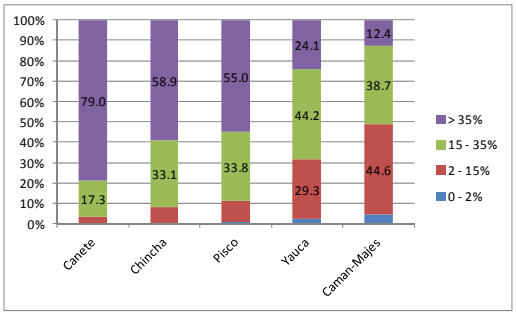


Figure 1.9 **Comparison between River Basins (Area Ratio of shrub by Slope Angel Classification)**
(Source: JICA Study Team based on the study by INRENA 1995)

3) Chira Rive Basin

It can be said in Chira River Basin that the shrub forest covers more than 50% of the slope angle classification 35%. It means the steep slope area is distributed in the area with good climate condition relatively. The distribution of the shrub forest is concentrated in the upper stream area of the Chira River Basin and the forestation/vegetation recovering plan is require in the area above. However, the ratio of the steep slope area covers about 20% only, and the gentle slope area covers

about 50% of the total river basin area. Therefore, the weakness of the whole river basin can be evaluated as low. (See ***Table 1.23*** and ***1.24***).

The relation between slope angel and vegetation distribution in Chira River Basin is shown in ***Appendix 7 Figure 2.6***.

Table 1.23 **Area of Vegetation Zone in each Slope Angle Classification (Chira River Basin)**

(Unit: km^2)

R. Basin	S.A. Class (%)	Vegetation zone							
		Desert (Cu, Dc)	G/C (Ms)	X.F. (Bs)	M.H.F (Bh)	S.F. (Msh, Mh)	W.B.	Grass (Pj)	Total
Low	0 - 2	346.37	10.48	285.96		8.47			651.28
	2 - 15	311.67	25.98	2,371.20		150.50			2,859.35
	15 - 35	125.64	15.78	261.18		63.26			465.86
	35<	35.90	28.00	121.66		76.20			261.76
	Total	819.58	80.24	3,040.00	0.00	298.43	0.00	0.00	4,238.25
Upper	0 – 2	3.15	0.00	23.22	0.25	6.78	93.71	4.51	131.62
	2 - 15	3.29	0.00	1,728.44	61.21	294.51	0.00	80.24	2,167.69
	15 - 35	0.00	0.00	1,254.65	21.54	561.36	0.00	15.24	1,852.79
	35<	0.00	0.00	852.79	98.85	1,269.98	0.00	16.01	2,237.63
	Total	6.44	0.00	3,859.10	181.85	2,132.63	93.71	116.00	6,389.73
Total	0 – 2	349.52	10.48	309.18	0.25	15.25	93.71	4.51	782.90
	2 - 15	314.96	25.98	4,099.64	61.21	445.01	0.00	80.24	5,027.04
	15 - 35	125.64	15.78	1,515.83	21.54	624.62	0.00	15.24	2,318.65
	35<	35.90	28.00	974.45	98.85	1,346.18	0.00	16.01	2,499.39
	Total	826.02	80.24	6,899.10	181.85	2,431.06	93.71	116.00	10,627.98

Note 1:R. Basin = River Basin, S.A. = Slope Angle
Note 2: G/C = Grass/Cactus, X.F = Xerophile Forest, S.F. = Shrub Forest, W.B. = Water Body
(Source: JICA Study Team based on the study by INRENA 1995)

Table 1.24 **Area Ratio of Zone in each Slope Angle Classification (Chira River Basin)**

(Unit: %)

R. Basin	S.A. Class (%)	Vegetation zone							
		Desert (Cu, Dc)	G/C (Ms)	X.F. (Bs)	M.H.F (Bh)	S.F. (Msh, Mh)	W.B.	Grass (Pj)	Total
Total Area		44.6	1.3	39.5	0.0	1.9	12.0	0.6	99.9
	2 - 15	6.3	0.5	81.6	1.2	8.9	0.0	1.6	100.1
	15 - 35	5.4	0.7	65.4	0.9	26.9	0.0	0.7	100.0
	35<	1.4	1.1	39.0	4.0	53.9	0.0	0.6	100.0

Note 1:R. Basin = River Basin, S.A. = Slope Angle
Note 2: G/C = Grass/Cactus, X.F = Xerophile Forest, S.F. = Shrub Forest, W.B. = Water Body
(Source: JICA Study Team based on the study by INRENA 1995)

(c) Isohyet and Vegetation

The isohyet map was prepared by the Meteorological Office I Peru (SERVICIO NACIONAL DE METEOROLOGIA E HIDROLOGIA DEL PERU: SENAMHI) based on the climate data during 1965 to 1974[4]. The JICA Study Team scanned the maps and took the date into the GIS system.

[4] The survey including the isohyet mapping was carried out by the Public Works Center, Ministry of Environment (CENTRO DE ESTUDIOS Y EXPERIMENTACION PUBLICA: CEDEX) and the Irrigation Plan in Peru, Ministry of Agriculture (PLAN NACIONAL DE IRRIGACIONES DEL PERU).

The GIS data was used for the analysis in this chapter.

1) Canete, Chincha, Pisco, Yauca River Basin

The area and area ratio to the annual rainfall classification are shown in ***Table 1.25*** and ***1.26***. The relation between annual rainfall and vegetation in each river basin are shown in ***Appendix 7 Figure 3.1*** to ***3.4***.

The grass and cactus zone covers the most of the area of less than 200 to 300mm of annual rainfall. The shrub zone is distributed in the area of more than 300m of annual rainfall. However, the grass zone covers the most of the area of more than 500m of annual rainfall. The arboreous plants cannot survive in the area where the annual rainfall is less than 500m, but the area with 500mm of annual rainfall is high elevation area. Therefore, that area is difficult for the arboreous plants to survive because of the low temperature.

Table 1.25 **Area of Vegetation Zones in each Annual Rainfall Classification (Canete and the other 3 River Basins)**

(Unit: km^2)

R. Basin	Annual Rainfall (mm/year)	Vegetation Zone					
		Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
Canete	0-25	703.03					703.03
	25-50	192.32	5.43				197.75
	50-100	141.04	95.63				236.67
	100-200	41.11	191.38	26.82	4.03		263.34
	200-300	11.59	119.75	151.12	35.83		318.29
	300-400	2.64	88.29	100.36	60.81		252.10
	400-500		75.53	228.06	191.12		494.71
	500-750			514.69	1,434.19	6.40	1,955.28
	750-1000			105.05	1,450.77	88.75	1,644.57
	Total	1,091.73	576.01	1,126.10	3,176.75	95.15	6,065.74
Chincha	0-25	642.76	0.16				642.92
	25-50	209.05	16.67				225.72
	50-100	148.14	53.87				202.01
	100-200	128.67	185.37	32.99	6.39		353.42
	200-300	23.53	102.54	50.95	34.02		211.04
	300-400	3.66	107.54	58.98	49.74		219.92
	400-500		73.60	112.59	109.75		295.94
	500-750		6.87	200.07	945.98		1,152.92
	750-1000						0.00
	Total	1,155.81	546.62	455.58	1,145.88	0.00	3,303.89
Pisco	0-25	828.96					828.96
	25-50	191.17					191.17
	50-100	256.73					256.73
	100-200	213.67	93.42				307.09
	200-300	77.81	217.82	66.54	14.48		376.65
	300-400		70.53	105.94	54.37		230.84
	400-500		28.09	111.95	71.28		211.32
	500-750		8.08	288.45	1,093.73		1,390.26
	750-1000				479.07		479.07
	Total	1,568.34	417.94	572.88	1,712.93	0.00	4,272.09
Yauca	0-25	865.07					865.07
	25-50	319.22	18.70				337.92
	50-100	221.45	127.88				349.33
	100-200	83.68	295.16				378.84
	200-300	26.04	195.96	24.71			246.71

R. Basin	Annual Rainfall (mm/year)	Vegetation Zone					
		Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
	300-400	0.69	200.54	113.02			314.25
	400-500		141.88	530.72	28.47		701.07
	500-750			351.99	402.17		754.16
	750-1000				375.22		375.22
	Total	1,516.15	980.12	1,020.44	805.86	0.00	4,322.57

(Source: JICA Study Team based on the isohyet Maps by SENAMIH)

Table 1.26 **Area Ratio of Vegetation Zones to each Annual Rainfall Classification (Canete and the other 3 River Basins)**

(Unit: %)

R. Basin	Annual Rainfall (mm/year)	Vegetation Zone					
		Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
Canete	0-25	100.0					100.0
	25-50	97.3	2.7				100.0
	50-100	59.6	40.4				100.0
	100-200	15.6	72.7	10.2	1.5		100.0
	200-300	3.6	37.6	47.5	11.3		100.0
	300-400	1.0	35.0	39.8	24.1		99.9
	400-500		15.3	46.1	38.6		100.0
	500-750			26.3	73.3	0.3	99.9
	750-1000			6.4	88.2	5.4	100.0
Chincha	0-25	100.0					100.0
	25-50	92.6	7.4				100.0
	50-100	73.3	26.7				100.0
	100-200	36.4	52.5	9.3	1.8		100.0
	200-300	11.1	48.6	24.1	16.1		99.9
	300-400	1.7	48.9	26.8	22.6		100.0
	400-500		24.9	38.0	37.1		100.0
	500-750		0.6	17.4	82.1		100.1
	750-1000						0.0
Pisco	0-25	100.0					100.0
	25-50	100.0					100.0
	50-100	100.0					100.0
	100-200	69.6	30.4				100.0
	200-300	20.7	57.8	17.7	3.8		100.0
	300-400		30.6	45.9	23.6		100.1
	400-500		13.3	53.0	33.7		100.0
	500-750		0.6	20.7	78.7		100.0
	750-1000				100.0		100.0
Yauca	0-25	100.0					100.0
	25-50	94.5	5.5				100.0
	50-100	63.4	36.6				100.0
	100-200	22.1	77.9				100.0
	200-300	10.6	79.4	10.0			100.0
	300-400	0.2	63.8	36.0			100.0
	400-500		20.2	75.7	4.1		100.0
	500-750			46.7	53.3		100.0
	750-1000				100.0		100.0

(Source: JICA Study Team based on the isohyet Maps by SENAMIH)

2) Camana -Majes River Basin

The area and area ratio to the annual rainfall classification are shown in ***Table 1.27*** and ***1.28***. The relation between annual rainfall and vegetation in Camana-Majes River Basin is shown in

Appendix 7 Figure 3.5.

The area with 0 to 50mm or less is covered by grass/cactus zone. The shrub zone ranges in the area with annual rainfall of 100mm or more. The area with annual rainfall of 500mm or more is covered by the grass zone. It is assumed that the high annual rainfall area is almost same as high elevation area, therefore, it is difficult for the tree vegetation to grow in this area. The distribution of the shrub zone covers wide range of annual rainfall classes (as 100 to 500mm) and it is peculiar to the vegetation in this river basin.

Table 1.27 **Area of Vegetation Zones in each Annual Rainfall Classification**

(Camana-MajesRiver Basin)

(Unit: km^2)

Annual Rainfall (mm/year)	Vegetation Zone					
	Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
0-25	2,939.30	304.13				3,243.43
25-50	126.04	494.42	4.41			624.87
50-100	37.53	408.20	287.06	91.04		823.83
100-200	44.29	168.94	289.48	244.35	15.41	762.47
200-300	65.50	104.16	127.82	456.20	115.45	869.13
300-400		86.52	218.10	301.80	139.87	746.29
400-500		3.71	499.96	1,621.01	188.86	2,313.54
500-750			63.14	5,664.20	88.80	5,816.14
750-1000				1,756.78	93.04	1,849.82
Total	3,212.66	1,570.08	1,489.97	10,135.38	641.43	17,049.52

(Source: JICA Study Team based on the isohyet Maps by SENAMIH)

Table 1.28 **Area Ratio of Vegetation Zones to each Annual Rainfall Classification**

(Camana-Majes River Basin)

(Unit: %)

Annual Rainfall (mm/year)	Vegetation Zone					
	Desert (Cu, Dc)	G/C (Ms)	S.F. (Msh, Mh)	Grass (Cp, Pj)	S.C.M (N)	Total
0-25	90.6	9.4				100.0
25-50	20.2	79.1	0.7			100.0
50-100	4.6	49.5	34.8	11.1		100.0
100-200	5.8	22.2	38.0	32.0	2.0	100.0
200-300	7.5	12.0	14.7	52.5	13.3	100.0
300-400		11.6	29.2	40.4	18.7	99.9
400-500		0.2	21.6	70.1	8.2	100.1
500-750			1.1	97.4	1.5	100.0
750-1000				95.0	5.0	100.0

(Source: JICA Study Team based on the isohyet Maps by SENAMIH)

Table 1.29 **Area and Area Ratio of Shrub Zone (Msh, Mh) to each Annual Rainfall Classification**

(Camana-Majes River Basin)

Annual Rainfall Classification (mm/year)									
0-25	25-50	50-100	100-200	200-300	300-400	400-500	500-750	750-1000	計
Area(km^2)									
-	4.41	287.06	289.48	127.82	218.10	499.96	63.14	-	1489.97
Area Ratio (%)									
-	0.3	19.3	19.4	8.6	14.6	33.6	4.2	-	100.0

(Source: JICA Study Team based on the isohyet Maps by SENAMIH)

(Comparison between Camana-Majes River Basin and Canete River Basin and the other 3 river basins): The shrub zone in Camana-Majes River Basin covers much wide annual rainfall classification compared with the one in Canete River basin and the other 3 river basins. The features of relation of annual rainfall and vegetation can be said as; 1) most of the shrub zone area (about 40% of the area) covers 50 to 300mm of annual rainfall classification, and 2) little area of shrub zone (about 20 % of the area) covers 300 to 500mm of annual rainfall classification. (Please refer to ***Figure 1.10***).

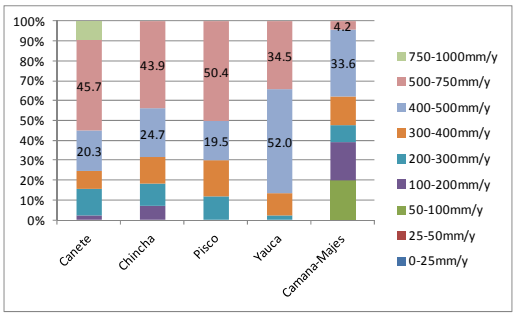


Figure 1.10 **Comparison between River Basins (Area Ratio of shrub by Annual Rainfall Classification)**

(Source: JICA Study Team based on the isohyet Maps by SENAMIH)

3) Chira River Basin

The area of the vegetable zones and their area ratio to the classification of the annual rainfall are shown in ***Table 1.30*** and ***1.31***. The relation between the isohyet and vegetation in Chira River Basin is shown in ***Appendix 7 Figure 3.6***.

The xerophile forest is the distinguishing in Chira River Basin. The forest has three types as savanna, terrace, and mountainous, therefore this forest is distributed to the most of the classifications of the annual rainfall. However, in the classification of more than 500mm of the annual rainfall is covered by the other vegetation type, the shrub forest.

Table 1.30 **Vegetation Zone Area in each Annual Rainfall Classification (Chira River Basin)**

(Unit: Km^2)

R. Basin	A.R. Class (%)	Vegetation Zone							
		Desert (Cu, Dc)	G/C (Ms)	X.F. (Bs)	M.H.F (Bh)	S.F. (Msh, Mh)	W.B.	Grass (Pj)	Total
Lower	0-25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	25-50	228.67	0.00	559.89	0.00	0.00	0.00	0.00	788.56
	50-100	179.52	9.67	657.69	0.00	0.00	0.00	0.00	846.88
	100-200	223.20	67.63	836.51	0.00	0.00	0.00	0.00	1,127.34
	200-300	115.57	2.94	432.37	0.00	0.00	0.00	0.00	550.88
	300-400	72.62	0.00	267.19	0.00	0.00	0.00	0.00	339.81
	400-500	0.00	0.00	167.89	0.00	3.69	0.00	0.00	171.58
	500-750	0.00	0.00	106.39	0.00	93.40	0.00	0.00	199.79
	750-1000	0.00	0.00	12.07	0.00	201.34	0.00	0.00	213.41
	1000-1500	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Total	819.58	80.24	3,040.00	0.00	298.43	0.00	0.00	4,238.25
Upper	0-25								0.00
	25-50								0.00
	50-100								0.00
	100-200								0.00
	200-300	6.44		855.86			73.29		935.59
	300-400			1,809.09		79.48	20.42		1,908.99
	400-500			519.13	4.22	189.91			713.26
	500-750			113.21	14.65	961.43		78.13	1,167.42
	750-1000			295.38	64.69	764.04		37.87	1,161.98
	1000-1500			266.43	98.29	137.77			502.49
	Total	6.44	0.00	3,859.10	181.85	2,132.63	93.71	116.00	6,389.73
Total	0-25								0.00
	25-50	228.67		559.89					788.56
	50-100	179.52	9.67	657.69					846.88
	100-200	223.20	67.63	836.51					1,127.34
	200-300	122.01	2.94	1,288.23			73.29		1,486.47
	300-400	72.62		2,076.28		79.48	20.42		2,248.80
	400-500			687.02	4.22	193.60			884.84
	500-750			219.60	14.65	1,054.83		78.13	1,367.21
	750-1000			307.45	64.69	965.38		37.87	1,375.39
	1000-1500			266.43	98.29	137.77			502.49
	Total	826.02	80.24	6,899.10	181.85	2,431.06	93.71	116.00	10,627.98

Note 1:R. Basin = River Basin, A.R. = Annual Rainfall
Note 2: G/C = Grass/Cactus, X.F = Xerophile Forest, S.F. = Shrub Forest, W.B. = Water Body
(Source: JICA Study Tem based on the isohyet Maps prepared by SENAMIH)

Table 1.31 **Area Ratio of Vegetation Zone to the Classification of Annual Rainfall (Chira River Basin)**

(Unit: %)

R. Basin	S.A. Class (%)	Vegetation Zone							
		Desert (Cu, Dc)	G/C (Ms)	X.F. (Bs)	M.H.F (Bh)	S.F. (Msh, Mh)	W.B.	Grass (Pj)	Total
Lower	0-25	0.0							0.0
	25-50	29.0		71.0					100.0
	50-100	21.2	1.1	77.7					100.0
	100-200	19.8	6.0	74.2					100.0
	200-300	21.0	0.5	78.5					100.0
	300-400	21.4		78.6					100.0
	400-500			97.8		2.2			100.0
	500-750			53.3		46.7			100.0
	750-1000			5.7		94.3			100.0
	1000-1500					0.0			0.0
Upper	0-25								0.0
	25-50								0.0
	50-100								0.0
	100-200								0.0
	200-300	0.7		91.5			7.8		100.0
	300-400			94.8		4.2	1.1		100.1
	400-500			72.8	0.6	26.6			100.0
	500-750			9.7	1.3	82.4		6.7	100.1
	750-1000			25.4	5.6	65.8		3.3	100.1
	1000-1500			53.0	19.6	27.4			100.0
Total	0-25								0.0
	25-50	29.0		71.0					100.0
	50-100	21.2	1.1	77.7					100.0
	100-200	19.8	6.0	74.2					100.0
	200-300	8.2	0.2	86.7			4.9		100.0
	300-400	3.2		92.3		3.5	0.9		99.9
	400-500			77.6	0.5	21.9			100.0
	500-750			16.1	1.1	77.2		5.7	100.1
	750-1000			22.4	4.7	70.2		2.8	100.1
	1000-1500			53.0	19.6	27.4			100.0

Note 1:R. Basin = River Basin, A.R. = Annual Rainfall
Note 2: G/C = Grass/Cactus, X.F = Xerophile Forest, S.F. = Shrub Forest, W.B. = Water Body
(Source: JICA Study Tem based on the isohyet Maps prepared by SENAMIH)

1.2 Transition of the Forest Area

(a) District Wise Transition

The transition of the forest area has not been studied in detail in Peru. The Annex 2 of the National Forestation Plan in Peru 2005 – 2024 (Plan Nacional de Reforestacion Peru 2005 – 2024) shows the decreased forest areas of each District until 2005. ***Table 1.32*** shows the cumulated decreased forest area in the related Districts which cover the study areas. The relevant Districts to the Study areas are Arequipa, Ayacucho, Huancavelica, Ica, Lima, and Piura. The each study area is a part of the District. The forest area has been decreased about 0.1 milion ha in Ayacucho, about 10,000 ha in Huancavelica and Piura District.

Table 1.32 **Decreased Forest Area until 2005**

District	District Area (ha)	Cumulated decreased forest area (ha), the ratio of the cumulated forest area to the District area (%)	Land-use after logging	
			Non-used area(ha)	Used areas for any (ha)
Arequipa	6,286,456	-	-	-
Ayacucho	4,326,169	97,992 (2.3%)	73,554	24,438
Huancavelica	2,190,402	11,112 (0.5%)	11,112	-
Ica	2,093,457	-	-	-
Lima	3,487,311	-	-	-
Piura	3,580,750	9,958 (0.3%)	5,223	4,735

(Source: Abstract from Anexo 2 of the National Forestation Plan in Peru 2005 – 2024 (Plan Nacional de Reforestacion Peru 2005 – 2024)

(b) River Basin Wise Transition

1) Canete, Chincha, Pisco, Yauca River Basin

JICA Study Team transported the data of the vegetation zones which was studied by FAO in 2005 (the source of the data was the satellite images in 2000) and the one by INRENA in 1995 (the source of the data was the satellite images in 1995) into the GIS system. The transition of each vegetation zone between 1995 to 2000 was measured on the GIS map (please refer to ***Table 1.33***).

Table 1.33 shows that the dry areas (desert area, cactus area: Cu, DC, and MS) were decreased, the shrub forests (Msh, Mh) and snow capped mountain (N) were increased.

Table 1.33 **Transition of Vegetation Zones between 1995 to 2000 (Canete River Basin and the other 3 River basins)**

R. Basin	Vegetation Zone								
	Cu	Dc	Ms	Msh	Mh	Cp	Pj	N	R. Basin Area
(Vegetation zone area: km^2)									
Pisco	-3.59	-3.44	-50.99	46.88	7.01	-9.52	13.65	ー	4,272.09
Chincha	-5.09	-19.37	-95.91	86.85	3.55	-5.54	35.51	ー	3,303.89
Canete	-13.46	-28.34	-50.22	7.24	23.70	34.89	-2.18	28.37	6,065.74
Yauca	-20.22	33.63	-10.87	34.13	21.15	-42.62	-15.20	ー	4,322.57
Subtotal (a)	-42.36	-17.52	-207.99	175.10	55.41	-22.79	31.78	28.37	17,964.29

(b)	518.69	4,870.12	2,729.74	2,502.17	444.89	2,143.36	4,688.54	66.78	17,964.29
(a/b) (%)	-8.2	-0.4	-7.6	+7.0	+12.5	-1.1	+0.7	+42.5	

Note 1: (b) = Area of Vegetation zone in 2000
Note 2: (a/b) = Area Ratio of the decreased area to the whole area in 2000
(Source: JICA Study Team based on the results of INRENA study 1995 and FAO study 2005)

2) Camana-Majes River Basin

Same as above, vegetation transition between 1995 and 2000 was measured (please refer to ***Table 1.34***).

The shrub zone (Msh) was decreased about 30km^2 (as of 2.3%), (Mh) about 5km^2 (3.2%). The decreasing of the areas of grass land in high elevation (Pj) and the snow covered mountain (N) is particular, Pj was decreased as 364 km^2 (3.6%) and N was decreased as 60 km2 (9.4%), while, wet grass land (Bf) was increased about 12 km^2 (18.2%). The mostly increased zone is the desert (DC), it was increased ahout 404 km^2 (13.0%).

Table 1.34 **Transition of Vegetation Zone between 1995 to 2000 (Camana-Majes River Baisin)**

Area	Vegetation Zone							
	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
Transition (b-a) (km2) (c)	27.01	404.12	16.40	-30.22	-4.95	12.02	-364.19	-60.19
Ratio of transition (%) (c/a)	25.8	13.0	1.0	-2.3	-3.2	18.2	-3.6	-9.4

Note 1: (b) = Area of Vegetation zone in 2000
Note 2: (a/b) = Area Ratio of the decreased area to the whole area in 2000
(Source: JICA Study Team based on the results of INRENA study 1995 and FAO study 2005)

1.3 Forestation Condition

1) Canete, Chincha, Pisco, Yauca River Basin

As described above, the conditions of the river basins; Canete, Chincha, Pisco and Yauca are not suitable for the tree vegetation to grow up. Therefore, the natural tree vegetation can be found very few. Exceptionally, the trees of big size can be found along the rivers where the ground water level is higher than the other areas.

Because of less of the suitable areas for the tree vegetation in the study areas, a large scale of the forestation/reforestation have not been implemented. No information of any commercial purposed forestation could be found at least.

There are three types of forestation/plantation as follows in the area from the downstream to the middle stream of the river basin in the study areas, i) forestation along the rivers to prevent disaster, ii) forestation surrounding the farmlands to protect them from wind and sand, iii) forestation surrounding the houses. These forestation are very small scaled. Eucalyptus is the most common for these forestation followed by Casuarina and the native species are not used as a major species

for these forestation types.

While, the implementation of the forestation in the Andes highland is popular. The purposes of the forestation are, i) to supply the fuel wood, ii) to protect the farmlands from the damage of the crops by the cold weather or animals, and iii) to conserve the water source forest. The most of the planted tree species are Eucalyptus and Pine. The forestation is usually implemented by the program by the AGRORURAL (as previous PRONAMACHCS). There are also forestation by the Regional Governments, but the forestation area by the Regional Government is less than the one by the AGRORURAL. The forestation system that the GRORURAL supplies the seedlings to the farmers and the farmers plant/maintain them is common for the forestation by the AGRORURAL Programs. It is necessary to develop the agreement between AGRORURAL and the farmers for the selection of the forestation areas for this system. However, most of the farmers would like to increase the area of the farmlands and it takes long time to meet the agreement of the forestation. Therefore, the forestation implementation takes long time too and not easy for the implementation. Additionally, the existing data/documents of the AGRORURAL has been scattered and lost during the institutional reforming, and almost no records has been collected about the achievements of the forestation.

The forestation achievements from 1994 to 2003 in each Region (as the previous Department) are shown in the national forestation plan (INRENA, 2005). ***Table 1.35*** shows the achievement of the forestation in the Regions related to the study area. The data was abstracted from the national forestation plan. In accordance with ***Table 1.35***, the forestation area in 1994 was large, but it has been decreased steeply after 1995. The forestation areas in Arequipa, Ica, and Lima are only little. The reason of above is supposed that the available area is less and demand is low in Arequipa, Ica and Lima Regions because of very small amount of the rainfall. Meanwhile, in Ayacucho, Huancavelica Regions, the demands of protection of the farmlands/pastoral lands and fuel woods are high, also the rainfall amount there is much. However, the suitable areas for the forestation is limited because of the climate condition (low temperature), and it is not easy to make agreement with farmers, who would like to put priority on expanding farmlands, to implement forestation. Therefore, the forestation are is not large in Ayacucho, Huancavelica Regions.

Table 1.35 **Forestation Achievements 1994 to 2003 (Region wise)**

(Unit: ha)

Region	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	Total
Arequipa	3,758	435	528	1,018	560	632	nr	37	282	158	7,408
Ayacucho	14,294	9,850	3,997	8,201	2,177	6,371	4,706	268	2,563	220	52,647
Huancavelica	12,320	1,210	2,587	2,061	294	7,962	6,001	545	1,035	0	34,015
Ica	2,213	20	159	159	89	29	61	15	4	1	2,750
Lima	6,692	490	643	1,724	717	1,157	nr	232	557	169	12,381
Piura	7,449	971	2,407	3,144	19,070	2,358	270	1,134	789	48	37,640

Note: Department means the Region currently.
(Source: The National Forestation Plan 2005, INRENA)

2) Camana – Majes River Basin

In accordance with hearing from Agrorural, the forestation in Arequipa District is shown in ***Table 1.36***. The forestation was carried out in 4 places, but those areas were small and most of them were trial. And, the international NGO, Nature Conservacy, is taking activities of recovry of Malos vegetation which is indiginious vegetation in the seashore areas in Peru.

Table 1.36 **Forestation Achievements in District Arequipa**

Year	Place	Implementation Agency	Species	Area (ha)	Remarks
1992	Arequipa	Univ. Nac. San Agustín	Native species	2	Forest survey and trial forestation
2004	Usuña, Bellavista Dsitrito de Polobaya, Prov. Arequipa	AGRORURAL	Eucalyptus, Pinus, Cypress	3	
2005	Arequipa	graduation thesis	Molle	0.5	

(Source: JICA Study Team based on hearing from Agrorural)

1.4 Superordinate Plan

(1) The National Forestation Plan

(a) Circumstances Enactment of the National Forestation Plan

- The law of Forestry and wildlife (Ley Forestal y de Fauna Silvestre, No. 27308, July 15th 2000) was established. The Article 4 of it shows the national forest development plan. The national forestation plan was included in the article.
- The President Decree[5] (Decreto Supremo); No. 031-2004-AG was established on August 17th 2004. The national forest strategy (Estrategia Nacional Forestal – ENF- 2002-2021) was included in it.
- The President Decree, No. 003-2005-AG was established on January 13th 2005. The decree means that the national forestation plan should be prepared by the INRENA mainly with supports of PRONAMACHCS.
- The National Forestation Plan (Plan Nacional de Reforestacion) was established on January 4th 2006 as the decree of ministry of agriculture (Ministry Decree[6]: resolucion Suprema) (No. 002-2006-AG).

(b) Concept and Vision of the National Forestation Plan

(Concept): The targets of this plan are i) development of productivity, ii) restoring the ecosystems, and iii) improvement of environment. The local developments, which are for the continuous development on the economic/social/environment, are implemented in the higher prior areas of forestation.

(Vision): The harmonized livelihood improvement keeping the competitive power in the world-wide markets of the wood product

(c) Relation between the program of the national forestation plan and The Project

The national forestation plan rises the following three (3) major points as the program.

1. Forestation of the productive forests

[5] President Decree (Decreto Supremo): it is enacted by the President, the Prime Minister and the Minister
[6] Ministry Decree (Resolucion Suprema): It is enacted by the President and the Minister

2. Nature protection and watershed management
3. Management of the strategy for market competition

The second program, Nature protection and watershed management) is close to The Project. The contents of the program are shown in ***Table 1.37***.

Table 1.37 **Program of Nature Protection and Watershed Management (National Forestation Plan)**

Mission	Restoration of ecosystem, increasing of green area in the whole country, forestation on the damaged areas (for production), increasing carbon absorption	
Effects	Carbon absorption by increasing biomass Water conservation by soil improvement Reduction of soil erosion by development of roots system and vegetation cover Livelihood improvement of local people	
Major activities	1. Establishment of watershed management committee	
	2. Conservation of soil and water resource	: capture of surface runoff water by ditch/channel and forestation surrounding them
	3. Restoration of damaged forests	: Rehabilitation of damaged forests and forestation on the poor vegetation areas
	4. Improvement and management of native pasture grasses	: Improvement of native pasture grasses and forestation for the vegetation rehabilitation in water source
	5. Plantation in the urban areas	: Improvement of landscape, conservation of ground water
	6. Identification of vulnerable area	: Identification of vulnerable areas for vegetation recover, ecosystem conservation, slope stabilization, stream bed conservation, etc.
	7. Forestation for purification ofwater	
	8. Prevention of desrtifaication	: Forestation on the desertification area
	9. Establishment of fund system	: Establishment of PES system and carbon credit

(Source: JICA Study Team abstract/summarize the National Forestation Plan 2005)

The National Forestation Plan expects some effects by forestation. Tow of them as, i) Water conservation by soil improvement, and ii) Reduction of soil erosion by development of roots system and vegetation cover, would contribute directly and indirectly to prevention of the flood disaster which is the main target of the Project. The water conservation i) decreases the amount of the direct runoff and ii) increases the amount of the intermediate runoff. These functions contribute to the mitigation of thhe flood disaster indirectly. The prevention of the soil erosion contributes to the prevention of the sediment runoff. Therefore, the forestation/vegetation recover meet to the superordinate plan, can be evaluated as appropriate.

(2) The Other Projects Related to the Forestation

There are two projects related to the Project including forestation, i) Catamayo – Chira project, ii) forestation project by the AGRORURAL in Huancavelica Region.

(a) Catamayo – Chira Project

The Catamayo – Chira project is implementing the management of the water resources of the Catamayo – Chira River which flows both countries of Peru and Ecuador. This project started by the assistance of Spain[7].

[7] http://www.infoandina.org/sites/default/files/recursos/caract_biofisica.pdf
http://www.paramo.org/files/recursos/caract_biofisica.pdf

1) Background of the Project

[1971]: The "Peru Ecuador mix commission" was established targeting the social and economical maximum use of the Catamayo Chira River Basin.

[2002 to 2007]: Peru Ecuador two countries plan set three prior program as i) watershed development, ii) watershed management, and iii) watershed classification (please see ***Figure 1.1***).

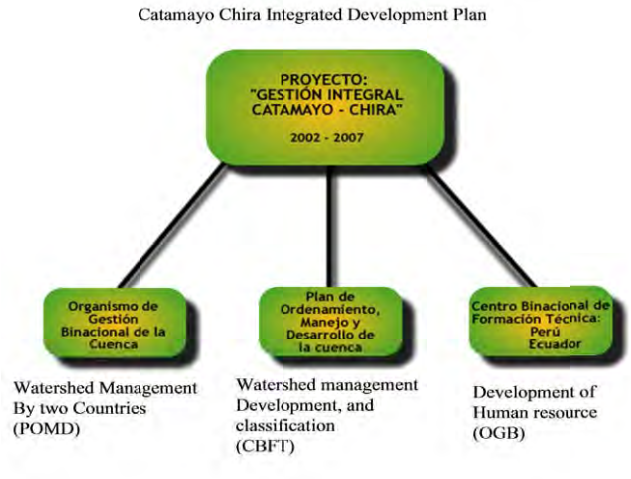


Figure 1.11 **Outline of Catamayo Chira Project**

(Source: Piura Regional Govenment HP)

[2009 to 2011]

Plan of Watershed management, development and classification (POMD) is implementing. The targets of the plan are to contribute to i) protection and sustainable use of the natural resources thorough the integrated watershed management, ii) improvement of the livelihood of the local people. The official counterparts are " Peru Ecuador two countries plan".

The implementing counterparts are Piura Regional Government (Peru side) and Roja local congress (Ecuador side).

2) Project Location

Ecuador Site: Celica, Pindal, Macará, Sozoranga, Calvas, Espíndola, Gonzanamá, Quilanga, Loja, Catamayo, Paltas, Olmedo, Puyango and Zapotillo in Roja Region. 66.82 % of whole Roja Region area is covered by the project.

Peru side: Sullana, Ayabaca, Huancabamba, Morropón, Paita, Talara and Piura in Piura Region. 27.91 % of the whole Piura Region is covered by the project.

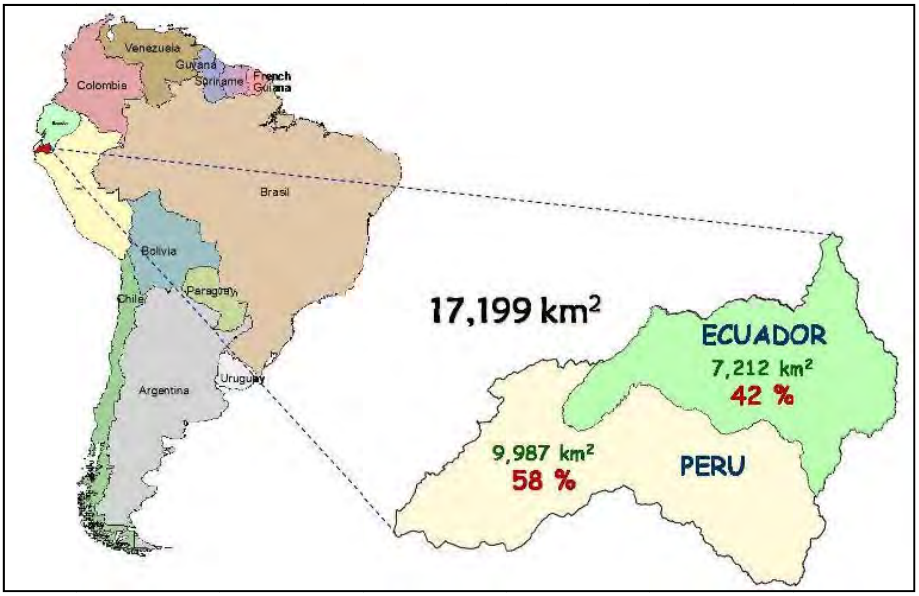


Figure 1.12 **Project Location**

(Source: **P**iura Regional Government HP)

3) Important Area

The areas more than 1,200m above sea level are evaluated as important for the watershed management (please refer to ***Figure 1.13*****)**.

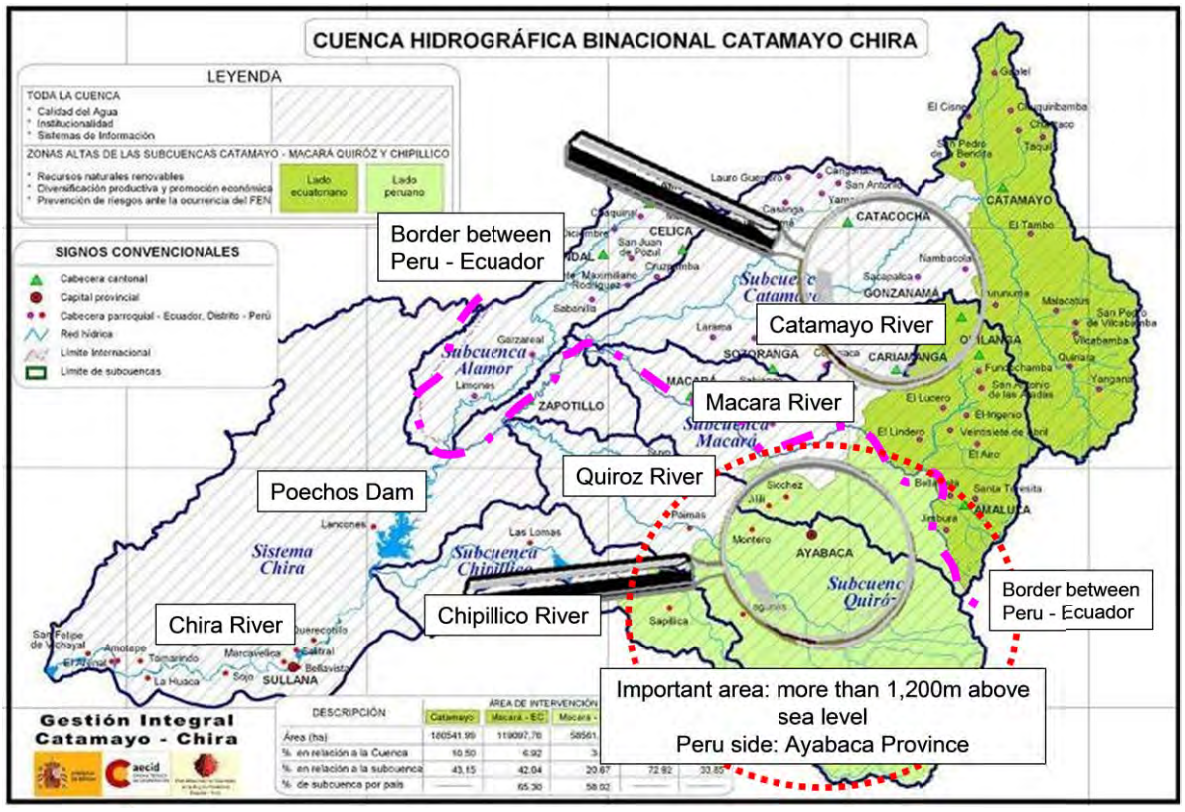


Figure 1.13 **Catamayo – Chira Project Detailed Location**

(Source: JICA Study Team based on the HP of Piura Regional Government)

4) Contents of the Project

The Catamayo – Chira project is classified into A to F as major items. The major items are classified into some programs. Each program has some projects, totally 28 projects are planed. The outline of Catamayo – Chira project is shown in ***Table 1.38***. Following two projects are related directly to the plan of forestation/vegetation cover which is one of the prevention/mitigation measures of the flood disaster in the Project; i) B.2.1 protection/conservation and rehabilitation of the vegetation and soil resource and ii) B.2.2. Management of the risk caused by water. The indirectly related project to the Project are; i) A.1.7 Payment for water environment service (PES), and ii) C.3.3. Forestry production development.

Table 1.38 **Outline of Catamayo – Chira Project**

Program: Purposes	Project: Purposes
A: Integrate water resource management	
A1: Integrate water resource management (Purpose): Sustainable and fair water use	A.1.1 Drinking water system management (Purpose): management of sustainable drinking water supply system
	A.1.2 Sewage water management (Purpose): Sewage water treatment for the water quality improvement, reducing contamination
	A.1.3 Waste treatment (Purpose): Reducing contamination of air/soil/water by the waste treatment
	A.1.4 System management (Purpose): Management of efficient and effective irrigation system
	A.1.5 Management of water monitoring network (Purpose): Development of reliable water monitoring information
	A.1.6 Water quality management (Purpose): Development of information of surface water
	A.1.7 Payment for environment service (PES) related water environment (Purpose): Conservation of the area where the payment for water environment service will be provided.
B: Natural resource management	
B2: Management of renewable natural resources (Purpose): Rehabilitation of damaged vegetation and soil resource	B.2.1 Protection/conservation and rehabilitation of the vegetation and soil resource (Purpose): Appropriate management of vegetation and soil resource
	B.2.2 Management of the risk caused by water (Purpose): Reduce negative impacts on roads
C: Activities for social economy and production	
C.3: Agriculture and forestry development (Purpose): - Improvement of social economic capacity, Contribution to society by nature friendly agriculture production (including gender), improvement of food self-sufficiency, livelihood improvement, and conservation of natural resources - Improvement of socio economic power of villages (including gender) - Integrate improvement of productivity and strategy/system for acceleration of commercialization	C.3.1 Agricutural development by irrigation or rai water (Purpose): Development of environmentally friendly agricultural production
	C.3.2 livestock development (Purpose): Development of the environmentally friendly and fair production process of livestock
	C.3.3 Forestry production development (Purpose): Sustainable use of the forest resources
	C.3.4 Food sovereignity (Purpose): Securement of necessary amount of food for the farmers
	C.3.5 Fruit production (Purpose): Development of environmentally friendly and fair production process of fruits
	C.3.6 Diversification of production (Purpose): Accomplishment of subsidiary income by production and commercialization of hopeful products
C.4. Sustainable development of tourism	C.4.1 Production and commercialization of folk art objects (Purpose): Enhancement of corroboration of production of folk art objects and tourism

	C.4.2 Eco-tourism (Purpose): Accomplishment of subsidiary income of farmers
C.5 Assistance of production and commercialization process	C.5.1 Connection of the financial systems of farm villages (Purpose): Easy credit loan for the production initiatives of the farm villages
	C.5.2 Service for production and commercialization (Purpose): Improvement of the conditions of production and commercialization at village level
	C.5.3 Corroboration of innovation and study of production techniques (Purpose): Improvement of the conditions of production and commercialization at village level
D: Institution	
D6: Enhancement of institution (Purpose): Realization of governance for the implementation of watershed plan	D.6.1 Enhancement of relation between local government and central government (Purpose): Institutional organization of "Plan of management, development and classification of Catamayo - Chira"
	D.6.2 Socialization (Purpose): Improvement of social momentum for implementation of "Plan of management, development and classification of Catamayo - Chira"
	D.6.3 Enhancement of social production institution
D7:	D.7.1 Development of gender focus institution (Purpose): Watershed management with consideration of Gender
	D.7.2 Institutionalization of women (Purpose): Institutionalization of women of both countries
E: Human resource development	
E8: Human resource development (Purpose): Development of sustainable environmental strategic vision for integrate watershed management	E.8.1 Environmental education (Purpose): Human resource development for environmental theme
	E.8.2 Operation and leadership (Purpose): Development of sustainable environmental strategic vision for integrate watershed management
	E.8.3 Training of techniques of production management (Purpose): Contribution to human resource development for technology and production
	E.8.4 Environmentally considered sustainable development (Purpose): Improvement of environment management for sustainable development, and improve environment at the same time
F: Information System	
F9: Securement of disclosure and usage of information system (Purpose): Availability of appropriate decision by the access /disclosure of information	F.9.1 Information system ad communication (Purpose): Implementation of "information and communication" considering Gender

(Source: Catamayo – Chira project office)

5) Projects of Catamayo – Chira project related to the Project directly

The projects of the Catamayo – Chira project related to the Project are, B.2.1 and B.2.2. The outline of the projects are shown below.

Table 1.39 **Outline of Project B.2.1**

B.2.1 Protection/conservation and rehabilitation of the vegetation and soil resource		
Purpose	Appropriate management of vegetation and soil resource	
Componets, period		
1	Propose of natural protected area system to protect forests and vegetation	5 year
2	Setting up and management of the water resource areas where PES is necessary to be applied	15 years
3	Setting up and management of the protected or conserved areas of biodiversity	10 years
4	Rehabilitation of the damaged areas	15 year
Project cost (plan) (Unit: Sol)		

Seedling production	2587,200
Plantation	4000,000
Soil banking	500,000
Watering	1500,000
Fertilizer	5,000,000
Condition check of planted trees	5,000
Total	9092,200
Beneficiaries (Unit: Families)	
Catamayo: 400, Macara: 400, Alamor: 200, Quiroz: 250, Chipillico: 250, Chira: 500	Total: 2,300

(Source: JICA Study Team based on the documents of Catamayo - Chira Project Office)

Table 1.40 **Outline of Project B.2.2**

B.2.2 Management of the risk caused by water	
Purpose	Reduce negative impacts on roads
Period	15 年
Components	
1	Enhancement of corroboration: between both countries, in whole country, between local areas
2	Protection and control of infrastructures: Risk management of water disaster on the roads
3	Forecasting and warning system: Development of monitoring and forecasting system at stations. Information distribution for the reactions before/during/after the disasters
4	Community participation Community participation for livelihood improvement, soil erosion control Control of immigration
Project Cost (plan) (Unit: US$)	
Component 1	29,800,000
2	29,800,000
3	530,000
4	855,000
Subtotal	32,310,000
Administration fee (20%)	6,462,000
Monitoring fee (5%)	1,615,500
Total	40,387,500
Beneficiaries (Unit: Families)	
Number of people with high risk of damage by flood: 248,322 (Peru side: 218,322, Ecuador side: 30,000) Number of people with high risk of damage by drought (Peru side: 77,000, Ecuador side: 911,000)	

(Source: JICA Study Team based on the documents of Catamayo - Chira Project Office)

(b) Forestation plan by AGRORURAL in San Juan Chincha River Basin

AGRORURAL planed forestation in San Juan Chincha River Basin (Chincha River Basin), but it was not implemented because of budget problem8. The outline of the plan is described below.

1) Location of the forestation project by AGRORURAL

The project areas of San Juan Chincha forestation project are shown below. The project areas are located in two (2) Provinces and ten (10) Districts in Huanacavelica Region.

Project Area		
Province	No.	District
Casrovirreyna	1	San Juan de Castrovirreyna
	2	Tantara、
	3	Huamantambo
	4	Chupamarcas
	5	Aurahua
	6	Capilla

[8] Source: Hearing and documents (Perfil report, Progress report: Chicha, San Juan River Basin Forestation Plan) at AGRORURAL

	7	Villa de Arma
	8	Villa de Arma
Chincha	9	San Pedro de Huarpana
	10	San Juan de Yamac

2) Purpose of the project

The purpose of the project is enhancement of sustainable development of communities by the benefit exchange between the downstream area, middle area, and upper stream area of San Juan River Basin (= Chincha River Basin).

3) Contents of Study (Deskwork-1, Fieldwork, Laboratory tests, and Deskwork-2)

The contents of the study are as follows.

- Deskwork-1: information collection, research of the requirements for the project
- Fieldwork: stakeholder meetings (explanation of the project) at 10 Districts, selection and location confirmation of the planed forestation area (the areas were decided with communities at field, and the locations were confirmed by GPS), agreement documents preparation for the project
- Laboratory test: Soil test (sampling)
- Deskwork-2: Establishment of GIS system, preparation of the project plan

4) Project Plan

The project is composed with four components as follows.

(i) Forestation and vegetation recover: 44,789.27ha of forestation totally
(ii) Management of grassland: management plan of 39,718.52ha of the grassland
(iii) Enhancement of i) self-management capacity of the producers and ii) institutional capacity of the producers
(iv) Capacity development of forest management and plantation management

5) Planted species

The planted species were decided through the discussion with communities. The planted species are different by the forestation areas. The planed species were Pine, Eucalyptus, and following native species; Aliso, Quinual, Colle, Tara, and Abogado.

6) Project cost

In ccordance with the documents prepared by AGRORURAL, total cost of the project is huge quantity as about 270million Sol (about 6.14Billion Japanse Yen). The breakdown of the project cost is shown in ***Table 1.41***.

Table 1.41 **Breakdown of Project Cost of Forestation Project in San Juan Chincha River Basin (AGRORURAL study)[9]**

Contents	Unit	Amount	Unit Price	Cost
Total				(270,248,245)
Preparation of technical specification	Set	1	250,000	(250,000)
Component 1: Forestation/reforestation				(217,860,599)
1.1 Preparation of nurseries				(1,174,057)
1.1.1. Nurseries establishment	Set	10	102,343.94	1,023,439.40
1.1.2. Tools	Set	10	15,061.83	150,618.30
1.2 Seedling production				(21,683,339)
1.2.1. Seedling production (Pine)	Piece	44,249,583	0.45	19,912,312.35
1.2.2. Seedling production (Eucalyptus)	Piece	218,713	0.45	98,420.85
1.2.3. Seedling production (Aliso)	Piece	59,956	0.48	28,778.88
1.2.4. Seedling production (Quinual)	Piece	1,317,940	0.48	632,611.20
1.2.5. Seedling production (Colle)	Piece	1,318,593	0.48	632,924.64
1.2.6. Seedling production (Tara)	Piece	706,734	0.47	332,164.98
1.2.7. Seedling production (Abogado)	Piece	14,597	3.16	46,126.52
1.3 Reforestation by exotic/native species				(184,515,796)
1.3.1. Planting of seedlings				
1.3.1.1. Planting	Ha	41,559.28	3,974.25	165,166,968.54
1.3.1.2. Agro-forestry forestation	Ha	699.85	2,068.50	1,447,639.73
1.3.1.3. Pastoral forestry	Ha	2,519.14	2,068.50	5,210,841.09
1.3.2. Tools for planting	Set	11	88,515.00	973,665.00
1.3.3. Protection of the planted trees	Ha	44,778.27	261.66	11,716,682.13
1.4 Creation of forestation area	Ha	44,789.27	234.15	(10,487,407)
Component 2: Earthwork for soil conservation				(52,017,646)
2.1 Penetration works (heavy equipments)	Ha	18,444.86	277	5,109,226.22
2.2 Penetration works (man power)	Ha	21,273.66	2,205	46,908,420.30
Component 3: enhancement of capacity of management and institution of the producers				(120,000)
3.1 Training of promoters	Set	20	2,000.00	40,000.00
3.2 Establishment of management committee	Set	20	2,000.00	40,000.00
3.3 Administration and management fee	Set	20	2,000.00	40,000.00

(Source: Perfil, Progress report prepared by AGRORURAL)

7) Location of forestation areas

The locations of the forestation areas are sown in ***Figure 1.14***.

[9] The costs are re-calculated by JICA Study Team based on the amount and Unit price of the data source.

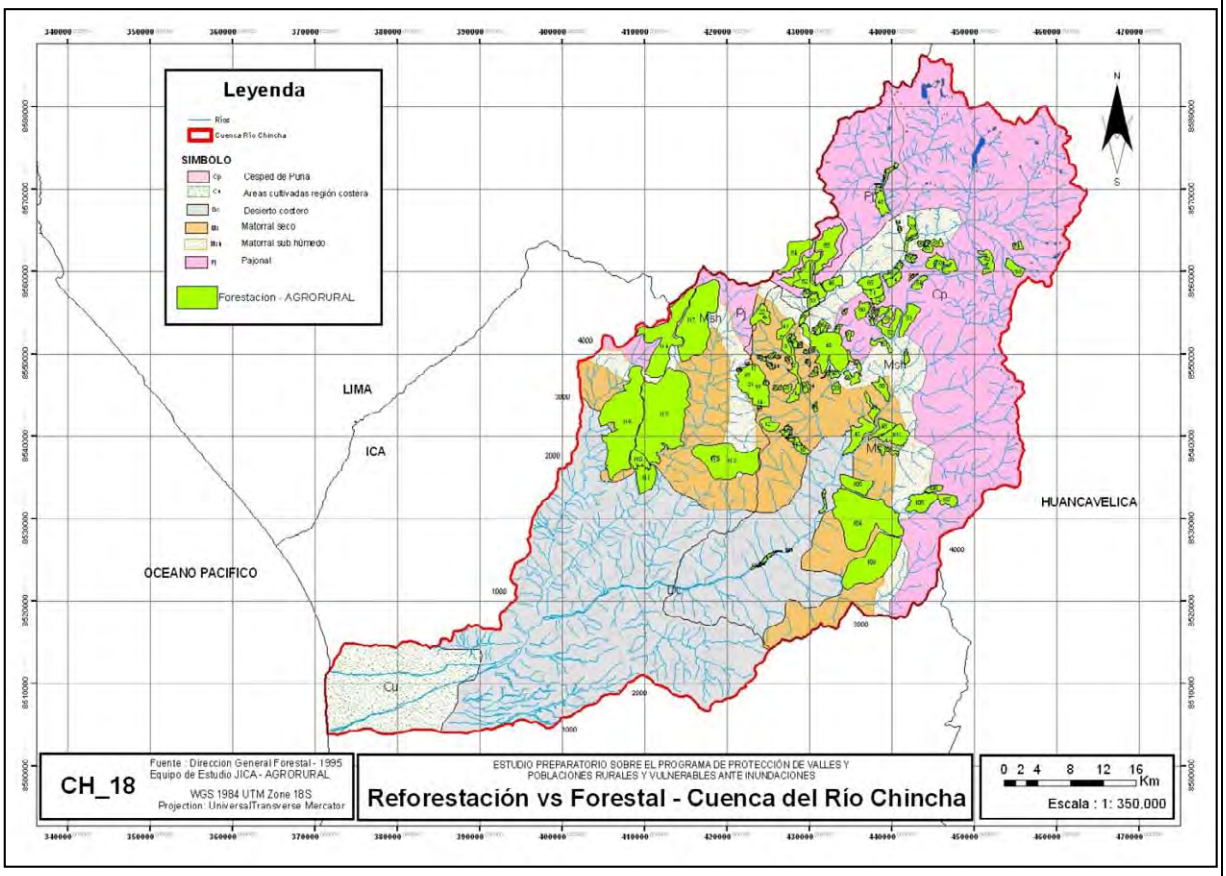


Figure 1.14 **Location of Forestation Areas in Chincha Riber Basin (AGRORURAL study)**

(Source: JICA Study Team based on the documents/data of AGRORURAL)

CHAPTER 2 EXPECTED FUNCTIONS AND ISSUES OF AFFORESTATION/VEGETATION RECOVERY

The main purpose of the Project is prevention of the disasters caused by the rivers. The functions of the forests against to the disasters caused by the rivers are described below. The issues of the implementation of the forestation by the Project are described after description of functions.

In Peru, the effects of the forest are described as ***Table 2.1***. The effects are classified into direct and indirect, and the indirect effects are classified into i) effects introduced by the environmental functions of the forest and ii) effects introduced by the social functions of the forest. The direct effects of the forest are introduced by the functions of the productive forest. The environmental functions described in the Table are same as the public functions described generally in Japan. The effects by the social economic function are the results by the environmental functions' works.

Table 2.1 **Effects of Forest (in Peru)**

Category I	Category II	Effects	Remakrks
Direct Effects	Direct Effects	1. Produce of log	Log, fire wood, paper
		2. Produce of the other than to log	Resin, tannin, oil, fruit, charcoal, craft, etc.
		3. Produce of hunting/fishing	
Indirect Effects	Effects by the environmental function of forest	1. Keeping back of slope failure & sediment runoff	
		2. Low temperature protection	
		3. protection of Wildlife	Evacuate place for wildlife
		4. Increasing groundwater	
		5. Storm protection	Protection of farmlands & houses
		6. Soil erosion protection, keeping water in soil layer	
		7. Water treatment	
		8. Water cycle treatment	
		9. Prevention of global warning & desertification	Carbon absorption
		10. Disaster prevention	
	Effects by the socio-economic functions of forest	1. Protection & increasing of agricultural production	
		2. Protection of road infrastructure	
		3. livelihood improvement by tourism	

(Source: JICA Study Team based on sevelal sources in Peru[1])

Especially, "1. Keeping back of slope failure & sediment runoff", "4. Increasing groundwater", and "6. Soil erosion protection, keeping water in soil layer" in ***Table 2.1*** can be evaluated as effective

[1] -Ecología - Medio ambiente (http://www.vidaecologica.info/)
Daniel Rivas, beneficio del bosque (http://www.rivasdaniel.com/BENEFICIOS_DE_LOS_BOSQUES.pdf)
Comaco Forestal (http://www.comacoforestal.com/esp/beneficios_del_bosque/)
Certiciación PEFC (http://www.pefcgalicia.org/?q=es)
En buenas manos (http://www.enbuenasmanos.com/articulos/muestra.asp?art=2270)
Forest Seminar by a committee (participants: Peru forest engineering association, general department of forest & wildlife (Ministry of Agriculture), Forestry faculty of La Molina National Agrarian University, Forest police, etc.)

much to prevention/mitigation of the disasters caused by the rivers.

2.1 Functions of Prevention/Mitigation of Slope Failure & Soil Runoff

Generally, raindrops causes soil erosion on the slope. Next, a gully erosion gets large, and a slope failure is caused finally. The soil runoff generated by the slope failure goes down the slope, into the stream. The soil runoff in the stream erodes the river bank and river bed. As the results, a lot of mixed soil (original + eroded one) goes down. Finally, the runoff attacks the protection area.

The forest has a function to prevent or mitigate the slope failure as shown in ***Figure 2.1***. During the soil runoff goes on the slope or the stream, the forest works to keep the slope of the river bank as shown in ***Figure 2.2***. Those forest functions are evaluated as the effects of disaster prevention/mitigation.

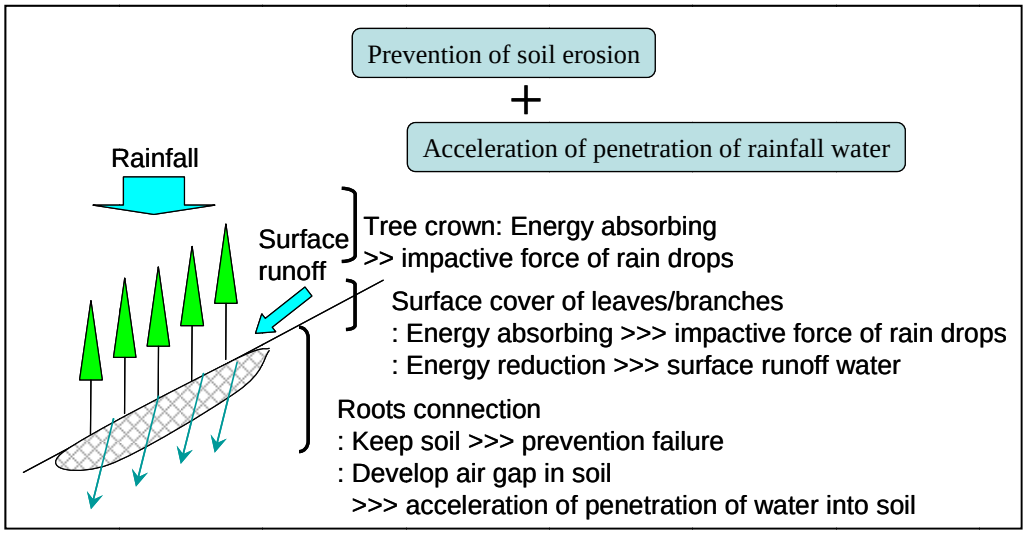


Figure 2.1 **Forest Functions for Prevention of Slope Failure**
(Source: JICA Study Team)

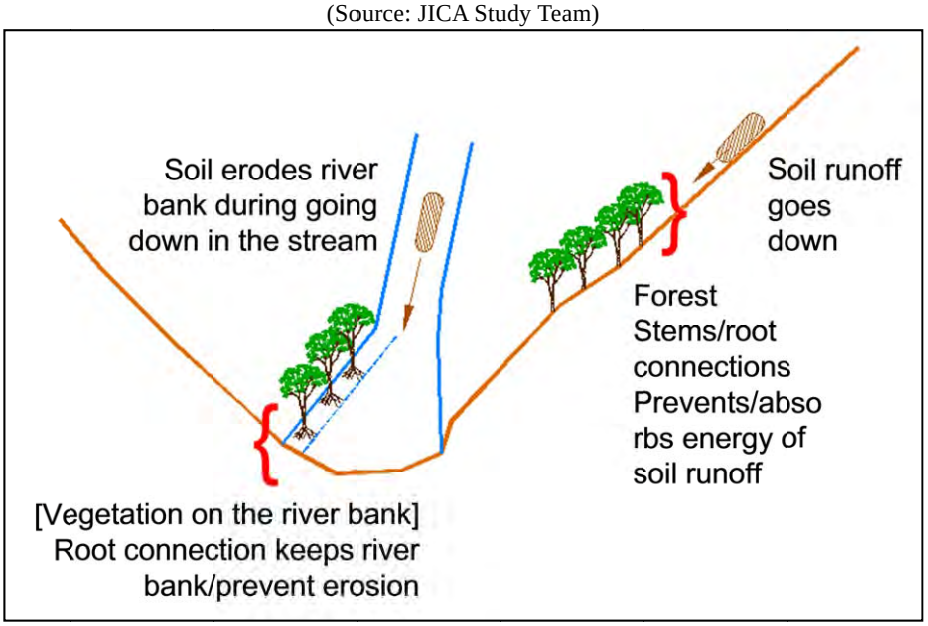


Figure 2.2 **Forest Function of Prevention/Mitigation of Soil Moving**

(Source: JICA Study Team)

(1) Function of Prevention/Mitigation of Slope Failure

A forest blocks off the rain drops by its canopy, and grasses/litter layer (fallen leaves and branches) covering the ground surface absorb impactive force of the rain drops. These are the functions of forest to prevent/mitigate the slope failure. Especially, in case of a forest with multiple layer structure such as, high trees- low trees- grasses, the function is much effective.

(2) Function of Prevention/Mitigation of Soil Runoff

The stems of trees in a forest stop the soil runoff on the slope. Also, the root networks of the forest keep the soil of river bank, have a function to prevent/mitigate the erosion of the river bank by the soil runoff in the stream.

(3) Issues of the Project Areas

(Problems in Canete, Chincha, Pisco and Yauca River Basins) As described in Chapter 1, 1.1 (3) (b), most of the weak areas for the erosion (= steep slopes; about more than 35% of slope angle) are covered by following vegetation zones; i) desert zone, ii) grass/cactus zone or iii) grass zone in high elevation. This means: it is difficult to recover the vegetation in the weak area for the erosion, because the vegetation afforestation/ vegetation recovery in the area are difficult due to the hard weather conditions (little rainfall, low temperature).

(Problems in Chira River Basin) Meanwhile, in the Chira River Basin, the steep slope areas are covered by the xerophile forests or the shrub forests and it is assumed that afforestation/ vegetation recovery are not difficult in the weak areas for the slope failure. However, the area ratio of the steep slope are to the whole river basin area is about 20%, the area ratio of gentle slope is about 50% in Chira River Basin. Therefore, the weakness of the river basin for the slope failure or slope erosion is not much totally, and the necessity of vegetation recover is not high.

(Issues in the Project Area) (i) In the Project area, the desert zone, grass/cactus zone are required to recover the vegetation. However, afforestation/vegetation recovery in these zones are much difficult, because those zones are basically any vegetation cannot survive naturally. (ii) The grass zone in the high elevation area is required for afforestation/vegetation recovery too. In this zone, the rainfall condition has no problem, but the low temperature is one of inhibitory elements. Therefore, the afforestation plan with highly-resistant species against the low temperature such as Pine is required. (iii) Most of the lands in the Andes highland are not government own lands. They are owned by the communities or individuals. The afforestation in their lands is required to obtain the agreements and understandings of the communities/local people. The education/expansion activities are necessary and usually take long time.

2.2 Function of Increasing of Groundwater (Decreasing Direct Runoff)

(1) Increasing of Groundwater

Generally, forest is called as green dam. The infiltration of rainfall into the ground is improved by increasing of the air gaps in the soil layer, which developed by the roots connection of forest. The high infiltration can increase the amount of groundwater. Those can work to mitigate the flood at the downstream. Therefore, forest is evaluated as to work to mitigate the flood indirectly. ***Figure 2.3*** shows general understanding about water movement in a watershed in Peru.

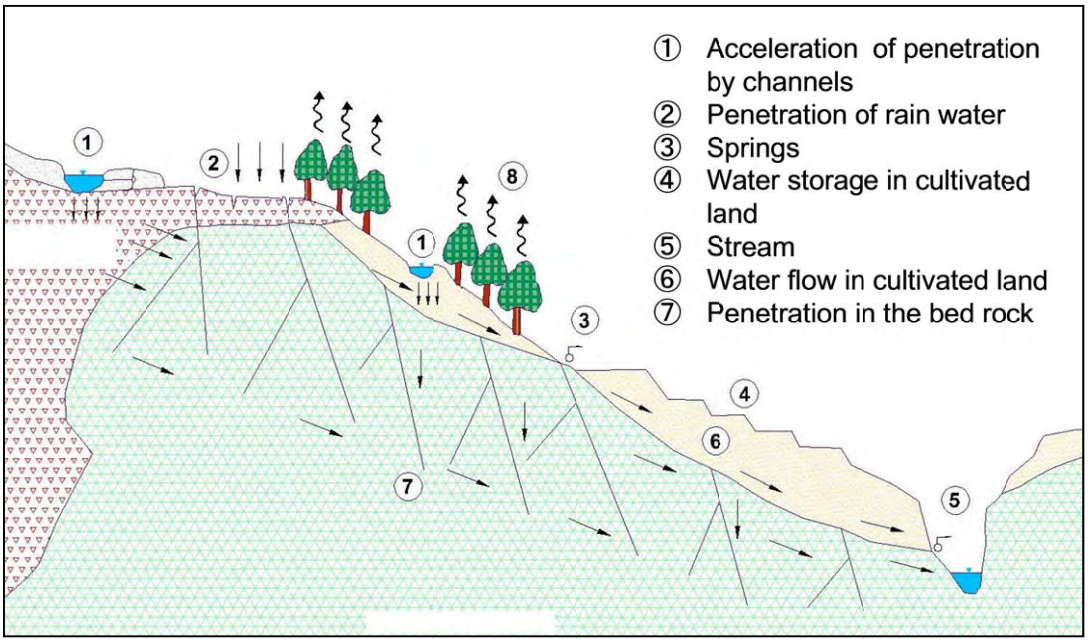


Figure 2.3 **Water Movement in a Watershed (General in Peru)**

(Source: KENDALL, 2008. Traditional Technology in Andes (Agriculture & Renovation of Environment)[2])

[2] KENDALL, Ann. 2008. Tecnología Tradicional Andina: Rehabilitación agrícola y ambiental para el desarrollo del sector comunal. Asociación Andina Cusichaca. 2da Edición. Perú

The rainfall penetrates into the soil layer, and it is divided into three flows as i) middle flow, ii) under ground water flow, and iii) surface flow. The flood peak flow volume is mainly composed of the iii) surface flow above. The much surface flow (= less amount of middle flow and underground flow) increases the amount of rainfall which goes into the stream also the amount of flood peak flow volume. The much flood peak flow volume leads flood easily and the scale of flood becomes bigger. Therefore, if the amount of i) middle flow and ii) underground water flow would be increased, flood scale can be expected to be reduced. The flood prevention/mitigation functions by the forest would be described as following two points.

(i) The forest crown and grasses/ litter layer (leaves & branches) on the ground reduce the impactive energy of the raindrops. Then, the less surface flow occurs and it increases the penetration capacity of the soil layer.
(ii) The development of root system of the forest increase the air gaps in the soil layer. And the it increases the penetration capacity of the soil layer.

These lead increasing of the middle flow /underground flow, the direct runoff is decreased. Those are integrally cut the amount of the flood peak amount and introduce the decreasing of the flood at last.

(2) Issues of the Project

(i) The potentially afforestation /vegetation recovery areas to prevent/mitigate the flood effectively in the Project area are quite limited compared to the huge river basin area. Therefore, the flood mitigation by the forest is not expected much.

(ii) Generally, forests have uncertainties as below.
- The survival ratio of planted trees and growing trees cannot be guaranteed,
- There are risks of climate and disease/insects, especially the low temperature is high risk for the planted trees, and
- There are human activities risks such as illegal logging.

(iii) Long time period until the forest becomes matured and equip enough functions, decreasing the functions during regeneration

Afforestation and developing the root networks and canopies take long time period. The time period is different by the tree species but any species take long time. Even though Eucalyptus, which is fastest growing up species, takes about seven years until its matured. Pine takes about 10 and some year, and the native species need longer time period. Until the forest becomes matured, its functions to prevent/mitigate the flood cannot be expected much. In addition, during the harvesting and regenerating period of the forest it takes long time period until the forest equips its function as same as the beginning of the forestation. The forest has many public functions, forestation has less demerit and much merit on the long-term aspect. However, the short-term or direct effects cannot be expected on the

forestation. Additionally, local community's cooperation is necessary for maintenance of the planted trees and keep the good forest condition, therefore, the cooperation system with the local community is required. But, it is not easy and takes long time.

(iv) Working efficiency

The population density in the Sierra area is very low. The working efficiency will be low much, because the number of labors at unit area is small. The following description shows the results of the trial calculation of necessary time period for the about 44 thousands ha afforestation plan, which was planned by AGRORURAL in Chincha River Basin. The result is 14 years for afforestation is required. The Project is flood prevention/mitigation project, the urgent measures is prior. The Project time period is set as three to five years usually for the Japan's loan projects. The afforestation/ vegetation recovery areas are limited for the project, and the prior area should be selected.

【The trial calculation of the time period for the implementation of forestation plan of AGRORUAL】

Assumption:

- The area surround 8km from the forestation areas is delineated as the area which the labors can be collected for the forestation work.
- The age of labors is set from 15 years to 59 years old.
- The ratio of the number of available population for the forestation work is calculated from the data of census 2007. (57.8%, please refer to Table 2.1.2).
- 50 % of the available population will join to the forestation work.
- The possible working period of the year is three months from December to March except the busy time of agriculture.

a: Population in the area where the labors can be collected	12,0698	(person)
b: Population of a (15 to 59 years old) :(a x 57.8%)	6,976	(person)
c: Number of labors for forestation works :(b x 50%)	3,488	(person)
d: Forestation area paned by AGRORURAL	44,068.53	（ha）
e: Number of labors per forestation area 1 ha :(c/d)	0.0791	(person/ha)
f: Number of planting trees per ha (Figure 3.1.3)	2,963	(trees/ha)
g: Number of planting trees per day	40	(piece/day)
h: Necessary number of labors per ha :(f/d)	74	(person/ha)
i: Total working period (three months)	90	(days)
j:	13	(weeks)
k: Working days in case of five days work per week	65	(days)
l: Possible number of labors per day :(=c)	3,488	(person)
m: Possible number of labors to forestation works :(k x l)	226,720	(person/day)
n: Possible forestation area :(m x g)	9,068,800	(Pieces)
o: Possible area of forestation per year :(n/f)	3,061	(ha/year)
p: Necessary years for total forestation :(d/o)	14	(years)

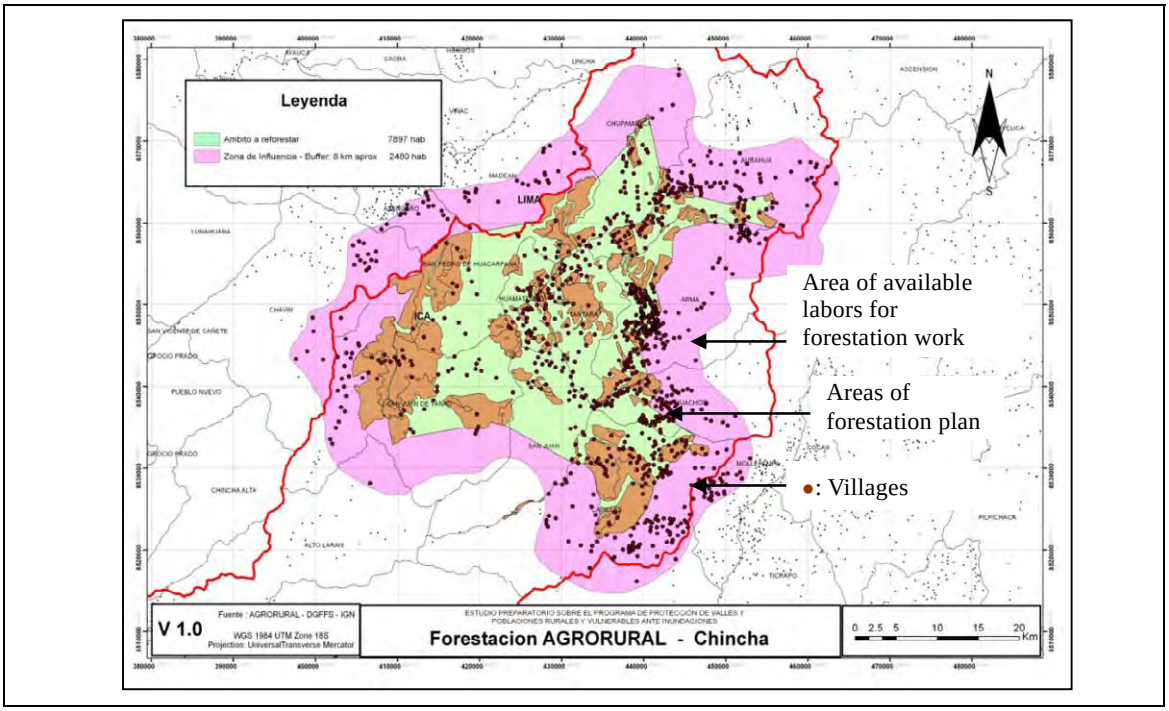


Figure 2.4 **Forestation Project Areas (AGRORURAL plan) and Distribution of Villages**

(Source: JICA Study Team based on the documents of AGRORURAL and Census 2007)

Table 2.2 **Population in Districts (Distrotos) (AGRORURAL forestation plan)**

Districts (Distrito)	Total population (A) (person)	Population of aged 15 to 59 old (B) (person)	Ratio (B/A) (%)
Arahua	2,140	1,593	74.4
Arma	1,504	709	47.1
Capillas	1,402	691	49.3
Chupamarca	1,129	550	48.7
Huachos	1,174	923	78.6
Huamatambo	447	203	45.4
San Juan	620	291	46.9
San Juan de Yanac	471	253	53.7
San Pedro de Huacarpana	1,576	879	55.8
Tantara	780	406	52.1
Total	11,243	6,498	57.8

(Source: Census 2007, Peru)

2.3 Functions of Riparian Forest

(1) Functions of Riparian Forest

The riparian forest, which is located next to the river, fixes the soil layer by its roots network. Fix of the soil layer prevents erosion of the river bank. It is one of the functions of the riparian forest. The riparian forest also, has a function to prevent/mitigate the flood by the stems of the trees. The stems gradually reduce the fluid force and lead the sands/stones in the forest and protect the properties along the rivers. (Please refer to ***Figure 2.5***.)

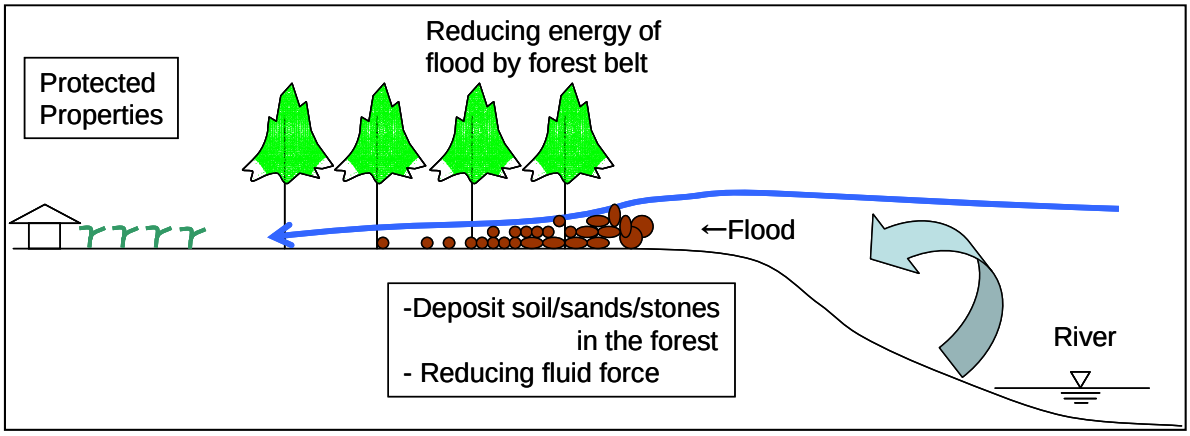


Figure 2.5 **Conceptual Diagram of Riparian Forest**

(Source: JICA Study Team)

(2) Issues of the Project

Generally, it is difficult to estimate the mechanical resistance force of the trees. The trees cannot guarantee the consistent quality as concrete/earth constructions. Therefore, it is not possible to prevent the flood by only the riparian forests. The target flood of the Project is the big scaled one which is caused by El Nino effect or abnormal climate. Therefore, the scale and power of the flood is expected much bigger than the one which can be blocked by the riparian forest. It is necessary for planting of the riparian forestation by the Project to consider the combination of the hard constructions such as dike and riparian forestation. It should be avoid to take measure for the flood only by the riparian forests.

2.4 Summary of the Issues of the Forestation Plan of the Project

As mentioned in ***Chapter 2.1*** to ***2.3***, the forest has the functions which work effectively to prevent or mitigate the flood. On the other hand, there are many limitation factors and disadvantage conditions for the flood prevention/mitigation by the afforestation/ vegetation recovery. Therefore, it is hard to say that the flood disaster can be prevented/mitigated by only the afforestation/ vegetation recovery plans. The functions of the forest and issues of the afforestation/ vegetation recovery of the Project are summarized in ***Table 2.3***.

Table 2.3 **Functions of Forest and Issues for the Project**

Functions of Forest	Issues for the Project	Necessary Considerations
Prevention of slope failure/ soil runoff	- The area of high risk of erosion is not suitable for plantation.	- Selection of forestation area is necessary, and large area of forestation plan cannot be expected efficiency.
Increasing groundwater (decreasing direct flow amount)	- The available area for vegetation developing is limited. Therefore, the function of flood mitigation does not work effectively. - The uncertainties of the forest - (Survival ratio of planted seedlings/ growing trees, several damages, damages caused by human) - Taking long time for production of effect	- Selection of forestation area is necessary. - It is necessary to recognize difference between forestation and concrete construction, because of uncertainties of forest/forestation.

	- Working efficiency is not good, taking long time period for the implementation of forestation	
Raiparian forest	- Difficult to estimate the mechanical resistance force of the trees - No guarantee for consistent quality of forest	- Not taking measures for flood disaster by riparian forest - Riparian forestation plan should be taken with combination of Dikes and other hard structures.

(Source: JICA Study Team)

CHAPTER 3 AFFORESTATION/VEGETATION RECOVERY PLAN

The afforestation/vegetation recovery plan can be classified into two categories as i) afforestation along the river protection constructions (as same as riparian afforestation), ii) afforestation in the upper stream area. The first one has direct effect for prevention of flood and also can be expected will produce its effect early relatively. It can be expected for the second one to have indirect effect for prevention/mitigation of flood, but it would take long time to begin to produce its effect. There is big different between those two type of afforestation/vegetation recover plan. Therefore, the plans were considered with following basic principle.

1) The afforestation along the river protection constructions (riparian afforestation) plan is proposed as short-term plan.

The riparian afforestation can produce its effect in short-term. It is planned as short-term plan, and will be incorporated into the Yen Loan Project as one of components.

2) The afforestation in the upper stream area is proposed as medium-long-term plan.

The afforestation shall take long term period. Especially, in the remote areas as the mountainous area, the shortage of man powers for the afforestation operation is expected. The operation efficiency would be low, and also the operation period would be limited in short rainy season, then the afforestation scale will be small amount in a year. While, the target river basin is quite large, and it is the undisputed fact that small scaled afforestation in the large river basin can produce little effect. The flood mitigation functions of forest is known well. However, some decades period is required for this type of afforestation and it shall be continued to produce the flood mitigation effect.

In accordance with the trial calculation based on the afforestation plan in the upper stream of Chincha River Basin, which was prepared by AGRORURAL, total area of afforestation in the five river basins is approximately 611 thousand ha, total project cost is approximately 1.65 billion soles. Additionally, all the afforestation operation period is estimated as 98 years. It is inappropriate to the Yen Loan project, because its cost and operation period is much more than the one of river protection constructions. The constructions can provide direct effects to prevent/mitigate flood disasters, meanwhile, the afforestation in the upper stream requires long term period and much cost and its effect is indirect.

Thus, the afforestation plan is not match to the Yen loan project. Therefore, the total area of afforestation plan is proposed as long-term period plan, and some of them are proposed as medium-term plan, which can be implemented in some years.

3.1 Short-Term Plan (Afforestation Beside the River Protection Constructions)

(1) Basic Principle

The basic principle of the riparian afforestation plan is set as follows. The conceptual diagrams are shown in ***Figure 3.1*** and ***3.2***. In case type A in the Figures cannot be taken in Camana-Majes River Basin, type B will be taken and in the other river basins type-A is taken.

(i) Purpose: To reduce the energy of the flood by the riparian forest trees in case the river water level becomes over the planed water level that would be occurred by unexpected runoff amount or barricades. Therefore, the planted trees will not be individual property but common property of the water users group.

(ii) Afforestation manner: Riparian forest is developed with fixed width along the river protection constructions in side of the protected lowlands.

(iii) Measure of afforestation work: The afforestation works will be carried out as one of process of the river protection constructions. It will be implemented by the contractor of the river protection constructions, because 1) rooting of the planted trees shall e ensured and the supplemental plantation for the died planted trees must be ensured and 2) the planting operation will follow the construction works and the afforestation by the contractor is appropriate.

(iv) Maintenance of the planted trees: The maintenance will be carried out by the water users group voluntarily. In accordance with the previous cases, the following 2 points will be agreed and mentioned in the minutes of discussions between a water users gropu and DGIH, and it is ordinary course of events; 1) the ownership of planted trees is belong to the water users group, and 2) the maintenance cost shall be owed by the water users group with 100%.

(v) Planned place: The afforestation will be planned along the river protection constructions such as dike in the protected property side, because the afforestation is planned to mitigate the damages by the over flows. In case of afforestation without river protection constructions, the planted trees are expected to be fallen down by the direst impact by the flood and they will flow to the lower course. Then, flowing trees are expected to have high risk causing the second disasters such as closing the bridges.

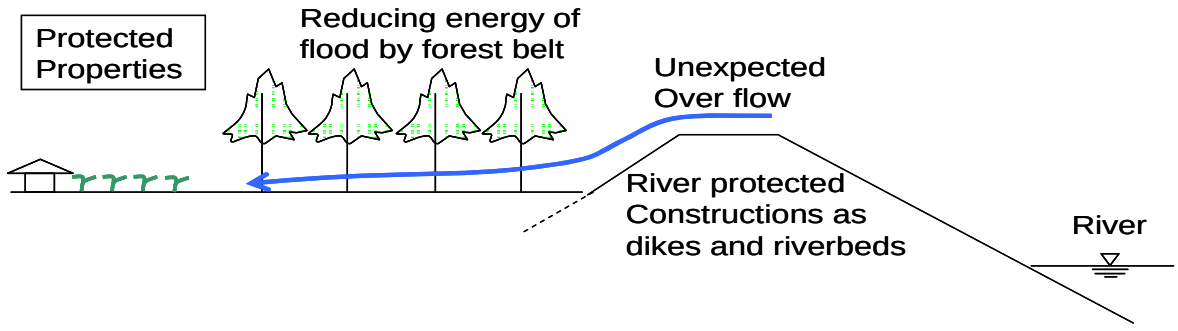


Figure 3.1 **Conceptual Diagram of Riparian Forestation Plan (Type A)**

(Source: JICA Study Team)

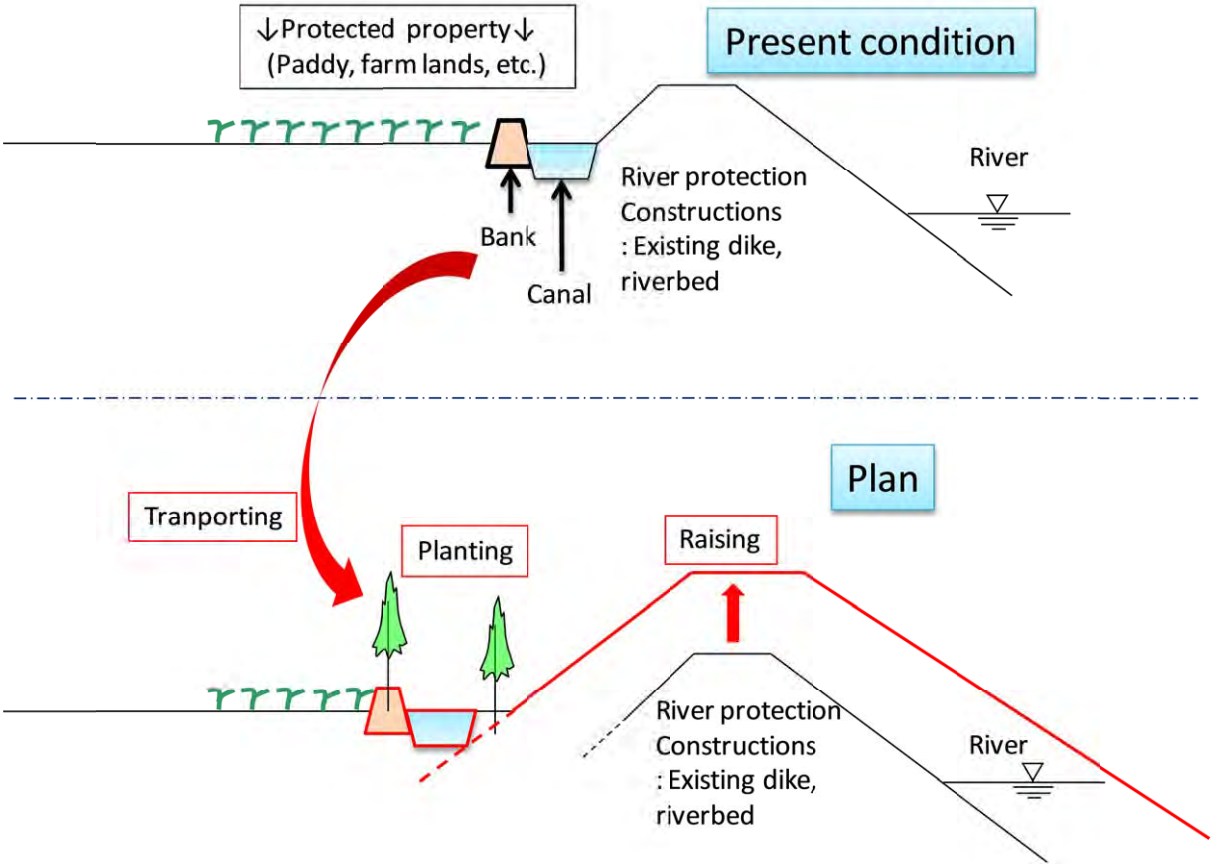
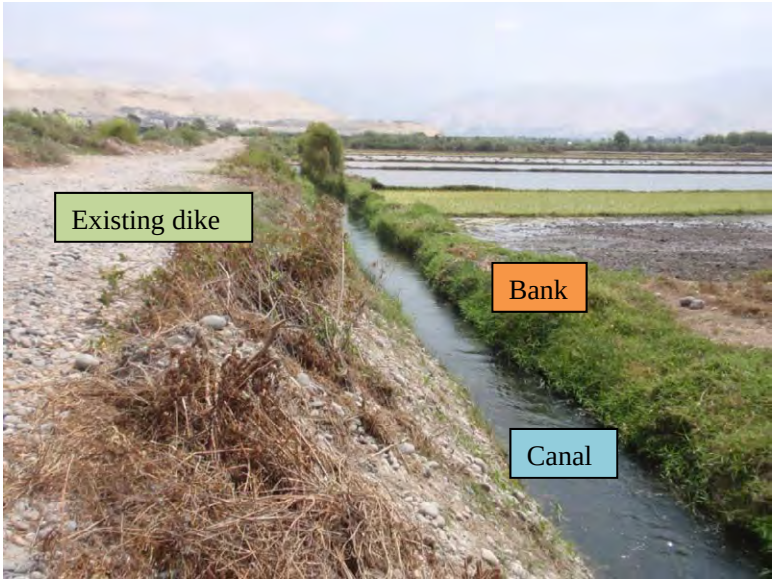


Figure 3.2 **Conceptual Diagram of Riparian Forestation Plan (Type B)**

(Source: JICA Study Team)

Most of the case in Camana-Majes River Basin, the canals are constructed along the existing dikes. Most of the paddy fields are cultivated until the canals. In accordance with hearing from the water users group, many farmers would not agree with 11m wide afforestation as type A. Some impossible cases with type A are easily expected. Therefore, in such case as the land can not be acquired, type B of afforestation plan will be taken. The afforestation will protect the canals but will not have effect produced by type A.



Ordinal Condition of existing dike, bank and canal in Camana-Majes River Basin
(Source: JICA Study Team)

(2) Amount of Afforstation along the River Protection Constructions

(a) Layout of Planting

- Type A: In Peru, the equilateral-triangular layout of the planting points is common. This layout is taken in the Project, the distance between the planting points is set as 3m (please refer to ***Figure 3.3***). In this layout (3m distance between trees), the tree distance in direction of right angle with the dike is approximately 2.6m, it can become 1.3m with the formation in the Figure. The 1.3m distance can be expected that a stone with 1m diameter would be bump into some trees and stop or its energy will be reduced. The four lines of plantation will become more effective. The afforestation width is calculated as 10.4m and it is planned 11m with additional width.

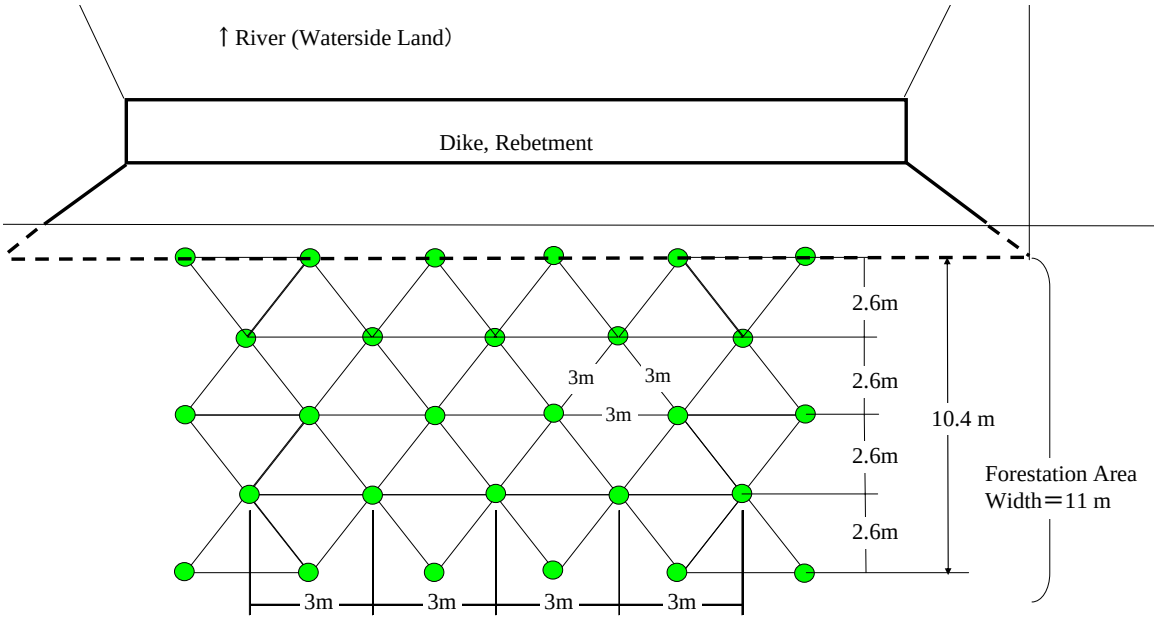


Figure 3.3 **Layout of Planting Points of Riparian Afforestation (Type A)**

(Source: JICA Study Team)

- Type B: The current condition in the planned area shows approximately 1m width planting parallel to canal. Its formation is taken in this planning. The layout of planting points (type B) is shown in ***Figure 3.4***.

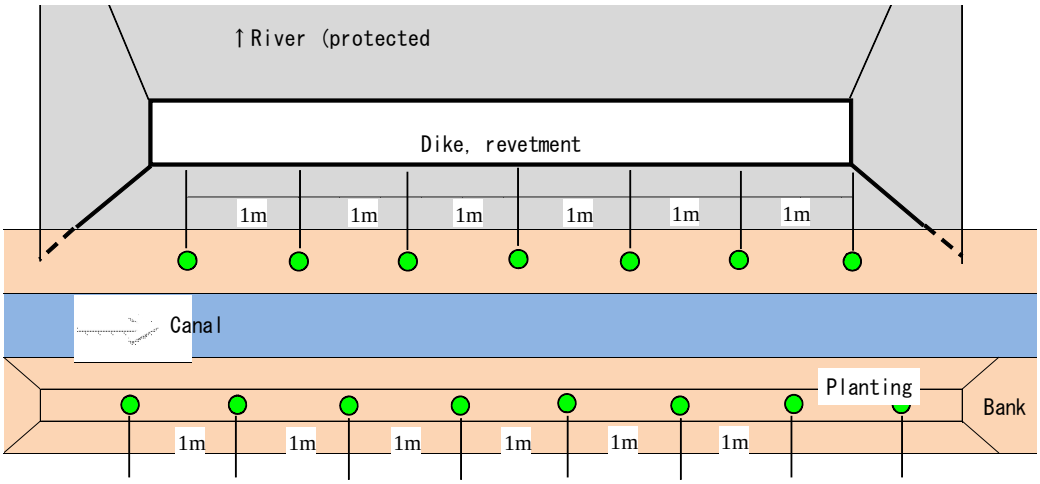


Figure 3.4 **Layout of Planting Points of Riparian Afforestation (Type B)**

(Source: JICA Study Team)

(b) Planting Species

The following lists of tree species was prepared for the selection of planting species.

- List of available production species (based on the information of the seedling providers): ***Table 3.1***,
- List of verified tree species in the field: ***Table 3.2***

The appropriate planting species were selected based on these lists of species. The tree species were evaluated based on the several items below and selected comprehensively. The selection criteria are shown in ***Table 3.4***, the results of the selection is shown in ***Table 3.3***.

(Evaluation criteria)

1. Possible to grow along the river based on its characteristics (desirable to grow near the planed area naturally),
2. Production of the seedlings is possible,
3. Logs/fruits are useful,
4. Local communities request,
5. Native species (desirable, but not must)

Table 3.1 **List of Available Production Species**

(Riparian afforestation)

Area	Provider	Production Place	Species produced usually	Species produced sometimes
Chira	AGRORURAL	Lambayeque	Algarrobo, Tara, Pine, Eucalyptus, Huarango (*Acacia Macracantha*)	Aliso, Quinual
	FOMECO SAC	Lima	Algarrobo, Tara, Eucalyptus	Molle, Huarango (*Acacia Macracantha*)
	MONTAÑA AZUL SAC	Piura	Algarrobo, Molle, Eucalyptus, Huarango (*Acacia Macracantha*)	Sauce, Casuarina, Paharobobo
Canete	AGRORURAL	Santa Eulalia	Pine, Molle, Eucalyptus, Huarango (*Prosopis limensis*)	Cypress, Tara
	FOMECO SAC	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	-
	AGRIMEX EIRL	Lima	Aliso, Algarrobo, Canya,Tamarix, Bamboo, Pine, Casuarina, Eucalyptus	-
Chincha Pisco	AGRORURAL	Lima	Pine, Molle, Eucalyptus, Hurango (*Prosopis limensis*)	Cypress, Tara
	FOMECO SAC	Lima	Tara, Molle, Huarango (*Prosopis limensis*)	-
	AGRIMEX EIRL	Ica	Aliso, Algorrobo, Canya,Tamalix, Bamboo, Pine, Casuarina, Eucalyptus	-
Yauca	FOMECO SAC	Huancayo	Aliso, Quinual, Colle, Pine, Eucalyptus	-
Camana -Majes	APAIC	Arequipa	Sólo Tara	
	Los Girasoles de Florentino	Arequipa	Sauce, Álamo, Molle, Casuarina, Tara	
	AGRORURAL	Arequipa		Tara, Sauce, Huarango, Acacia, Casuarina

(Source: Hearing from seedling providers[1])

[1] Refer to Appendix 7-Table 1 List of Seedling Provider

Table 3.2 **List of Verified Tree Species in the Field (for Riparian Forestation)**

Location	Tree Species	Characteristics
Chira	Algarrobo	Growing on the place 4m over the usual river water level
	Casuarina	Growing on the place 1 to 2m higher than usual river water level. It is not popular because of less usage.
	Eucalyptus	It is planted in the urban areas, but cannot be seen along the rivers. Its characteristics shows high adequateness. Most of people believe it should be planned in the high elevation areas.
	Tamalix	As same as Algarrobo. Fruit is edible. It is viewed with suspicion as invader species in some quarters.
	Paharobobo	Growing on the place 1 to 2m higher than usual river water level.
Canete	Eucalyptus	Common along the river, and its characteristics shows high adequateness.
	Casuarina	Common along the river, and its characteristics shows high adequateness.
	Sauce	Common along the river, and its characteristics shows high adequateness.
	Molle	Shrub species, its characteristics shows high adequateness.
Chincha	Eucalyptus	It has good track record in plantation/forestation, its characteristics shows high adequateness.
	Casuarina	Common along the river, and its characteristics shows high adequateness.
Pisco	Huarango (*Prosopis limensis*)	It has good track record in plantation/forestation, was taken as forestation species in the forestation plan of Cansus, Ica Region.
	Aromo	-
Yauca	Eucalyptus	Common along the river, and its characteristics shows high adequateness.
	Casuarina	Its characteristics shows high adequateness. Common surrounding farm lands to protect it against wind and sands.
	Sause	It grows along rivers naturally. Very common in usage for planting along the canals besides paddy. The branches are used for fuel wood. Germination from the stamp. The most common species in Camana-Majes River Basin.
	Callacas	It grows along rivers naturally. Growth with Sause is common. Trees along canal are not planted, remained from natural one.
	Eucalyptus	Most of the trees in the area is planted. It planted on a part of the river basin beside to the mountain. Most of the plantation of Eucalyptus in 2007 were almost died in accordance with hearing from water users group in Vamana-Majes River Basin.
	Casuarina	It grows in some areas along rivers, but not many. Sometimes it can be seen around houses.

(Source: JICA Study Team)

Table 3.3 **Results of Planting Species Selection (Details)**

River Basin	Tree Species	Adequateness to evaluation items*						Remarks
		1	2	3	4	5	Total**	
Chira	Aliso	C	B	A	C	A	--	Adequate for high elevation areas rather as
	Algarrobo	A	A	C	B	A	++	Adequate much for the area, common to there
	Tamalix	A	C	B	B	B	+	As invader plant in some quarters
	Casuarina	A	B	C	B	B	+	Survive near the seashore areas
	Eucalyptus	B	A	B	B	B	-	Fast growing up, useful for log/firewood
	Quinual	C	C	B	C	A	--	Adequate for high elevation areas rather as
	Sauce	A	B	C	B	A	+	Its characteristics shows high adequateness to riparian areas
	Tara	D	A	A	B	A	-	Recently, fruit was found as effectiveness, becomes popular for plantation
	Paharobobo	A	B	D	B	A	-	Its characteristics shows high adequateness to lower riparian places
	Pine	B	D	B	B	B	-	Adequate for high elevation areas rather as
	Molle	B	A	B	B	A	+	It is said as its root grows in deep
	Huarango (*Acacia Macracantha*)	A	A	B	B	A	+	Similar to Algarrobo
Canete	Aliso	C	B	A	C	A	--	Adequate for high elevation areas rather as
Chincha	Algarrobo	B	A	C	B	A	--	Similar to Huarango (*Prosopis limensis*), Prosopis is selected in the southern areas
Pisco	Canya (Cariso)	A	C	B	B	A	--	Grass
Yauca	Quinual	C	C	B	C	A	--	Adequate for high elevation areas rather as
	Colle	C	D	D	B	A	--	Adequate for high elevation areas rather as
	Tamalix	B	A	B	B	B	--	Its characteristics shows high adequateness in the Northern areas, but unknown in the southern areas
	Tara	D	A	A	B	A	-	Recently, fruit was found as effectiveness, becomes popular for plantation
	Bamboo	A	A	B	B	A	+	Unknown for forestation record
	Pine	B	D	B	B	B	-	Adequate for high elevation areas rather as
	Molle	B	A	B	B	A	+	It is said as its root grows in deep
	Casuarina	A	B	C	B	B	+	Adequate for high elevation areas rather as
	Eucalyptus	A	B	B	A	B	++	Adequate for high elevation areas rather as
	Huarango (*Prosopis limensis*)	A	A	D	A	A	++	Its characteristics shows high adequateness in the area near to the sea or dry area
Camana-	Sause	A	A	B	A	A	++	Adequate much for the area, good practice, requirements from water uses group
Majes	Callacas	A	D	D	B	A	--	Not producing seedlings
	Eucalyptus	B	A	B	B	B	-	Not adequate for silt soil and wet condition along the canals
	Casuarina	B	A	B	B	B	+	Not many achievement, but its character is adequate for the sea side areas
	Huarango (*Prosopis limensis*)	B	A	D	B	A	--	Not adequate for silt soil and wet condition along the canals

* Evaluation criteria are shown above, ** ++: Selected, +: second, -: nominated but not so good,--: not be selected
(Source: JICA Study Team based on hearing from the seedling providers)

The selection criterion 1:adequateness to the location, 2: possibility of seedling production are prior to the others. The others; 3: usage, 4: requests of local communities, and 5: native species are used for reference. The selection criteria are described in ***Table 3.4***.

Table 3.4 **Selection Criteria for Planting species**

		Evaluation item				
		1：Adequateness	2：Possibility of seedling production	3：Usage	4：Requests of local communities	5: native species
Evaluation point	A	Confirmed its growth in the field	Usual production	Wood and fruit are used	Requested from water users association	Native
	B	Not confirmed the growth, but generally its characteristics shows adequateness	Production sometimes	Single usage of fruit or wood	No requests from water users association	Not native
	C	Not applicable to the 2 points above	Possible, but rare	Not be used	-	-
	D	unknown	No production	Unknown	-	-

(Source: JICA Study Team)

The results of selection are shown in ***Table 3.5***. The species marked as "++" is planed mainly, the one marked as "+" is mixed of 30 to 50%. The reason of mix planting is to avoid to be big damage of the planted trees as being destroyed completely by the disease or insects.

Table 3.5 **Selected Tree Species**

Chira River Basin : Algarrobo (++), Tamalix (+), casuarina (+)
Canete and ither three river basins: Eucalyptus (++), Huarango (+), Casuarina (+)
Camana-Majes River basin: Sause (++), Casuarina (+)

(Source: JICA Study Team)

In Chira River Basin, Algarrobo, which is common in the local area and has much record of production, is selected as the main planting tree species. Tamalix has almost same characteristics as Algarrobo and its fruit is edible. Therefore, Tamalix is selected as the second species. Casuaria can survive near the sea shore, therefore, it is planned to be planted in the areas near the sea.

In Canete River Basin and the other three river basins, Eucalyptus is selected as the main species. Eucalyptus has a lot of record of plantation, also its characteristics shows high adequateness for there. Also, he water association requests them to plant. Huarango (Prosopis limensis: there is same local name species but different one in the northern area) is one of the most common species in the coastal areas in the southern areas of Peru. It has many records of planting along the Pan-American highway. Casuarina is common for plating surrounding the farmlands to protect it against wind and sands.

In Camana-Majes River Basin, Sause is selected as main species. Sause is adequate much for wet

land and has many achievements of plantation. It is planned by the water users group also. However, Sause/ Callacas are seen but not grow well because of effects by tied in the distance of approximately 1.5km from seashore line. Therefore, in this section, Casuarina which is adequate for tide, is planned to be planted mixed with Sause. Most of the farming lands in Camana-Majes River Basin are used as paddy, therefore, the planned places for afforeestation the ground water level would be much high, and the soil is composed to silt. With consideration of these conditions, Eucalyptus is not good for afforestation because of high ratio of dead.

(c) Amount of Afforestation Plan

The riparian afforestation/vegetation recovery is planned beside the structures along the rivers such as, revetments, dikes, sand pockets with the layout described in (a) and (b) above. The width of the planting area is set as 11m basically (Type A) and whole area except original river flow in the sand pocket. The amount of afforestation (Type B) is calculated with following conditions; i) two lines of plantation is planned with same length of dyke, ii) tree distance is 1m.

The amounts of the afforestation plan for each river basin are shown in ***Table 3.6***.

Table 3.6 **Amount of Afforestation/Vegetation Recovery Plan (Riparian Afforestation)**

(Chira River Basin, Type A)

No.	Side	Length	Width	Forestation Area	No. of Planting Stocks	Number of planting stocks for each Species (No.)			
		(m)	(m)	(ha)	(No.)	Algarrobo	Tamalix	Casuarina	Total
Cira-1	L	4,000	11	4.4	13,024	2,605	1,302	9,117	13,024
Cira-2	R	1,000	11	1.1	3,256	1,628	977	651	3,256
Cira-3	R	2,500	1	0.3	888	444	266	178	888
Cira-4				0.0	0	―	―	―	―
Cira-5	R	1,000	11	1.1	3,256	1,954	1,302	0	3,256
Cira-6	L	500	11	0.6	1,776	1,066	710	0	1,776
Total Chira		9,000		7.5	22,200	7,697	4,557	9,946	22,200

(Canete, Chincha, Pisco and Yauca River Basiin, Type A)

No.	Side	Length	Width	Forestation Area	No. of Planting Stocks	Number of planting stocks for each Species (No.)			
		(m)	(m)	(ha)	(No.)	Eucalyptus	Hurango	Casuarina	Total
Ca-1		0	0	0	0	0	0	0	0
Ca-2	R	1,600	11	1.8	5,328	2,664	1,598	1,066	5,328
Ca-3		0	0	0	0	0	0	0	0
Ca-4		0	0	0	0	0	0	0	0
Ca-5	R	1,750	11	1.9	5,624	2,812	1,687	1,125	5,624
Total Canete				3.7	10,952	5,476	3,285	2,191	10,952
Chico-1	Both	2,100	22	4.6	13,616	6,808	4,085	2,723	13,616
Chico-2		0	0	0	0	0	0	0	0
Chico-3		0	0	0	0	0	0	0	0
Ma-4	Both	2,500	22	5.5	16,280	8,140	4,884	3,256	16,280
Ma-5		0	0	0	0	0	0	0	0
Total				10.1	51,800	25,900	15,539	10,361	51,800

No.	Side	Length (m)	Width (m)	Forestation Area (ha)	No. of Planting Stocks (No.)	Number of planting stocks for each Species (No.)			
						Eucalyptus	Hurango	Casuarina	Total
Chincha									
Pi-1	L	2,000	11	2.2	6,512	3,256	1,954	1,302	6,512
Pi-2		0	0	0	0	0	0	0	0
Pi-3	L	1,500	11	1.7	5,032	2,516	1,510	1,006	5,032
Pi-4	L	1,000	11	1.1	3,256	1,628	977	651	3,256
Pi-5		0	0	0	0	0	0	0	0
Pi-6	Whole	1,450	11	1.6	4,736	2,368	1,421	947	4,736
Total Pisco				6.6	19,536	9,768	5,862	3,906	19,536
Ya-1	Whole	1,000	11	1.1	3,256	1,628	977	651	3,256
Ya-2		0	0	0	0	0	0	0	0
Ya-3		2,500	11	2.8	8,288	4,144	2,486	1,658	8,288
Ya-4		0	11	0	0	0	0	0	0
Ya-5	R	500	11	0.6	1,776	888	533	355	1,776
Ya-6	R	400	11	0.4	1,184	592	355	237	1,184
Total Yauca				4.9	14,504	7,252	4,351	2,901	14,504

(Camana-Majes River Basin)

No.	Side	Length (m)	Width (m)	Forestation Area (ha)	No. of Planting Stocks (No.)	Number of planting stocks for each species (No.)		
						Sause	Casuarina	Total
Type B								
Camana-1	L	1,500	—	—	3,000	1,500	1,500	3,000
Camana-1	L	3,000	—	—	6,000	6,000	0	6,000
Camana-2	L	2,000	—	—	4,000	4,000	0	4,000
Camana-3	L	6,000	—	—	12,000	12,000	0	12,000
Type A								
Majes-4	2,500	11	2.8	8,288	8,288	0	8,288	2,500
Majes-5	4,000	11	4.4	13,024	13,024	0	13,024	4,000
Majes-6	3,500	11	3.9	11,544	11,544	0	11,544	3,500
Majes-6	3,000	11	3.3	9,768	9,768	0	9,768	3,000
Majes-7	1,500	11	1.7	5,032	5,032	0	5,032	1,500
Majes-7	2,000	11	2.2	6,512	6,512	0	6,512	2,000
Total			18.3	79,168	77,668	1,500	79,168	

(Source: JICA Study Team)

The ratios of number of planting stocks by species for each construction along the river are shown in ***Table 3.7***

Table 3.7 **Ratios of Number of Planting Stocks by Species for each Construction**

(Chira Riber Basin)

Serial No.	No.	Ratio of No. by Species			Remarks
		Algarrobo	Casuarina	Tamalix	
1	Cira-1	2	7	1	Casuarina is used a lot, because the site is near the sea sied
2	Cira-2	5	2	3	Algarrobo is main species, Tamalix and Casuarina are sub species
3	Cira-3	5	2	3	
5	Cira-5	6	0	4	Casuarina is not used, because the site is far from the sea side

(Canete and three river basins)

Serial No.	No.	Ratio of No. by Species			Remarks
		Eucalyptus	Casuarina	Huarango	
8	Ca-2	5	2	3	Eucalyptus is main species, and Hurango is sub. Huarango is the native species, it is expected that its characteristics has much adequateness than Casuarina. Then, Huarango is planted with prior than Casuarina
11	Ca-5	5	2	3	
12	Chico-1	5	2	3	
15	Ma-4	5	2	3	
17	Pi-1	5	2	3	
19	Pi-3	5	2	3	
20	Pi-4	5	2	3	
22	Pi-6	5	2	3	
23	Ya-1	5	2	3	
25	Ya-3	5	2	3	
27	Ya-5	5	2	3	
28	Ya-6	5	2	3	

(Camana-Majes River Basin)

No.	Ratio of No. by Species		Remarks
	Sause	Casuarina	
Camana-1	5	5	Due to near to seashore line, Casuarina is used. Ratio of No. of Sause and Casuarina is same as 50%.
Camana-2	5	5	
Camana-2 Majes-3 to Majes-8	10	-	These areas are far from seashore line, not necessary to consider Casuarina usage.

(Source: JICA Study Team)

(d) Location of Forestation/Vegetation Recovery Plan

The locations (positions) of each forestation/vegetation recovery plan are same as the each construction along the river. Please see ***Annex-8***. The afforestation operation will start after completion of construction of river protections.

(3) Cost of Afforestation along the River Protection Constructions (Short-Term Plan)

(a) Unit Price

The direct cost of the forestation/vegetation recover is composed with the following items.

- Unit price of seedling (price of seedling and transportation cost)
- Labor cost
- Direct expense (equipments fee: 5% of the labor cost)

(b) Unit Price of Seedling

The seedling suppliers can be classified as i) AGRORUAL and ii) private companies. The seedlings for the afforestation in the upper stream areas of Chicncha River Basin will be purchased from AGRORURAL, and the seedlings for the riparian forestation will be purchased from the private companies. ***Table 3.8*** shows the unit price of seedling for the riparian afforestation. The prices in ***Table 3.8*** shows the averages of the hearings from several private companies. (The detail information related to the unit cost of seedlings is shown in ***Appendix 7-Table 2***).

Table 3.8 **Unit Price of Seedling (for Riparian Forestation)**

River Basin	Species	Unit Price (Sol./seedling)
Chira	Algarrobo	1.3
	Tamalix	5.4
	Casuarina	1.9
Canete	Eucalyptus	1.4
	Huarango	1.6
	Casuarina	1.9
Chincha, Pisco	Eucalyptus	1.4
	Huarango	1.8
	Casuarina	2.2
Yauca	Eucalyptus	1.5
	Huarango	1.8
	Casuarina	2.3
Camana-Majes	Sause	2.5
	Casuarina	2.8

Note: Unit price of seedling = (Seedling price + transportation fee)
(Source: Hearing from suppliers)

(c) Labor Costs

The number of capacity of planning work per day is planned as 40 planting stocks /day-person based on hearig from AGRORURAL and water users groups. The labor cost for the riparian forestation is estimated as 33.6 sol/man-day, which is used for the general construction.

(d) Direct expense

The direct expense is set as 5% of the labor cost. The direct cost will be used for the purchase of the equipments for soil digging, transportation of seedlings (from the delivery point to the planting area).

(e) Cost estimation of afforestation/ vegetation recovery work along the river protection constructions (riparian afforestation work)

The cost estimation for the afforestation/ vegetation recovery work (riparian afforestation) is shown in ***Table 3.9***. The total cost is 1,001,769 sol.

The implementation of the riparian afforestation works will be carried out by the construction company, which will carry out the constructions along the rivers. 88% of the direct cost is estimated as the indirect cost as same as general construction.

Table 3.9 **Cost Estimation of Afforestation along River Protection Constructions (Riparian Afforestation)**

No.	No. of Construction	Cost of Afforestation (Sol)					
		Direct Cost				Indirect Cost	Total
		Seedlings	Planting works	Direct Expense	Sub Total		
1	Cira-1	27,740	10,940	547	39,227	34,520	73,747
2	Cira-2	8,629	2,735	137	11,501	10,121	21,622
3	Cira-3	2,352	746	37	3,135	2,759	5,894
4	Cira-4	0	0	0	0	0	0
5	Cira-5	9,571	2,735	137	12,443	10,950	23,393
6	Cira-6	5,220	1,492	75	6,787	5,973	12,760
Chira Rver Basin		53,512	18,648	933	73,093	64,323	137,416
7	Ca-1	0	0	0	0	0	0
8	Ca-2	8,312	4,476	224	13,012	11,451	24,463
9	Ca-3	0	0	0	0	0	0
10	Ca-4	0	0	0	0	0	0
11	Ca-5	8,774	4,724	236	13,734	12,086	25,820
Canete River Basin		17,086	9,200	460	26,746	23,537	50,283
12	Chico-1	22,875	11,437	572	34,884	30,698	65,582
13	Chico-2	0	0	0	0	0	0
14	Chico-3	0	0	0	0	0	0
15	Ma-4	27,350	13,675	684	41,709	36,704	78,413
16	Ma-5	0	0	0	0	0	0
Chincha River Basin		50,225	25,112	1,256	76,593	67,402	143,995
17	Pi-1	10,940	5,470	274	16,684	14,682	31,366
18	Pi-2	0	0	0	0	0	0
19	Pi-3	8,454	4,227	211	12,892	11,345	24,237
20	Pi-4	5,470	2,735	137	8,342	7,341	15,683
21	Pi-5	0	0	0	0	0	0
22	Pi-6	7,956	3,978	199	12,133	10,677	22,810
Pisco River Basin		32,820	16,410	821	50,051	44,045	94,096
23	Ya-1	5,698	2,735	137	8,570	7,542	16,112
24	Ya-2	0	0	0	0	0	0
25	Ya-3	14,504	6,962	348	21,814	19,196	41,010
26	Ya-4	0	0	0	0	0	0
27	Ya-5	3,108	1,492	75	4,675	4,114	8,789
28	Ya-6	2,072	995	50	3,117	2,743	5,860
Yauca River Basin		25,382	12,184	610	38,176	33,595	71,771
29	Camana-1	7,950	2,520	126	10,596	9,324	19,920
30	Camana-1	15,000	5,040	252	20,292	17,857	38,149
31	Camana-2	10,000	3,360	168	13,528	11,905	25,433
32	Camana-3	30,000	10,080	504	40,584	35,714	76,298
33	Majes-4	20,720	6,962	348	28,030	24,666	52,696
34	Majes-5	32,560	10,940	547	44,047	38,761	82,808
35	Majes-6	28,860	9,697	485	39,042	34,357	73,399
36	Majes-6	24,420	8,205	410	33,035	29,071	62,106
37	Majes-7	12,580	4,227	211	17,018	14,976	31,994
38	Majes-7	16,280	5,470	274	22,024	19,381	41,405
Camana-Majes River Basin		198,370	66,501	3,325	268,196	236,012	504,208
Total		377,395	148,055	7,405	532,855	468,914	1,001,769

(Source: JICA Study Team)

(4) Implementation Schedule of the Afforestation/Vegetation Recovery along the River Protection Constructions (Riparian Afforestation)

The riparian aforestation is a part of the constructions along the rivers. Therefore, the implementation schedule of the riparian afforestation is same as the construction schedule. Normally, planting work should be started before the rainy season starts and finished about one month before the end of rainy season to ensure the survival of the planted seedlings. However, the Project area is almost no rain areas, so that the rainy or dry season are not considerable condition for the afforestation work. It is advisable to plant the seedlings at the season that the river water level rises up, but it is not must. Watering by a simple gavity watering system using a hors for about three months is proposed. This system is one of field technology which was implemented around Poechos Dam site. The methodology is simple as, i) a horse is set on same elevation line, ii) put holes on hors and watering from these holes.

3.2 Long-Term Plan (Afforestation Plan at Upper Stream Area)

(1) Basic Principle

(i) Purpose: Improve the infiltration of soil in the watershed areas, decrease the amount of surface runoff and increase the middle/ground water. These will be expected to cut the peak amount of the flood, increasing the water amount in the river basin area, and finally will contribute to prevent/mitigate flood disaster.

(ii) Target areas: Available areas in the watershed, or forest degradation areas should be selected as forestation areas. The afforestation area in each river basin is estimated based on the afforestation plan in Chincha River Basin, planned by AGRORURAL.

(2) Afforestation Area

The afforestation areas in Chira, Canete, Pisco, Yauca and Camana-Majes River Basin were calculated as following steps.

(Step-1) : Vegetation zones areas are referred to ***Table 3.10***

(Step-2) : Measurement of the afforestation area in Chincha River Basin. The ratio of afforestation plan area and vegetation zone area are calculated. (Please refer to ***Table 3.11***)

(Step-3) : Calculation of the afforestation area in each river basin based on the result of step-1 and 2 above. (vegetation zone area in ***Table 3.10*** is multiplied by A/B of each vegetation zone in ***Table 3.11*** is planned afforestation area for each river basin).

As the results, total afforestation area in Canete River Basin and the other three river basins is

approximately 300 thousand ha, the afforestation area in Camana-Majes River Basin is calculated as approximately 310 thusand ha, totally appoloximately 610 thousand ha.

Table 3.10 **Vegetation Zone Area of Each River Basin**

(Unit: ha)

River Basin	Vegetation Zone							
	Cu	Dc	Ms	Msh	Mh	Cp	N	Pj
Canete	4,789	104,384	57,601	103,201	9,409	22,228	9,515	295,447
Chincha	16,489	99,092	54,662	45,203	355	84,920	0	29,668
Oisco	21,429	135,095	41,900	42,843	14,702	66,307	0	104,933
Yauca	4,926	146,689	98,012	76,480	25,564	38,602	0	41,984
Chira	71,177	11,425	8,024	134,447	108,659	0	0	11,600
Camana-Majes	10,454	310,812	157,008	133,476	15,520	6,616	64,144	1,006,921

(Source: JICA Study Team based on the study by INRENA 1995)

Table 3.11 **Vegetation Zone-wise Afforestation Area in Chincha River Basin (Based on AGRORURAL Plan)**

(Unit: ha)

Classification	Vegetation Zone								
	Cu	Dc	Ms	Msh	Mh	Cp	N	Pj	Total
A: Afforestatio Area based on AGRORURAL plan(ha)	0.00	1,693.61	21,098.77	9,934.05	0.00	5,108.46	0.00	6,233.64	44,068.53
B: Vegetation Zone (ha)	16,489	99,092	54,662	45,203	355	84,920	0	29,668	330,389
A/B	-	0.0171	0.3860	0.2198	-	0.0602	-	0.2101	0.1334

(Source: JICA Study Team based on the documents of AGRORURAL and results of study by INRENA, 1995)

Table 3.12 **Overall Afforestation Area in each River Basin**

(Unit: ha)

River Basin	Vegetation Zone								
	Cu	Dc	Ms	Msh	Mh	Cp	N	Pj	計
Canete	-	1,785	22,234	22,684	-	1,338	-	62,073	110,114
Chincha	-	1,694	21,100	9,936	-	5,112	-	6,233	44,075
Pisco	-	2,310	16,173	9,417	-	3,992	-	22,046	53,938
Yauca	-	2,508	37,833	16,810	-	2,324	-	8,821	68,296
Chira	-	195	3,097	29,551	-	0	-	2,437	35,280
Caman-Majes	-	5,315	60,605	29,338	-	398	-	211,554	307,210
total	-	13,807	161,042	117,736	-	13,164	-	313,164	618,913

(Source: JICA Study Team based on the documents of AGRORURAL and results of study by INRENA, 1995)

(3) Cost Estimation (Long-Term Plan)

The overall afforestation plan area and cost in each river basin were calculated based on the afforestation plan in Chincha River Basin. The results were shown in ***Table 3.13***. The total project periods of the afforestation plan are 11 to 35 years for each river basin, and the total cost was approximately 1.67 billion Sol. The over all afforestation plan requires very long time and huge cost.

Table 3.13 **Overall Area, Period, and Cost of Afforestation Plan for Each River Basin**

River Basin	Afforestation area (ha) : A	Required Project Period (year) : B	Cost (Sol.) : C
Canete	110,114	35	297,212,406
Chincha	44,075	14	118,964,317
Pisco	53,938	17	145,585,872
Yauca	68,296	22	184,340,033
Chira	35,280	11	95,225,436
U. Chira	307,210	98	829,200,856
Total	618,913	–	1,670,528,920
Unit cost in Chincha River Basin = 2,699.13 (Sol/ha) (Calculation sample: in Canete River Basin) 110,111.72 / 44,068.53 x 14 = 35 (yeas) 110,111.72 / 44,068.53 x 118,946,853 = 297,206,251 (ha)			

(Source: JICA Study Team)

(4) Distribution of Nurseries (Reference)

The distributions of nurseries in each river basin are shown in ***Appendix 7 Figure 6.1*** to ***6.5*** to refer them for implementation of the long-term plan in future. Additionally, the figures show 5 river basins due to no community nurseries in Chira River Basin. The community nursery is prepared by the guidance and supports by AGRORURAL. It is suggested that the communities with the nurseries have experience of seedling producing and also they have concerning to afforestation. Therefore, it is assumed that the nurseries distribution can be one of indications of feasibility of afforestation implementation in the Sierra. The number of nurseries is large as shown in ***Table 3.14*** and it means a lot of communities have interest on afforestation. However, the average of productivity of seedlings is approximately 7 thousand, the possible production of seedlings in each river basin are approximately 80 to 380 thousand. If the seedlings would be provided from only those nurseries, the possible afforestation area per year is only 30 to 130 ha (assumption: 3,000 trees /ha). A drastic expansion of nursery scale is supposed to be necessary for the consideration of long/medium-term afforestatin plan, and it shall be considered deeply. The locations of distributions of the nurseries in each river basin and capacities are shown in ***Appendix 7-Table 3***.

Table 3.14 **Capacities and Areas of Community Nurseries in each River Basin**

River Basin	No. of Nurseries	Capacity of Seedling Production (No.)		Area (m^2)	
		Total	Average	Total	Average
Canete	43	292,000	6,791	6,885	160
Chincha	12	77,000	6,417	3,567	297
Pisco	22	158,000	7,182	7,035	320
Yauca	22	189,700	8,623	10,110	460
Camana-Majes	52	379,800	7,304	16,658	320
Total	151	1,096,500	7,263	44,255	311

(Source: JICA Study Team based on AGRORURAL documents)

3.3 Medium-Term Afforestation Plan (in Upper Stream Area)

(1) Basic Principle

(i) Purpose: Improve the infiltration of soil in the watershed areas, decrease the amount of surface runoff and increase the middle/ground water. These will be expected to cut the peak amount of the flood, increasing the water amount in the river basin area, and finally will contribute to prevent/mitigate flood disaster.

(ii) Target areas: Available areas in the watershed, or forest degradation areas should be selected as forestation areas. The target areas are selected based on the afforstation plan in Chincha River Basin (by AGRORURAL). The areas with feasibility to implemented within short time period relatively are selected.

(iii) Afforestation manner: Forestation works should be carried by the local communities. It will be managed by following three items; i) the promoters of the communities themselves, ii) filed work management by the NGOs, and iii) education/management of NGOs by the Consultant.

(iv) Maintenance of planted trees: The maintenance of the planted trees will be carried out by the communities which implemented the forestation work. The maintenance fee will be paid by the beneficiaries of the down stream (= water users groups). The PES (payment for environment service) system is required to be established for it.

(v) Notes: The re-plantation after harvesting should be carried out for the sustainable forest conservation. Control and maintenance of the forest with long term aspect is required. For this point of view, incentive of the communities in the upper stream areas is necessary. The long-term forest conservation can be realized with maintenance and reforestation after harvesting by the communities, and the functions of the forest for prevention/mitigation of flood can work well. The required points of education and expansion activities for the communities in the upper stream during the Project period are: i) significance of forestation, ii) contribution to the downstream areas, necessity of forestation with wide view as whole Peru.

(2) Selection of Target Afforestation Area

The target areas are selected from the existing plan, the reasons are followings.

(i) The afforestation in the upper stream will be implemented by local communities. They would contribute to the afforestation work between farm works. However, it is assumed that they have not much enough time for this, because their agriculture/grazing activities are all under sever conditions. Therefore, usually promotion of their understanding and agreement take long time for afforestation implementation. Thus, the areas where the

communities have agreed with afforestation implementation are adequate.

(ii) Only Chincha and Chira River Basin have existing project plans. I Chincha River Basin, the water users group has discussed with the communities located in the upper stream in the watershed for about 10 year. They have obtained agreements with some communities. The PRONAMACHCS (present AGRORURAL) followed these agreements and conducted the study in the upper stream of Chincha Rive Basin.

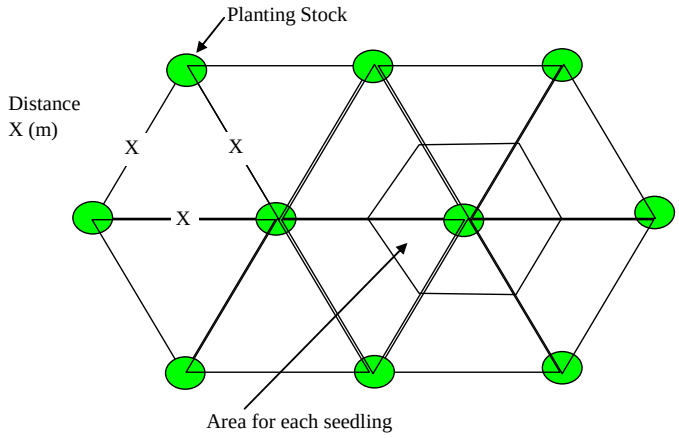
(iii) The Catamayo – Chira project, which is based on the cooperation study between two countries (Peru and Ecuador). Some activities of soil conservation and watershed forest conservation are on-going. These are the parts of the components of the project. The project budget is shared by three funds as; funded by the Government of Spain (70% of whole budget), by the Government of Peru (15%), and by the Government of Ecuador (15%). The forestation plans are located in the watershed areas. Those areas overlap with the target areas of forestation by the Project. Such overlap of the project target areas should be avoided.

Aa described above, the target areas of the medium-term afforestation plan are selected from the existing planed areas in Chincha River Basin, because i) the agreement with communities are formulated, ii) the plan was prepared but not implemented due to shortage of budget in the river basin.

(3) Amount of Afforestation (medium-term plan)

(a) Layout of Planting

In Peru, the equilateral-triangular layout of the planting points is common. This layout is taken in the Project, the distance between the planting points is set as 3m. The number of planting stocks per ha is 2,960.



Distance	Area for each seedling	No. of planting seedlings per ha
2m	1.50 m^2	6,670 (Sp/ha)
3m	3.38 m^2	2,960 (Sp/ha)
5m	9.38 m^2	1,070 (Sp/ha)
6m	13.50 m^2	740 (Sp/ha)

Figure 3.5 **Layout of Planting Points (Forestation in Upper Stream)**

(Source: JICA Study Team)

(b) Planting Species

Eucalyptus is common for the forestation species in the Andes highland in Peru followed by pine. Especially, pine is used for the forestation in the area of more than 4,000m in elevation. The other used species are, Quinual, Molle, Aliso, that are all native species, are used too but not many. The reason why Eucalyptus or pine are used for forestation commonly are i) they generate income and ii) they can be used for fuel wood. Tara is used for agro-forestry species. Recently, it becomes popular because, it generate high cash income relatively. ***Table 3.15*** shows list of planting stock production in Huancavelica Region.

Table 3.15 **List of Planting Stock Production (Forestation in Upper Stream)**

River basin	Provider	Location of Producing	Producing Usually	Producing Sometimes
Chincha River Basin (Upper Strem)	AGRORURAL	Hancavelica	Quinual, Pine Eucalyptus	Aramo Colle Sauce Tara
	FOMECO SAC	Huancayo (Junin Region)	Quinual Colle Pine Eucalyptus	Aliso Sauce Cypress

(Source: Hearing from providers)

Usually, the afforestation in upper stream areas of any river basins is planed and implemented based on the agreement between the community and the project initiator. The afforestation plan in upper stream of Chincha River Basin was planed by AGRORURAL. During the study, AGRORURAL held the stakeholders meetings, took discussions, and decided the planting species

through these communication with the communities. Also, AGRORURAL explained the public function of the forests, characteristics of the tree species, and made effort to build consensus. Therefore, the decided planting species are evaluated as appropriate. The locations of the planed forestation areas are shown in ***Figure 3.6***. The figure shows that pine is used in the most of the planed area, Quinel is used in the low elevation areas. These planting tree species are used for the Project.

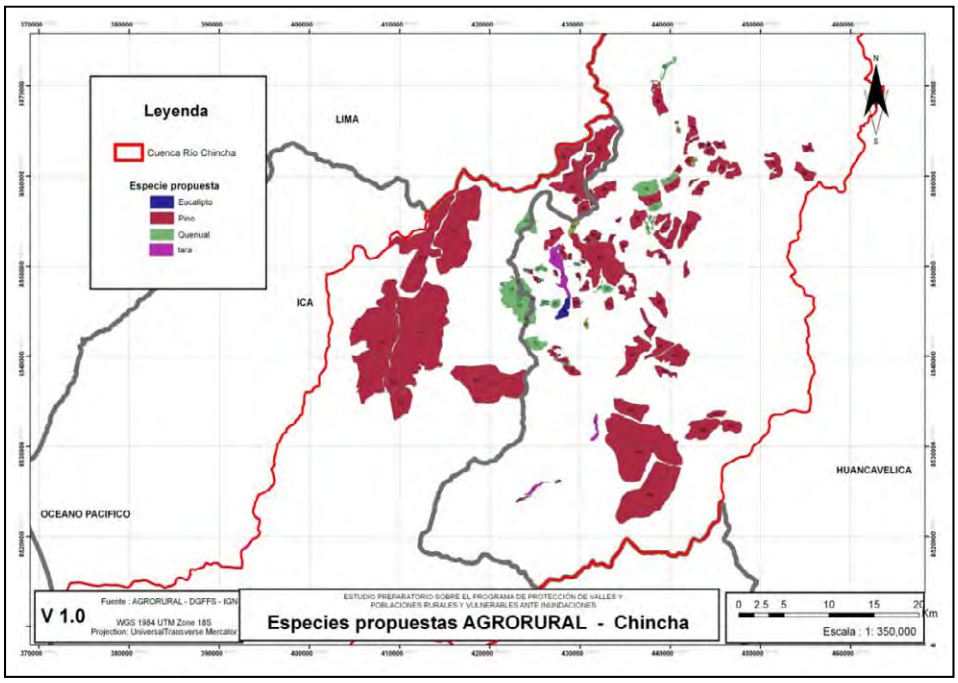


Figure 3.6 **Location of Afforestation Areas by Species (Existing Plan in Chincha River Basin)**
(Source: JICA Study Team based on Documents of AGRORURAL)

(c) Amount of Afforestation/Vegetation Recovery Plan

The area of the existing afforestation plan in the upper stream areas of Chincha River Basin is 44,068.53 ha. The criteria below are set to refine the afforestation/vegetation recovery areas for the Projects from the original plan. The criteria are considered that the plan can be finished in the project period.

(Criteria to refine the forestation areas)

- The area is located in the watershed, (to be effective)
- The area is expected to be eroded much, (to be effective, refer to ***Appendix 7-Figure 4***)
- Villages are located near to the area and labors for forestation work can e recruited easily (for the operation effectiveness, refer to ***Figure 3.7***)
- The area is located lower then 4,000m above sea level to prevent cold weather damage (refer to ***Appendix 7-Figure 5***).

Table 3.16 **Area of Afforestation/Vegetation Recovery (in the Upper Stream of Chincha River Basin)**

Group A

No.	Forestation area (ha)			No. of plating stocks（ x 1,000）			Annual Year
	Pine	Quinel	Total	Pine	Quinel	Total	
47	650.04	－	650.04	1,924	－	1,924	2
48	311.91	－	311.91	923	－	923	2
49	211.90	－	211.90	627	－	627	3
50	276.40	－	276.40	818	－	818	3
51	79.94	－	79.94	237	－	237	3
52	166.27	－	166.27	492	－	492	3
53	55.96	－	55.96	166	－	166	3
56		0.05	0.05	－	0	0	3
61	67.58	－	67.58	200	－	200	4
102	548.38	－	548.38	1,623	－	1,623	4
103	161.45	－	161.45	478	－	478	4
Total	2,529.83	0.05	2,529.88	7,488	0	7,488	

Group B

No.	Forestation area (ha)			No. of plating stocks（ x 1,000）			Annual Year
	Pine	Quinel	Total	Pine	Quinel	Total	
42	－	63.03	63.03	－	187	187	2
43	－	24.30	24.30	－	72	72	2
44	－	12.22	12.22	－	36	36	2
45	249.00	－	249.00	737	－	737	3
65	－	397.23	397.23	－	1,176	1,176	2
66	14.69	－	14.69	43	－	43	3
67	1.06	－	1.06	3	－	3	3
68	26.90	－	26.90	80	－	80	3
69	30.28	－	30.28	90	－	90	3
70	0.00	－	0.00	0	－	0	3
71	236.58	－	236.58	700	－	700	3
72	－	76.53	76.53	－	227	227	4
73	－	128.96	128.96	－	382	382	4
74	173.82	－	173.82	515	－	515	4
75	55.19	－	55.19	163	－	163	4
76	66.34	－	66.34	196	－	196	4
77	14.82	－	14.82	44	－	44	4
78	165.11	－	165.11	489	－	489	4
79	89.24	－	89.24	264	－	264	4
Total	1,123.03	717.09	1,825.30	3,324	2,080	5,404	

(Source: JICA Study Team)

(Annual Year Plan): The Project is planned to be implemented in four years. The first year is preparation stage, the forestation works will be implemented in three years as from the second year to the fourth year. The amount of forestation areas is planned to be almost same for each year. The planed areas located near each other are planned in same year for implementation. The plan of forestation areas for each annual year are shown in ***Table 3.17***.

Table 3.17 **Afforestation Areas in Each Year (in the Upper Stream of Chincha River Basin)**

Forestation No.	Forestation Area (ha)		
	Pine	Quinel	Total
Group A			
2nd year	961.95	0.00	961.95
3rd year	790.47	0.05	790.52
4th yeat	777.41	0.00	777.41
Subtotal	2,529.83	0.05	2,529.88
Group B			
2nd year	0.00	496.78	496.78
3rd year	558.51	0.00	558.51
4th year	564.52	205.49	770.01
Subtotal	1,123.03	702.27	1,825.30
Total	3,652.86	702.32	4,355.18

(Source: JICA Study Team)

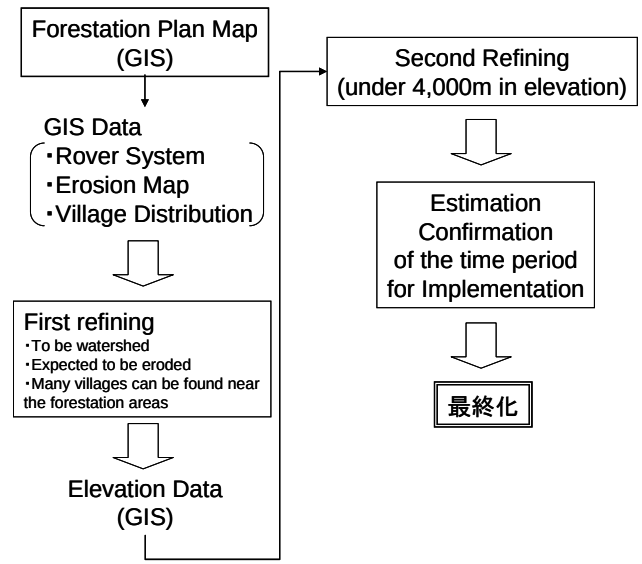


Figure 3.7 **Flow of Refining the Forestation Areas**

(Source: JICA Study Team)

The flow of refining the afforestation areas is shown in the left.

The first refining: location data of afforestation area was converted into GIS system. The areas were selected by the relation between the forestation area and river system/erosion map/village distribution map. Then, the area lower than 4,000m in elevation were selected in the second refining. The refined afforestation areas were grouped into A and B by layout, and each subtotal of the area were calculated. The necessary year period is estimated by the subtotal of the forestation area. The forestation areas for each group was confirmed to be finished within the Project period, then finalized. The finalized afforestation areas are shown in ***Figure 3.8***. The Group A and B are planed to be implemented by the Project. Additionally, the Group C was shown in the Figure to be show the ample of the not-selected areas. The population density in the Group C area is very low, and the amount of labors is estimated less. As the result of estimation, more than 10 years is required to implemented the group C. Therefore, Group C was not selected for the project.

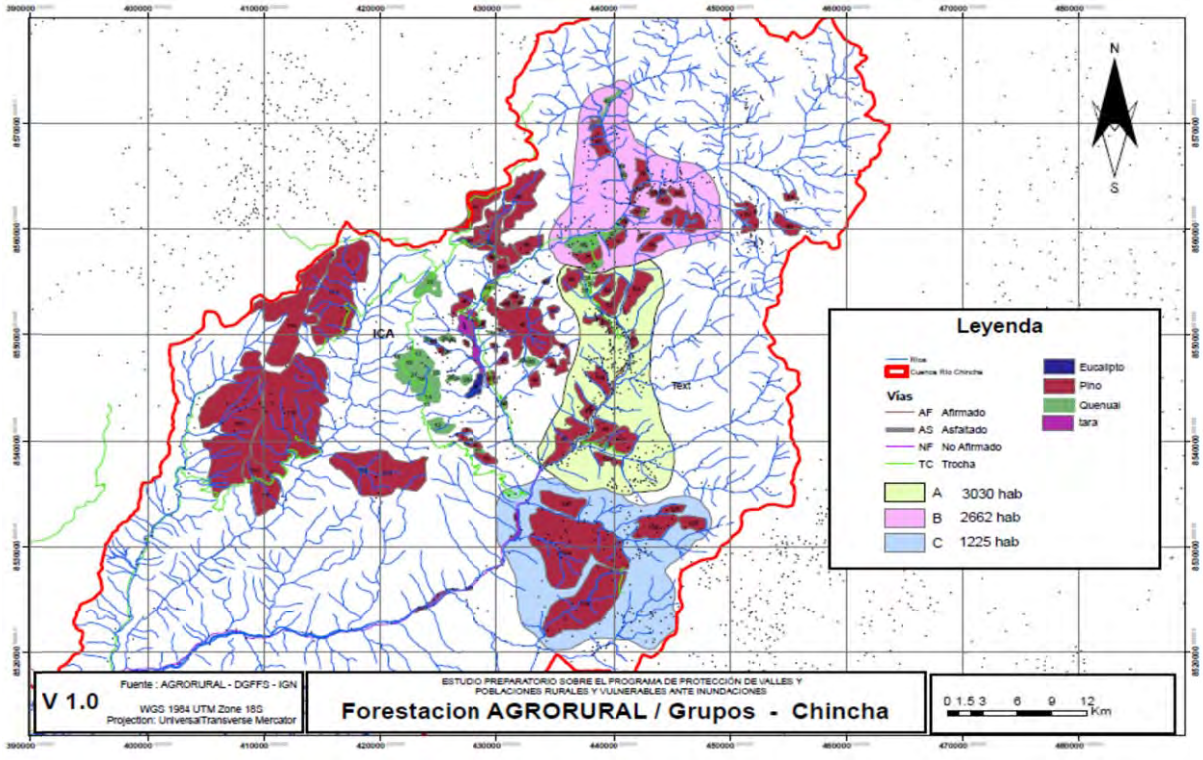


Figure 3.8 **Afforestation/Vegetation Recovery Plan in Upper Stream of Chincha River Basin**
(Source: JICA Study Team based on the documents of AGRORURAL)

(4) Cost of Afforestation Plan (Medium-Term Plan)

(a) Unit Price

The direct cost of the forestation/vegetation recover is composed with the following items.

- Unit price of seedling (price of seedling and transportation cost)
- Labor cost
- Direct expense (equipments fee: 5% of the labor cost)

(b) Price of Seedling

The unit prices of the seedlings for the upper stream of Chincha River Basin are shown in ***Table 3.18***. The Table was prepared by hearing from AGRORURAL Huancavelica Office. (Detail information of the unit cost is shown in ***Appendix 7-Table 2***).

Table 3.18 **Unit Price of Seedling (Upper Stream Area in Chincha River Basin)**

River Basin	Species	Unit Price (Sol./seedling)
Chincha	Pinus	0.50
	Quinel	0.45

Note: Unit price of seedling = (Seedling price + transportation fee)
(Source: Hearing from AGRORURAL)

(c) Labor cost

The labor cost for the riparian forestation is estimated as 33.6 sol/man-day, which is used for the general construction. The one in the upper stream in Chincha River Basin is estimated as 16.8 sol/man-day as the half of the general price, remaining half of cost is defrayed by communities, because the forestation is linked to the benefit for the communities.

(d) Cost Estimation for Afforestation/Vegetation Recovery in Upper Stream Areas in Chincha River Basin

The unit cost of afforestation work in the upper stream areas in Chincha is estimated as following procedure.

1) Unit price of seedling by species

The unit price of seedling by species is calculated based on hearing from AGRORURAL as below.

Classification	Unit	Pine	Quinel
Seedling price (Shipping stage)	Sol/seedling	0.40	0.35
Transportation fee	Sol/seedling	0.10	0.10
Seedling price (Delivery stage)	Sol/seedling	0.50	0.45

2) Planting cost per 100 seedlings

It is assumed as the planting density and difficulty of planting work are assumed as not be changed by species. The planting works cost per 100 seedlings is calculated as below.

Classification	Unit	Cost
Labor cost	Sol/man-day	16.8
Unit work amount	Seedlings/man-day	40.0
Planting cost per 100 seedlings	Sol/ 100 seedling	42.0

3) Unit cost of forestation work per ha

The unit cost of forestation work per ha is calculated by the unit cost of seedling and planting cost per 100 seedlings as below.

Classification	Unit	Pine	Quinel
No. of planting stocks/ha	Seedling/ha	2,960	2,960
Seedling cost	Sol/ ha	1,480	1,332
Planting cost	Sol/ ha	1,243	1,243
Forestation work cost	Sol/ ha	2,723	2,575

4) Afforestation cost

The direct cost of the forestation work in the upper stream areas in Chincha River Basin is shown in ***Table 3.19***.

Table 3.19 **Direct Cost of Afforestation/Vegetation Works in the Upper Stream of Chincha River Basin**

Group A

ID of Forestation Area	Direct Cost of Forestation Work (Sol)		
	Pine	Quinel	Total
47	1,770,059	-	1,770,059
48	849,331	-	849,331
49	577,004	-	577,004
50	752,637	-	752,637
51	217,677	-	217,677
52	452,753	-	452,753
53	152,379	-	152,379
56	-	129	129
61	184,020	-	184,020
102	1,493,239	-	1,493,239
103	439,628	-	439,628
Subtotal	6,888,727	129	6,888,856

Group B

ID of Forestation Area	Direct Cost of Forestation Work (Sol)		
	Pine	Quinel	Total
42	-	162,302	162,302
43	-	62,573	62,573
44	-	31,467	31,467
45	678,027	-	678,027
65	-	1,022,867	1,022,867
66	40,001	-	40,001
67	2,886	-	2,886
68	73,249	-	73,249
69	82,452	-	82,452
70	-	-	-
71	644,207	-	644,207
72	-	197,065	197,065
73	-	332,072	332,072
74	473,312	-	473,312
75	150,282	-	150,282
76	180,644	-	180,644
77	40,355	-	40,355
78	449,595	-	449,595
79	243,001	-	243,001
Group B Subtotal	3,058,011	1,808,346	4,866,357
Total of Group A & B	9,946,738	1,808,475	11,755,213

(Source: JICA Study Team)

5) Assistance of NGOs

In accordance with the principle of the forestation work in the upper stream areas in Chincha, the forestation work should be carried out by the local communities. The assistance of NGOs is required to realize this principle from the detail design stage. The details of this concept and cost on NGOs' assistance is described (7) 'Technical Support Plan'

(5) Cost by Benefit Estimation of the Forestation/Vegetation Works of the Project

The riparian afforestation/vegetation recovery works are the part of the construction along to the rivers such as, dikes, revetments, etc. Therefore, cost by benefit (B/C) of the forestation/vegetation works are calculated in the one of constructions.

The B/C of the forestation in the upper stream in Chincha was calculated by using the following items; i) sample of cash flow of the standard pine production forest in the Andes Highland in Peru, ii) "Advance evaluation manual of projects evaluation manual" prepared by the Forest/forestry Agency in Japan.

(a) Sample of cash flow in the Andes Highland in Peru

Table 3.20 is prepared based on the model which is shown in ***Table 3.21***, twice thinning and once main final cutting are assumed during 20 years.

Table 3.20 **Cash Flow of Pine Forestation/Production in the Andes Highland in Peru**

(Unit: US$/ha)

Year	Investment Cost	Operation Cost	Management Cost	Income	Cash flow (W/o tax)	Income Tax	Cash Flow (W tax)
	A	B	C	D	E=D-(A+B+C)	F	G=E-F
0	915.14	79.43	119.35	0.00	-1,113.92	0.00	-1,113.92
1	84.05	261.67	41.49	0.00	-387.21	0.00	-387.21
2	0.00	261.67	31.40	0.00	-293.07	0.00	-293.07
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	371.98	44.64	600.00	183.38	55.00	128.38
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	554.26	66.51	1,625.00	1,004.23	301.00	703.23
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	7,625.00	7,625.00	2,288.00	5,337.00
計	999.19	1,529.01	303.39	9,850.00	7,018.41	2,644.00	4,374.41

(Source: Basic Information for forestation in Peru (Bases para la promocion de plantaciones forestales en el Peru)

Table 3.21 **Harvest Model of Forest Operation of Pine per ha**

Content	1st cutting (7th year)	2nd cutting (14th year)	Final Cutting (20th year)
Volume (m3/ha)	30	65	305
Average Diameter (cm)	12	20	32
Average Height (m)	9.5	16.5	25.3
Harvesting No. of trees	550	250	300

(Source: Basic Information for forestation in Peru (Bases para la promocion de plantaciones forestales en el Peru)

(b) Cash flow of afforestation work and operation of the Project

The following revisions are taken to apply ***Table 3.20*** to the afforestation/vegetation recovery works of the Project.

(i) Replace the investment cost in the first (0) year to the cost of seedlings of the Project,

(ii) Replace the operation cost in the first year (0) to the planting work cost of the Project,

(iii) The other factors are revised by the ratio of No. of the planted trees per ha. The model, 1,100 seedlings planting, was used in ***Table 3.20***. The ratio of premium, the number of the model and the number of the planting seedlings in the Project (2,960 per ha) is used for re-calculation. The revised cash flow is shown in ***Table 3.22***.

Table 3.22 **Revised Cash Flow of Pine Forestation/Production**

(Unit: US$/ha)

Year	Investment Cost	Operation Cost	Management Cost	Income	Cash flow (W/o tax)	Income Tax	Cash Flow (W tax)
0	535.07	449.39	321.16	0.00	-1,305.62	0.00	-1,305.62
1	226.17	704.13	111.65	0.00	-1,041.95	0.00	-1,041.95
2	0.00	704.13	84.49	0.00	-788.62	0.00	-788.62
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	1,000.96	120.12	1,614.55	493.47	148.00	345.47
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	1,491.46	178.97	4,372.73	2,702.30	809.96	1,892.34
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	20,518.18	20,518.18	6,156.80	14,361.38
計	761.24	4,350.07	816.39	26,505.46	20,577.76	7,114.76	13,463.00

(Source: JICA Study Team based on "Basic Information for forestation in Peru (Bases para la promocion de plantaciones forestales en el Peru)"

(Estimation of benefit of Carbon Fix)

The system for evaluation of carbon fix in Peru is not build up yet. Therefore, the cost/benefit analysis of the forestation of the Project was carried out adding the carbon fix benefit which was calculated by the manual of the Forestry Agency in Japan.

(Formula of calculation of carbon fix benefit)

The carbon fix benefit is calculated by the following formula (referred to "Advance Evaluation Manual for the Public Works of the Forestry Projects in Japan", "List of Unit Price for the Project Evaluation in Japan, June 2009", Forest/Forestry Agency of Japan).

$$B = \sum_{t=1}^{Y} \frac{V2 - V1}{Y \times (1+i)^t} \times BEF \times (1+R) \times 0.5 \times \frac{44}{22} \times U$$

here,

U : Basic unit of carbonic anhydride (JPY6,046/CO2-ton)

V1 : Expected stock amount without project (m3/ha)

V2 : Expected stock amount with project (m3/ha)

Y : Evaluation period (year)

D : Bulk density (0.440: the value of Pine in Japan)

BEF : Coefficient of expanding biomass (1.51)

R : Rate of content of carbon of plant (0.5)

44/12 : Conversion factor from carbon to carbonic anhydride

The cost/benefit analysis was carried out with the following points in this Study.

U : JPY was Converted into US$

V2 : Annual stock per ha is calculated using ***Table 3.23***. The calculation annual growth, cutting Expected stock amount with project (m3/ha)

V1 : zero (the forestation of the Project is set at the area has not been a forest).

Y : 20 years

The yearly estimated stocks are shown in ***Table 3.23***.

Table 3.23 **Yearly Stocks per ha**

Year	Stocks (m3/ha)	Remarks
0	0	
1	4.29	
2	8.57	
3	12.86	
4	17.14	
5	21.43	No. of trees before cutting 1,100 trees/ha
6	25.71	Decrease of stocks by cutting; No. of trees after cutting 55 Trees/ha
7	30.00	15.00 : Stocks after cutting
8	22.14	
9	29.29	
10	36.43	
11	43.57	
12	50.71	No. of trees before cutting 550 Trees/ha
13	57.86	No. of trees after cutting 300 trees/ha
14	65.00	35.45 : Stocks after cutting
15	80.38	
16	125.30	
17	170.23	
18	215.15	

19	260.08	
20	305.00	

(JICA Study Team)

As a result, B/C (/ha) is calculated as 5.20, ENPV (Expanded Net Present Value) is 14,593US$. The details of calculation process is shown in ***Table 3.24***.

Table 3.24 **Calculation Sheet of Benefit per Cost of Pine Forestation Project (Unit: US$/ha)**

Year	Investment Cost	Forestry Operation Cost	Management Cost	Income	Cash Flow (w/o tax)	Income Tax	Cash Flow (w tax)	Total of Cost	Benefit by Carbon Fix	Total of Benefit
	(A)	(B)	(C)	(D)	(D) -(A)-(B)-(C)	(E)	(D)-(E)	(A)+(B)+(C)	(F)	(D)-(E)+(F)
0	481.56	449.39	321.16	0.00	-1,252.11	0.00	-1,252.11	1,252.11	0.00	0.00
1	226.17	704.13	111.65	0.00	-1,041.95	0.00	-1,041.95	1,041.95	222.79	222.79
2	0.00	704.13	84.49	0.00	-788.62	0.00	-788.62	788.62	445.58	445.58
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	668.37	668.37
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	891.16	891.16
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,113.95	1,113.95
6	0.00	1,000.96	120.12	1,614.55	493.47	148.00	345.47	1,121.08	1,336.74	2,803.29
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,559.53	1,559.53
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,151.08	1,151.08
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,522.39	1,522.39
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1,893.71	1,893.71
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,265.03	2,265.03
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2,636.34	2,636.34
13	0.00	1,491.46	178.97	4,372.73	2,702.30	809.96	1,892.34	1,670.43	3,007.66	6,570.43
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3,378.97	3,378.97
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4,178.43	4,178.43
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6,513.78	6,513.78
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8,849.13	8,849.13
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11,184.48	11,184.48
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	13,519.84	13,519.84
20	0.00	0.00	0.00	7,625.00	7,625.00	-2,288.00	5,337.00	0.00	15,855.19	21,192.19

Net Present Value (NPV) of cost = 3,477.84
NPV of Benefit =18,071.01
BCR ＝ 5.20
ENPV ＝ $14,593

(6) Implementation Plan (Upper Stream Area of Chincha River Basin)

(The First Year: Preparatory Phase): i) Selection of NGOs by the Consultant (the NGOs assist the communities' activities), ii) Detail design of the forestation by NGOs, iii) Institutional framework in the communities for the Implementation of forestation by NGOs, and iv) seedlings producing.
(Second year to Fourth year): The forestation work will be implemented during this three years. Normally, the seedling nursing can be carried out within three to six months. However, in the Project the matured seedlings will be used to rise the survival ration. The seedling nursing period in the Project will be taken longer than normal case. In particular, seedlings will be nursed during the dry season (April to October: about seven (7) months), the planting work will be carried out during the rainy season (November to March: about four (4) months).
During the Project, the re-forestation system is planned to be formulated using PES. The discussion and agreement between the beneficiaries in downstream (mainly water users group) and community in upper stream will be supported by the Project. In future, the communities in the upper stream will enable to benefits by logging and they would also implement re-forestation using the budget support from the water users groups.

Year	Dry Season							Rainy Season				
	Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1	Preparatory period											
2	Seedling production (8 months)							Planting work				Spare
3	-ditto-							-ditto-				Spare
4	-ditto-							-ditto-				Spare

Figure 3.9 **Implementation Schedule(Medium-Term Afforestation Plan)**

(Source: JICA Study Team)

(7) Technical Assistance Plan

The forestation at the upper stream of the river basin will be implemented after the following activities as, i) education and expansion of the necessity of the forestation to the local communities, ii) institutional framework in the communities for the forestation work. While, sustainable forest conservation in upper stream is required for flood deserter mitigation. Re-forestation works system shall be formulated to realize this, and the specialists' (consultants) technical supports and NGO who would support communities at the field are required.

(a) Support Framework

The followings show the lists of necessary supports by the Consultant and NGO.

(i) Supports by Consultant

a) Preparation of TOR for NGO activities
b) Selection of NGO
c) Management and technical support on NGO

(ii) Supports by NGO

a) Preparation of detail afforestation plan (including field survey)
b) Selection of communities who will implement afforestation work
c) Support to afforestation committee in the communities
d) Support to selection of the promoter in the communities
e) Assistance on afforestation techniques
f) Management of seedling production/producing
g) Management of afforestation works
h) Extension and education of afforestation/forest conservation
i) Assistance on PES formulation

The following Figure shows the relation among the Implantation Agency, Consultant, NGO, Community, AGRORURAL.

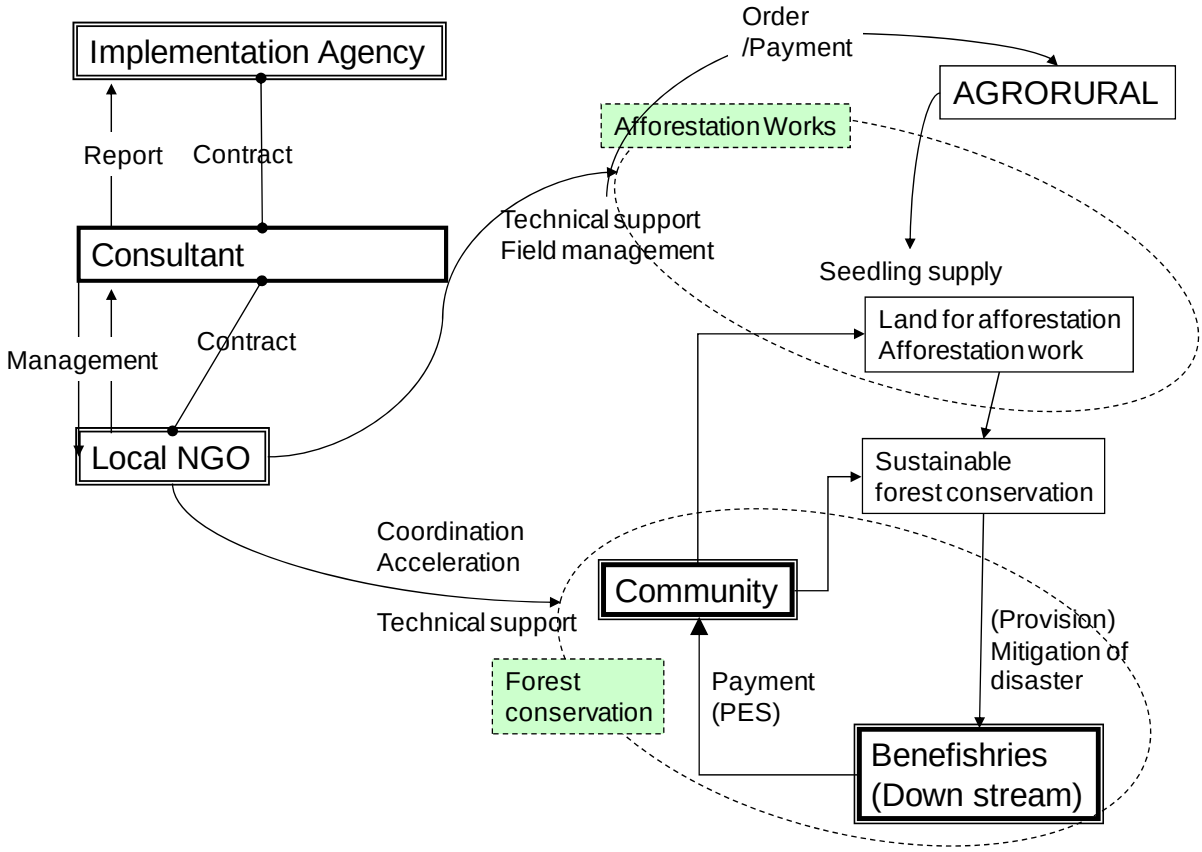


Figure 3.10 **Afforestation Implementation Framework**

(Source: JICA Study Team)

(b) Support Plan

The support of the afforestation/ vegetation recovery plan during the first year is preparation for the second year or later. The Consultant prepares TOR for NGO, select NGO, negotiation and making contract. After contract, the Consultant manages NGO works and technical support for them. NGO prepares the detail design and taking the preparation support works such as, selection of the promoter, afforestation committee, education/expansion of afforestation/ forest conservation, etc.

After the second year, the NGO manages the afforestation works in the field and the Consultant manages NGO and supports them technically. The NGO assists the communities on formulating PES system between the beneficiaries in the down stream. PES system works for the sustainable forest conservation after the Project.

These supports plans are shown in ***Figure 3.11*** to ***3.14***. Figure ***3.11*** and ***3.12*** show the support plans related to the afforestation works, and ***Figure 3.13*** and ***3.14*** show the supports for the activities after the project such as education/extension of forest conservation to the communities and PES formulation.

Year	Classification	Dry season								rainy season					Assignment schedule		
		Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	MM	Person	Total MM
(D/D)	(D/D Assignment)															
1st year	Afforestation Pro-A													7.0	1	7.0
	Afforestation Pro-B													15.0	1	15.0
	Afforestation Assistant													15.0	2	30.0
(Supervising)	(Supervise Assingment)															
2nd year	Afforestation Pro-A													3.5	1	3.5
	Afforestation Pro-B													8.0	1	8.0
	Afforestation Assistant													8.0	1	8.0
3rd year	Afforestation Pro-A													2.5	1	2.5
	Afforestation Pro-B													8.0	1	8.0
	Afforestation Assistant													8.0	1	8.0
4th year	Afforestation Pro-A													2.5	1	2.5
	Afforestation Pro-B													8.0	1	8.0
	Afforestation Assistant													8.0	1	8.0
	Supervise (Assingment Total)															
	Afforestation Pro-A															8.5
	Afforestation Pro-B															24.0
	Afforestation Assistant															24.0

Figure 3.11 **Supporting Plan on Afforestation/Vegetation Recovery Work (1) (by Consultant)**

(Source: JICA Study Team)

Year	Classification				Dry season							rainy season					Assignment schedule		
					Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	MM	Person	Total MM
(D/D)	(D/D Assignment)																		
1st year	AF Pro-B class: Planning																10.0	2	20.0
	AF Pro-B class: seedling, purchase																2.0	2	4.0
	Technical Assistant																12.0	6	72.0
	Pro-B class: Total																		24.0
	Technical Assitant: Total																		72.0
(Supervising)	(Supervise Assingment)																		
2nd year	AF Pro-B class: seedling																4.0	2	8.0
	AF Pro-B class: afforestation																5.0	2	10.0
	Technical assistant																9.0	6	54.0
3rd year	AF Pro-B class: seedling																4.0	2	8.0
	AF Pro-B class: afforestation																5.0	2	10.0
	Technical assistant																9.0	6	54.0
4年次	AF Pro-B class: seedling																4.0	2	8.0
	AF Pro-B class: afforestation																5.0	2	10.0
	Technical assistant																9.0	6	54.0
	Total of Pro-B class																		54.0
	Total of Technical assistant																		162.0

Figure 3.12 **Supporting Plan on Afforestation/Vegetation Recovery Work (2) (by NGO)**

(Source: JICA Study Team)

Year	Classification	Dry season							rainy season					Assignment schedule		
		Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	MM	Person	Total MM
(D/D)	(D/D Assignment)															
1st year	Community Development Pro-A													7.0	1	7.0
	C/D Pro-B													15.0	1	15.0
	C/D Assitant													15.0	2	30.0
	PES Pro-A													4.0	1	4.0
	PES Pro-B													7.0	1	7.0
	PES Assistant													7.0	2	14.0
	Total: Pro-A															11.0
	Total: Pro-B															22.0
	Total: Assistant															44.0
(support on	(suport on Community)															
community)	C/D Pro-A													2.0	1	2.0
2nd year	C/D Pro-B													5.0	1	5.0
Education	C/D Assitant													5.0	1	5.0
/extension	PES Pro-A													2.0	1	2.0
Livlifood Dev.	PES Pro-B													6.0	1	6.0
	PES Assistant													6.0	2	12.0
3rd year	C/D Pro-A													2.0	1	2.0
Education	C/D Pro-B													5.0	1	5.0
/extension	C/D Assistant													5.0	1	5.0
Livlifood Dev.	PES Pro-A													2.0	1	2.0
	PES Pro-B													6.0	1	6.0
	PES Assistant													6.0	2	12.0
4th year	C/D Pro-A													2.0	1	2.0
Education	C/D Pro-B													5.0	1	5.0
/extension	C/D Assistant													5.0	1	5.0
Livlifood Dev.	PES Pro-A													2.0	1	2.0
	PES Pro-B													6.0	1	6.0
	PES Assistant													6.0	2	12.0
	Total: Pro-A															12.0
	Total: Pro-B															33.0
	Total: Assistant															51.0

Figure 3.13 **Supporting Plan on Community (1) (by Consultant)**

(Source: JICA Study Team)

Year	Classification	Dry season							rainy season					Assignment schedule		
		Apr.	May.	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	MM	Person	Total MM
(D/D)	(D/D Assignment)															
1st year	C/D Pro-B													12.0	2	24.0
	C/D Assistant													12.0	2	24.0
	PES Pro-B													6.0	1	6.0
	PES Assistant													6.0	2	12.0
	Total: Pro-B															30.0
	Total: Assistant															36.0
(support on	(suport on Community)															
community)	C/D Pro-B													5.0	1	5.0
2nd year	C/D Assistant													5.0	2	10.0
Education																
/extension	PES Pro-B													6.0	1	6.0
Livlifood Dev.	PES Assistant													6.0	2	12.0
3rd year																
Education	C/D Pro-B													5.0	1	5.0
/extension	C/D Assistant													5.0	2	10.0
Livlifood Dev.																
	PES Pro-B													6.0	1	6.0
	PES Assistant													6.0	2	12.0
4th year																
Education	PES Pro-B													5.0	1	5.0
/extension	PES Assistant													5.0	2	10.0
Livlifood Dev.																
	PES Pro-B													6.0	1	6.0
	PES Assistant													6.0	2	12.0
	Total: Pro-B															33.0
	Total: Assistant															66.0

Figure 3.14 **Supporting Plan on Community (2) (by NGO)**

(Source: JICA Study Team)

(8) Cost Estimation of Medium-Term Plan (Afforestation/ Vegetation Recovery)

(a) Cost of NGO

The cost of NGO regards to the supporting activities described above (2) corresponds to the cost of the contractor's cost of the construction works. Therefore, this costs is included into the direct cost. The activities of NGO are: i) supports for afforestation work, ii) education/extension on the afforestation/forest conservation, PES formulation. The activities are divided into Detailed Design (D/D) and preparatory period 1st year) and implementation period (2nd to 4th year). The cost of NGO is estimated by i) D/D cost and ii) implementation cost. The cost of NGO shown in ***Table 3.25***, ***3-26***.

Table 3.25 **Cost of NGO (D/D)**

(Amount: Sol)

Item			Unit	Amount	Unit Price	Amount (x1000)
A	Tchnical remuneration					
	1	Pro- A, International Consultant	M/M		73,000	
	2	Pro- B, Local Consultant	M/M	54	13,000	702
	3	Technical Assistant	M/M	108	7,000	756
		A: Sub Total				1,458
B	Direct Cost					
	1	International Airfare	trip		33,170	0
	2	Travel fee	trip		270	0
	3	Trip fee	trip		1,075	0
	4	Allowance, Accommodation fee				
		Pro- A	M/M		9,950	0
		Pro- B	M/M	54	4,980	269
	5	Stationery, commodity	Office/M	12	269	3
	6	Print/Report	L.S.	2	5,400	10
	7	Rent car	Car/M	24	5,400	130
	8	Housing expenditure				
		Pro- A	M/M		5,400	0
		Pro- B	M/M		2,700	0
	9	Communication charge (international/Local)	Office/M	12	2,700	32
	10	Mobilization allowance	person	17	530	9
	11	Office equipment	L.S.	2	26,870	54
	12	Workshop fee	L.S.	3	16,667	50
	13	Fuel, maintenance	Car/M	24	270	6
	14	Office opening, administration fee	Office/M	12	1,340	16
		B: Sub Total				579
		Direct Cost (A+B)				2,037
		C: Indirect Cost (20% of direct cost)				407
		Tax(IGV)＝(A+B＋C) x 19%				464
		Grand total				2,908

(Source: JICA Study Team)

Table 3.26 **Cost of NGO (Supervising)**

(Amount: Sol)

		Item	Unit	Amount	Unit Price	Amount (x1000)
A	Tchnical remuneration					
	1	Pro- A, International Consultant	M/M		73,000	
	2	Pro- B, Local Consultant	M/M	87	13,000	1131
	3	Technical Assistant	M/M	228	7,000	1596
		A: Sub Total				2,727
B	Direct Cost					
	1	International Airfare	trip		33,170	0
	2	Travel fee	trip		270	0
	3	Trip fee	trip		1,075	0
	4	Allowance, Accommodation fee				
		Pro- A	M/M		9,950	0
		Pro- B	M/M	87	4,980	433
	5	Stationery, commodity	Office/M	36	269	10
	6	Print/Report	L.S.	2	5,400	10
	7	Rent car	Car/M	69	5,400	372
	8	Housing expenditure				
		Pro- A	M/M		5,400	0
		Pro- B	M/M		2,700	0
	9	Communication charge (international/Local)	Office/M	69	2,700	186
	10	Mobilization allowance	person	16	530	8
	11	Office equipment	L.S.	2	26,870	54
	12	Workshop fee	L.S.	15	16,667	250
	13	Fuel, maintenance	Car/M	69	270	19
	14	Office opening, administration fee	Office/M	36	1,340	48
		B: Sub Total				1,390
		Direct Cost (A+B)				4,117
		C: Indirect Cost (20% of direct cost)				823
		Tax(IGV)＝(A+B＋C) x 19%				939
		Grand total				5,879

(Source: JICA Study Team)

(b) Cost of the Consultant

The Consultant supports on the NGO's activities. The costs of the Consultant are shown in ***Table 3.27***, and ***3.28***.

Table 3.27 **Cost of Consultant (D/D)**

(Amount: Sol)

Item			Unit	Amount	Unit Price	Amount (x1000)
A	Tchnical remuneration					
	1	Pro- A, International Consultant	M/M	18	73,000	1,314
	2	Pro- B, Local Consultant	M/M	37	13,000	481
	3	Technical Assistant	M/M	74	7,000	518
		A: Sub Total				2,313
B	Direct Cost					
	1	International Airfare	trip	8	33,170	266
	2	Travel fee	trip	8	270	2
	3	Trip fee	trip	8	1,075	8
	4	Allowance, Accommodation fee				
		Pro- A	M/M	18	9,950	179
		Pro- B	M/M	37	4,980	185
	5	Stationery, commodity	Office/M	12	269	3
	6	Print/Report	L.S.	1	5,400	5
	7	Rent car	Car/M	24	5,400	130
	8	Housing expenditure				
		Pro- A	M/M	0	5,400	0
		Pro- B	M/M	0	2,700	0
	9	Communication charge (international/Local)	Office/M	24	2,700	64
	10	Mobilization allowance	person	12	530	6
	11	Office equipment	L.S.	2	26,870	54
	12	Workshop fee	L.S.	0	0	0
	13	Fuel, maintenance	Car/M	24	270	6
	14	Office opening, administration fee	Office/M	12	1,340	16
		B: Sub Total				924
		Direct Cost (A+B)				3,237
		C: Indirect Cost (20% of direct cost)				615
		Tax(IGV)＝(A+B＋C) x 19%				3,852

(Source: JICA Study Team)

Table 3.28 **Cost of Consultant (Supervising)**

(Amount: Sol)

		Item	Unit	Amount	Unit Price	Amount (x1000)
A	Tchnical remuneration					
	1	Pro- A, International Consultant	M/M	20.5	73,000	1497
	2	Pro- B, Local Consultant	M/M	57	13,000	741
	3	Technical Assistant	M/M	75	7,000	525
		A: Sub Total				2,763
B	Direct Cost					
	1	International Airfare	trip	18	33,170	597
	2	Travel fee	trip	18	270	5
	3	Trip fee	trip	18	1,075	19
	4	Allowance, Accommodation fee				
		Pro- A	M/M	20.5	9,950	204
		Pro- B	M/M	57	4,980	284
	5	Stationery, commodity	Office/M	54	269	15
	6	Print/Report	L.S.	2	5,400	10
	7	Rent car	Car/M	42	5,400	227
	8	Housing expenditure				
		Pro- A	M/M	0	5,400	0
		Pro- B	M/M	0	2,700	0
	9	Communication charge (international/Local)	Office/M	54	2,700	146
	10	Mobilization allowance	person	11	530	6
	11	Office equipment	L.S.	2	26,870	54
	12	Workshop fee	L.S.	0	0	0
	13	Fuel, maintenance	Car/M	42	270	11
	14	Office opening, administration fee	Office/M	36	1,340	48
		B: Sub Total				1,626
		Direct Cost (A+B)				4,389
		C: Indirect Cost (20% of direct cost)				834
		Tax(IGV)＝(A+B＋C) x 19%				5,223

(Source: JICA Study Team)

(9) Total Cost

The total cost related to the afforestation/ vegetation recovery (Medium-Term Plan) is shown in ***Table 3.29***.

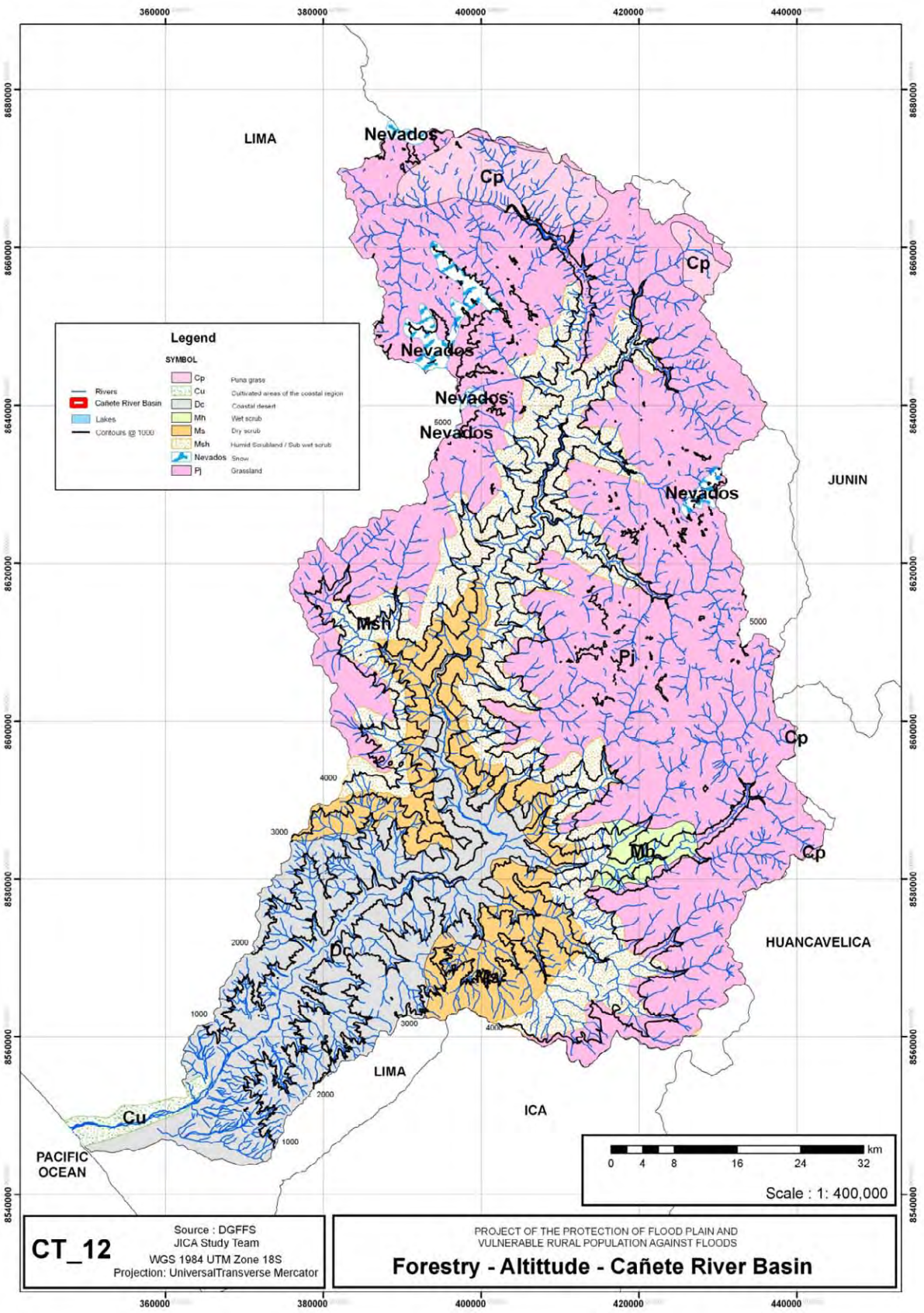
Table 3.29 **Total Cost of Afforestation/ Vegetation Recovery (Medium-Term Plan)**

(Unit: x 1,000 Sol)

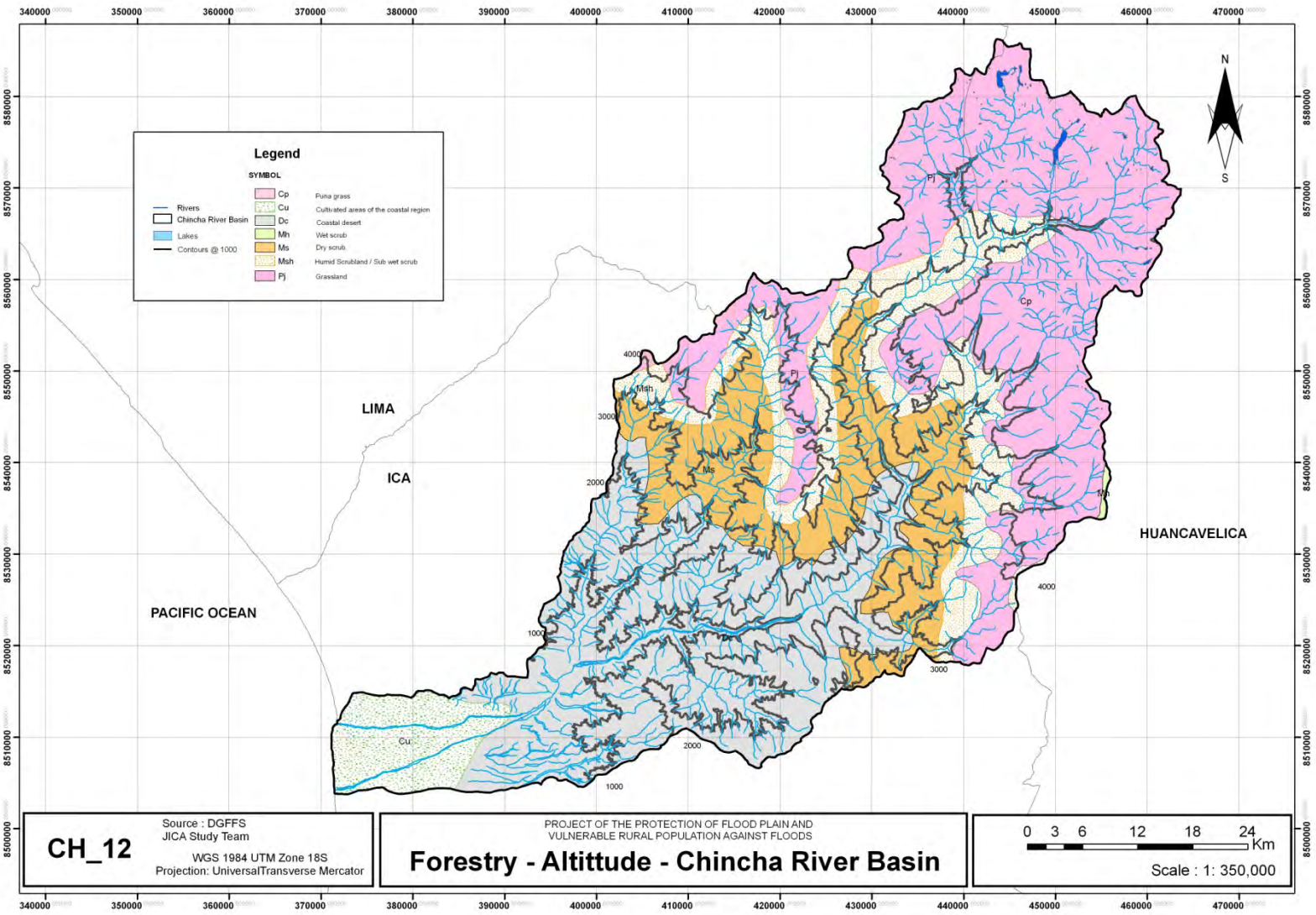
Direct Cost				Indirect Cost			Total
Cost of afoorestation	(NGO Cost)		Sub Total	(Consultant Cost)		Sub Total	
	D/D	Supervising		D/D	Supervising		
11,755	2,908	5,879	20,542	3,852	5,223	9,075	29,617

(Source: JICA Study Team)

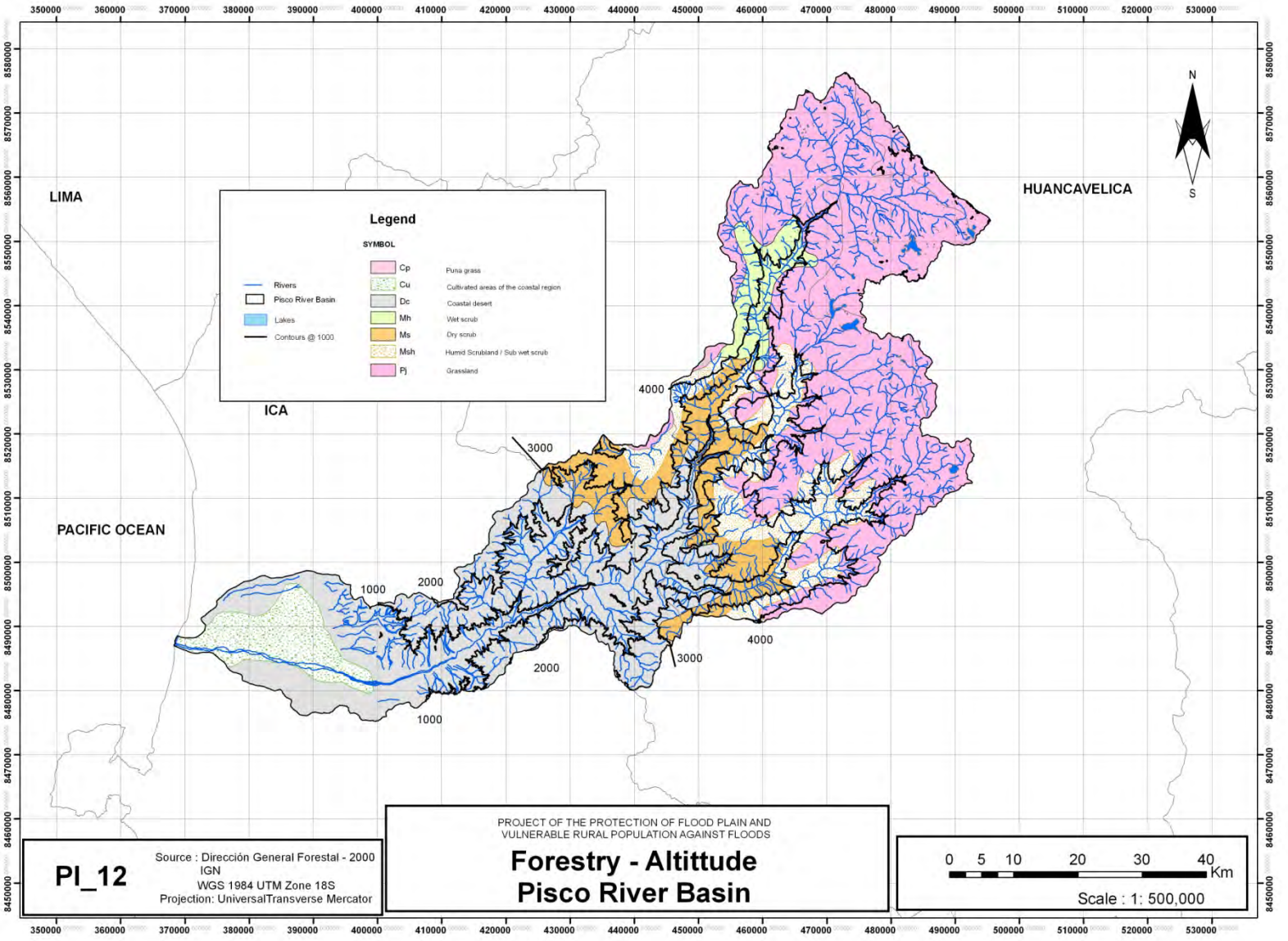
Appendix



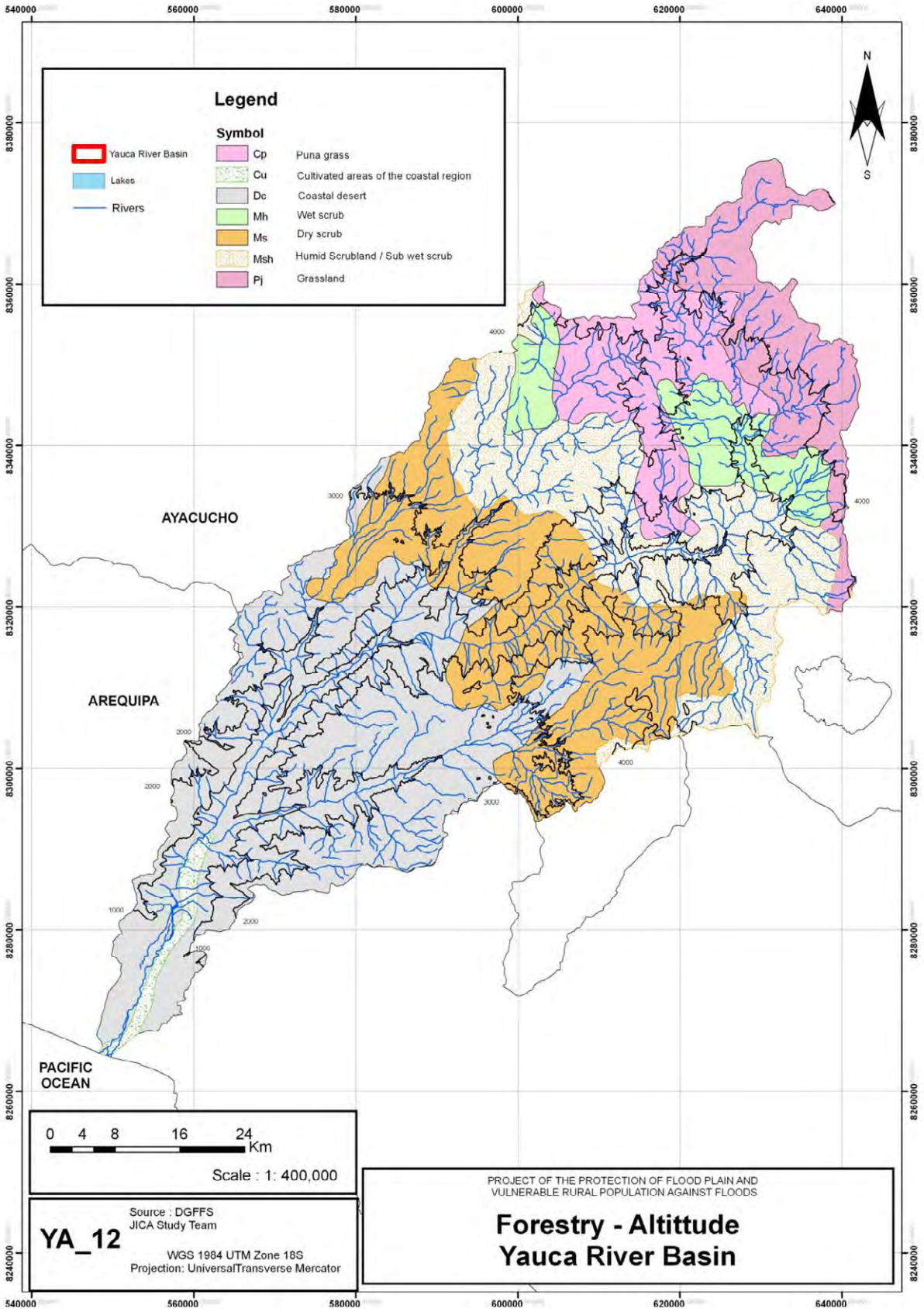
Appendix 7-Figure 1.1 Relation between Altitude and Vegetation (Canete River Basin)



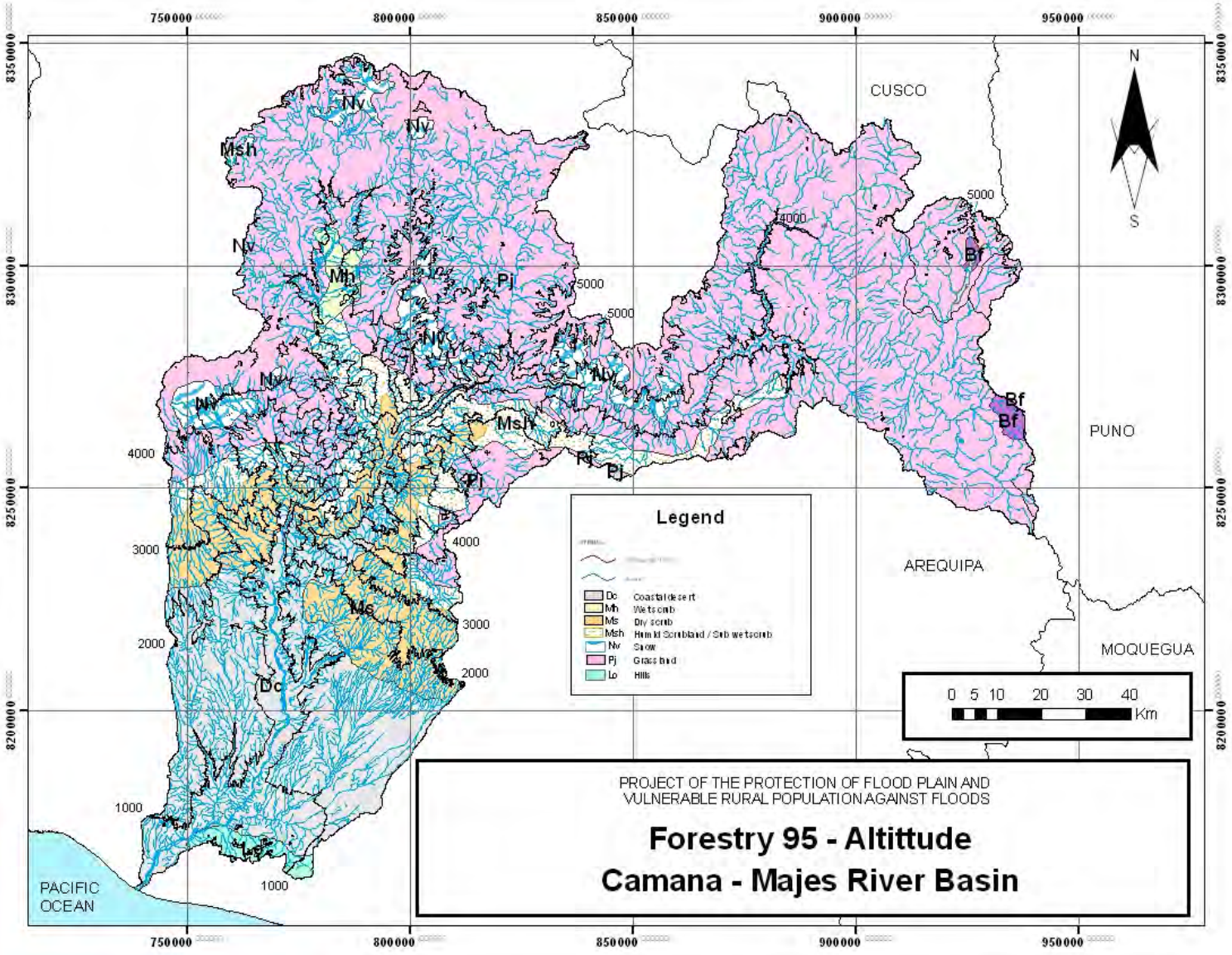
Appendix 7-Figure 1.2 Relation between Altitude and Vegetation (Chincha River Basin)



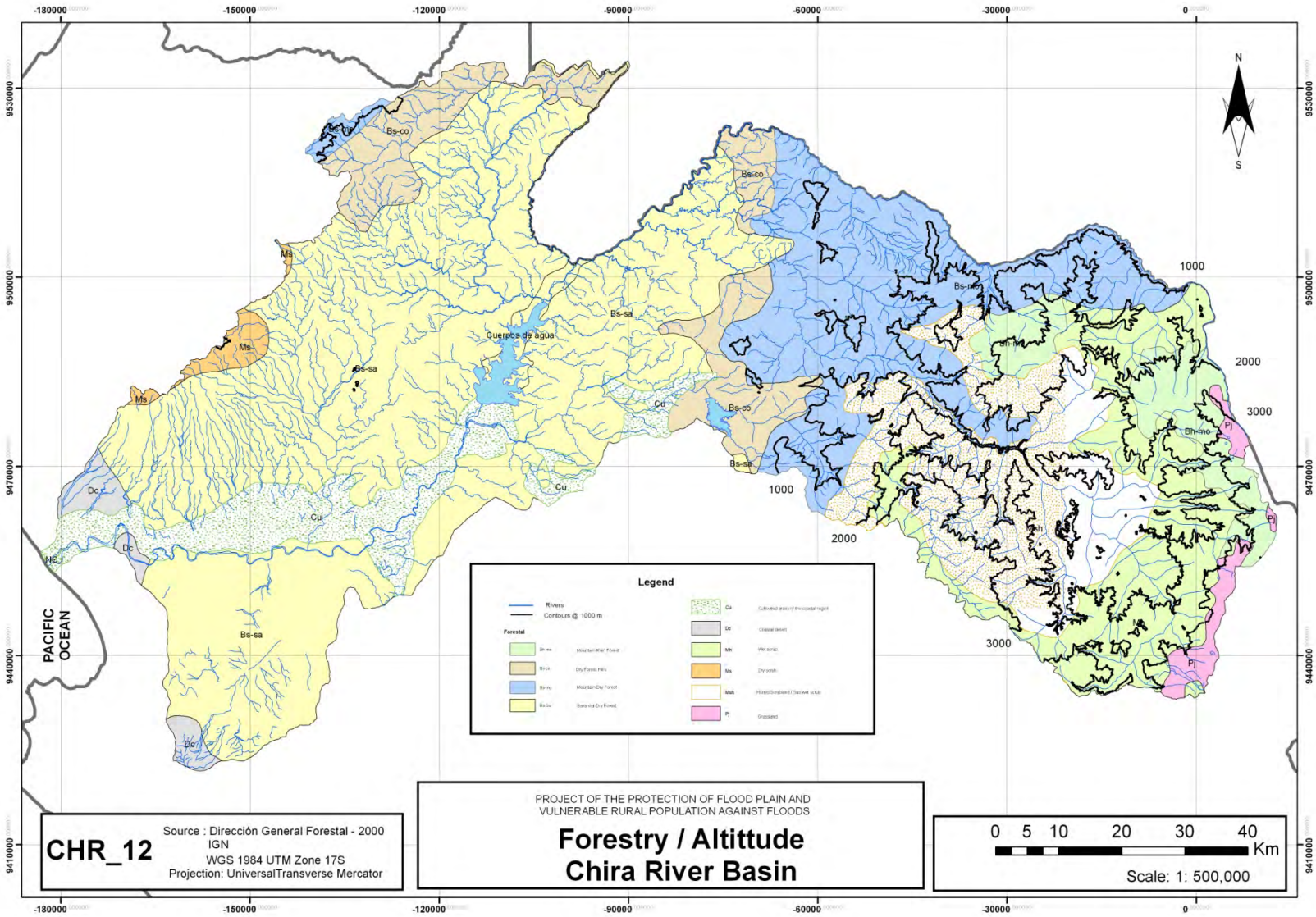
Appendix 7-Figure 1.3 Relation between Altitude and Vegetation(Pisco River Basin)



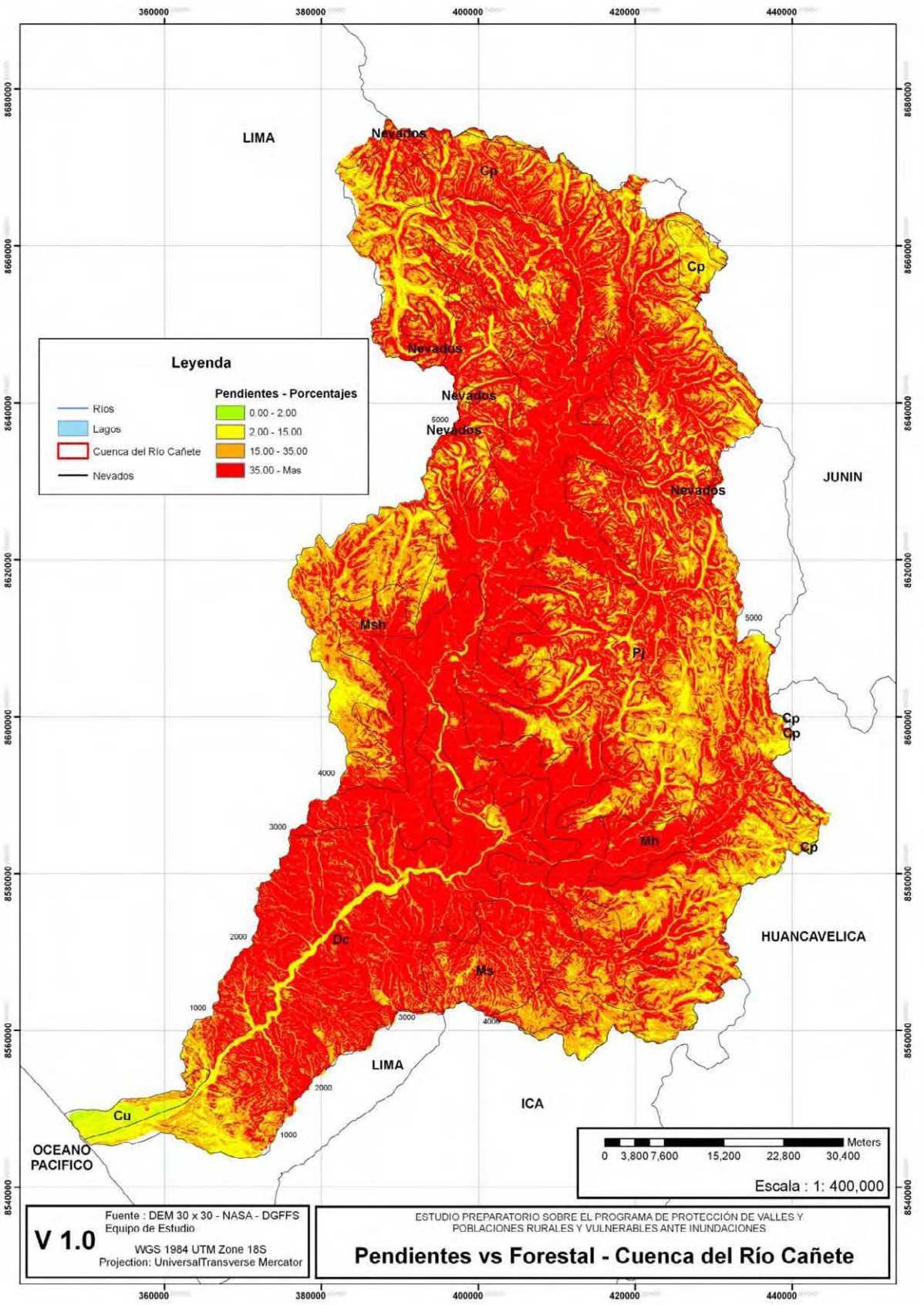
Appendix 7-Figure 1.4 Relation between Altitude and Vegetation (Yauca River Basin)



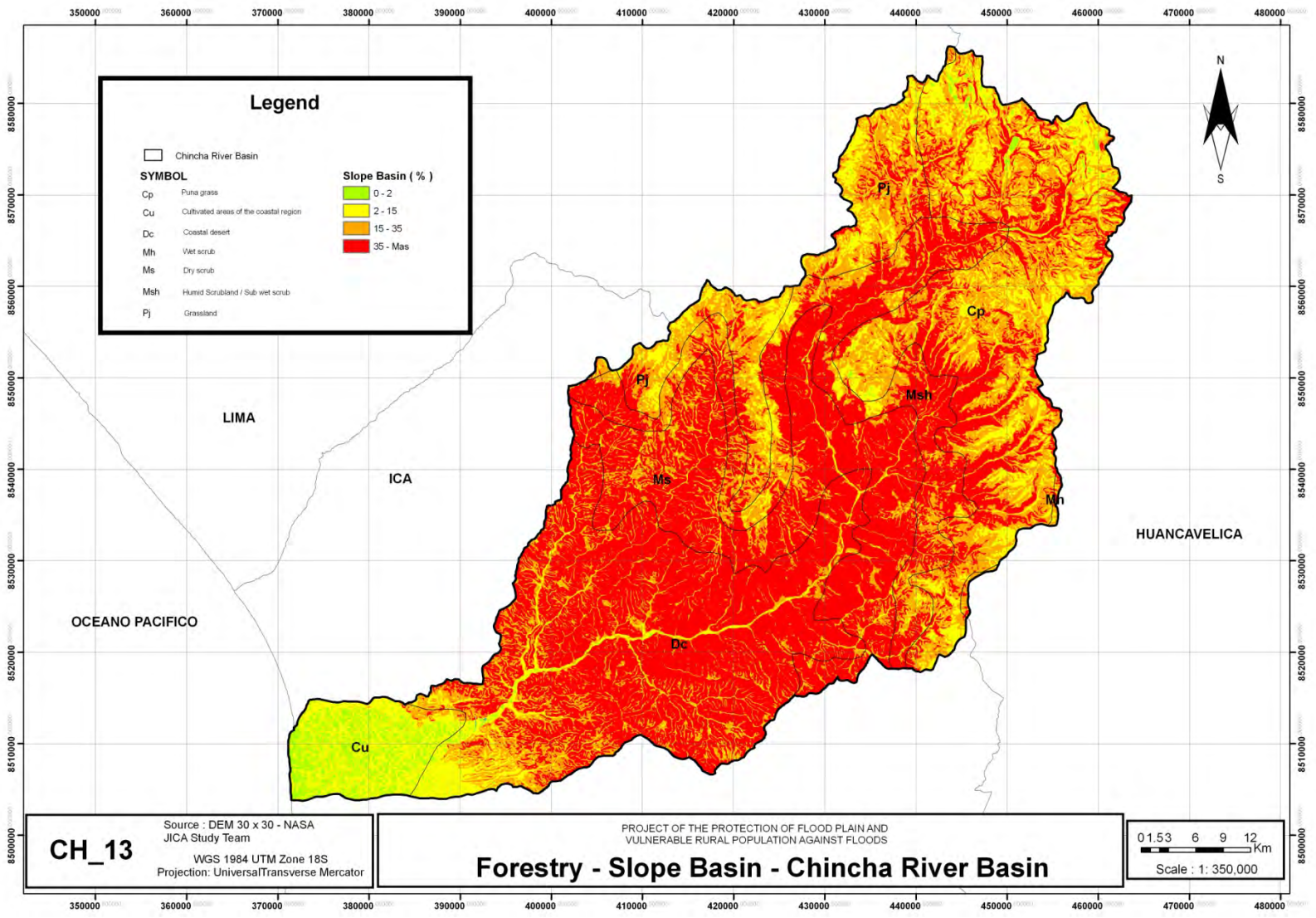
Appendix 7-Figure 1.5 Relation between Altitude and Vegetation (Camana-Majes River Basin)



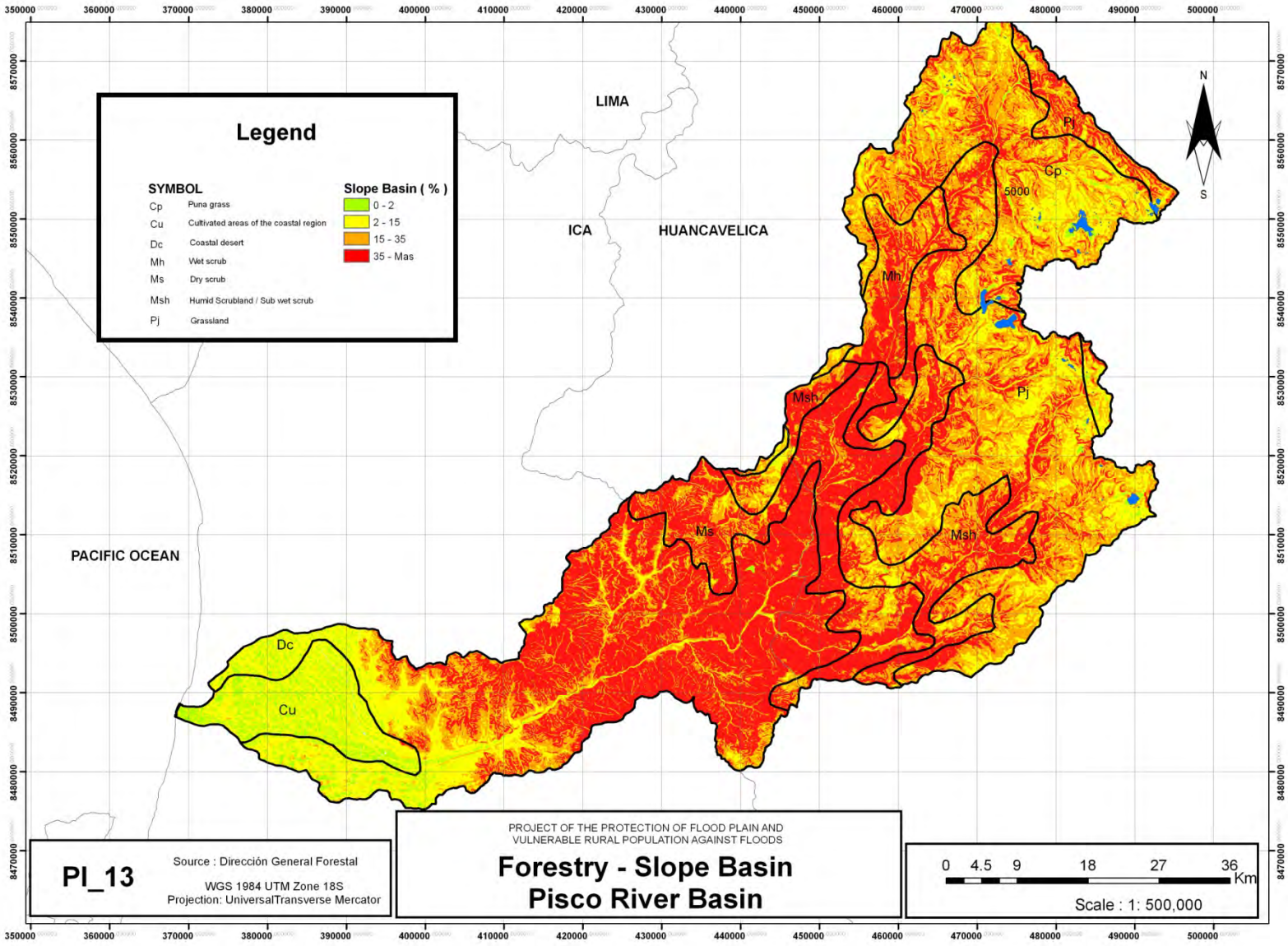
Appendix 7-Figure 1.6 Relation between Altitude and Vegetation (Chira River Basin)



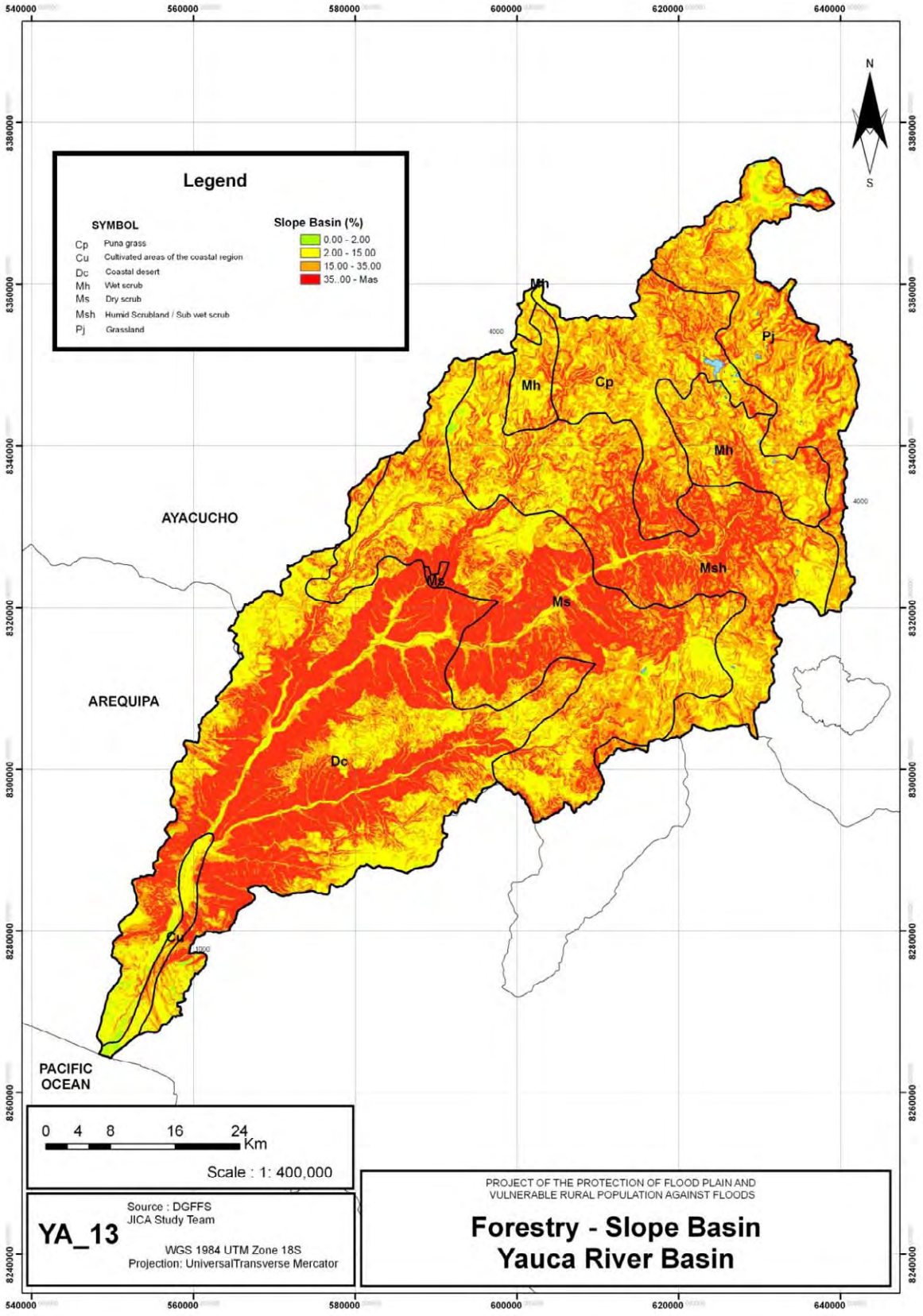
Appendix 7-Figure 2.1 Relation between Slope Angle and Vegetation (Canete River Basin)



Appendix 7-Figure2.2 Relation between Slope Angle and Vegetation (Chincha River Basin)



Appendix 7-Figure2.3 Relation between Slope Angle and Vegetation (Pisco River Basin)



Appendix 7-Figure2.4 Relation between Slope Angle and Vegetation (Yauca River Basin)