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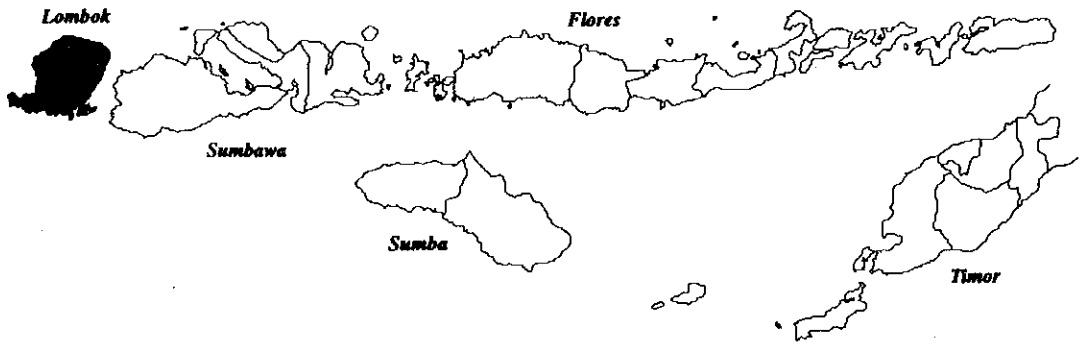
Japan International Cooperation Agency (JICA)

Directorate General of Water Resources Development, Ministry of Public Works

The Study on The Embung Development Project (Small Scale Impounding Pond Development Project) in East Nusa Tenggara and West Nusa Tenggara in The Republic of Indonesia

Final Report (Volume 8)

Feasibility Study Report
on
Four Embung Development Projects
in
Lombok Island in West Nusa Tenggara



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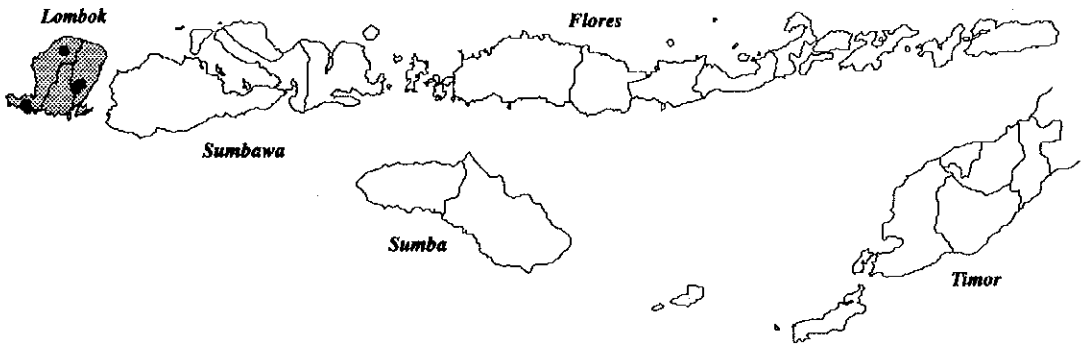

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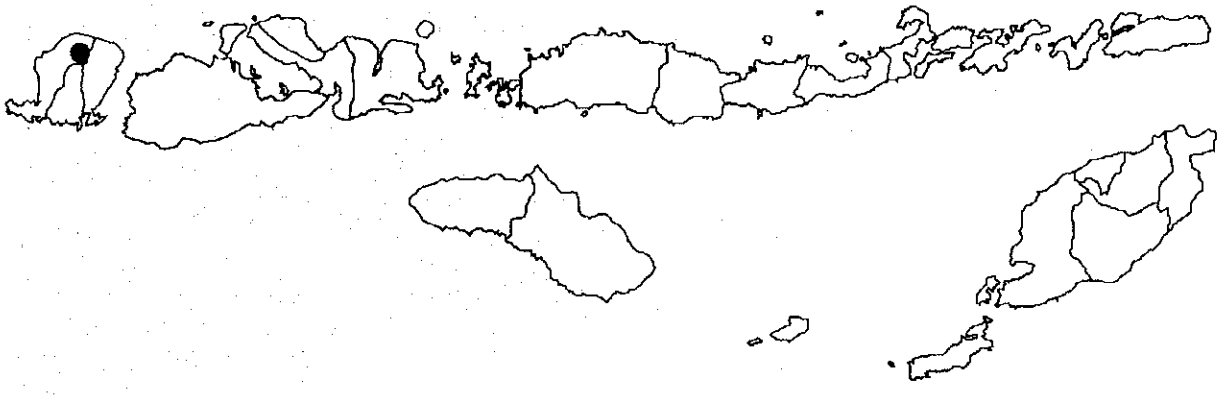

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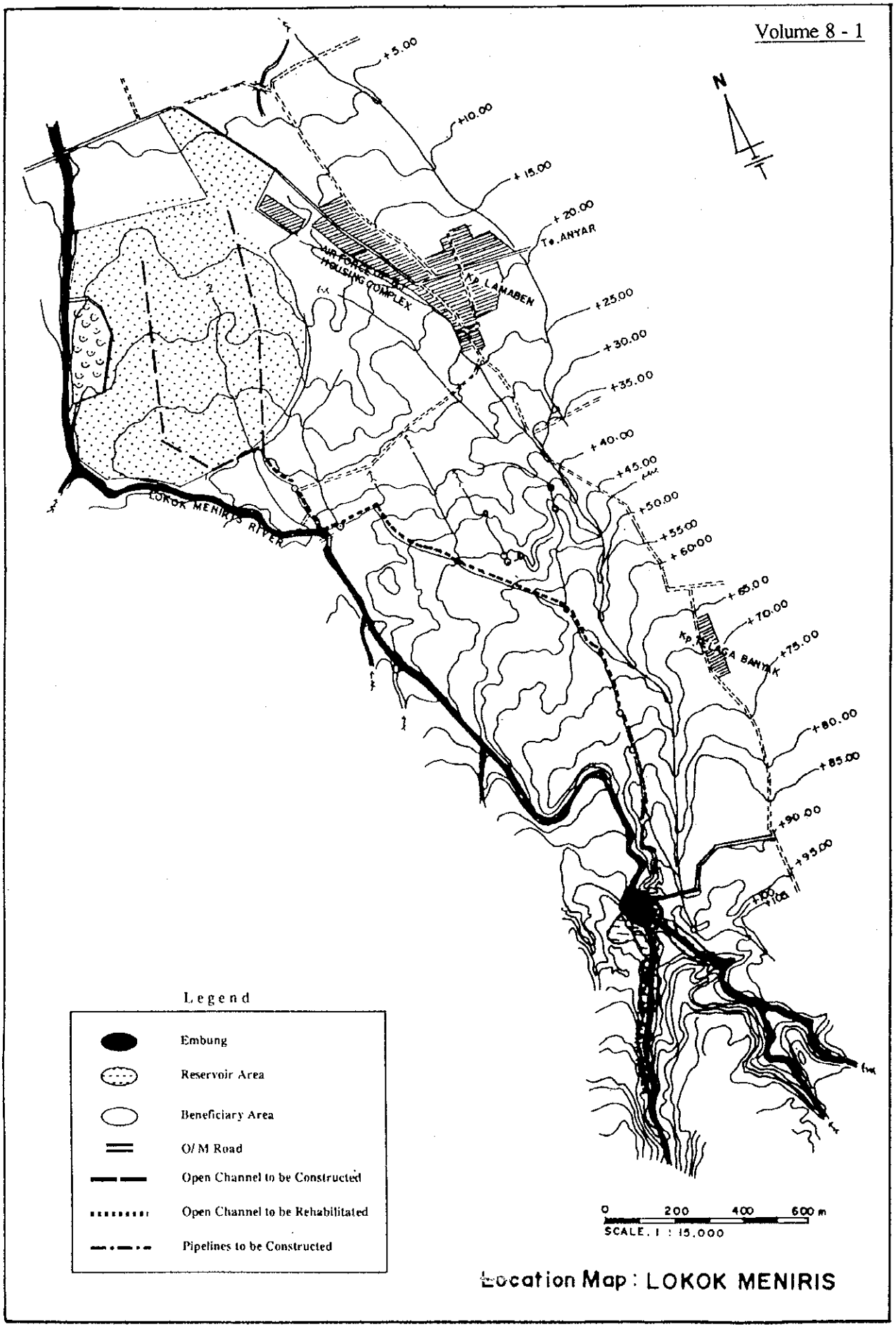

Location Map : LOKOK MENIRIS

THE STUDY
ON
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(SMALL SCALE IMPOUNDING POND DEVELOPMENT PROJECT)
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FINAL REPORT

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FEASIBILITY STUDY
ON
LOKOK MENIRIS EMBUNG DEVELOPMENT PROJECT

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1. PRESENT SITUATION OF THE PROJECT AREA

1.1 Location and Topography

The Project area is located on gentle slope land from mountain-skirt of Gunung Rinjani to the coastal zone of Anyar Village, Kabupaten Lombok Barat, northern part of Lombok Island. The proposed Embung site is at a distance of about 7.6 km from Mataram, the capital of West Nusa Tenggara (NTB) Province.

The Project area extends on gentle hill slope down toward the north up to the coastal area along the Meniris river, a tributary of the Koangan river. A hill with gentle slope is distributed along the Meniris river and forms, at the proposed Embung site, narrow valley at 70 to 90 m in elevation.

Major residential zone in the Project area is Anyar Village (Desa) located downward from the proposed Embung site and no inhabitant is in the reservoir area.

1.2 Climate and Hydrology

The nearest climate station from the proposed Embung site is the Sopak Bayan station while there are another two rainfall stations near the proposed Embung site; Dusun Anyar and Sopak Bayan. The wet season usually starts from December and ends March in the Project area with the average annual rainfall of 1,320 mm in Dusun Anyar Station. Mean annual temperature is 25.9 °C with the average maximum temperature of 29.8 °C and the average minimum temperature of 22.0 °C. Mean relative humidity is 71.0 %. Average sunshine hours are 4 to 5 hr/day during the wet season and increase to 7 to 9 hr/day in the dry season. Winds are stronger from June to September and weaker from December to March with the average wind velocity of 5.0 km/hr. Tables 1.1 and 1.2 show monthly rainfall record at the Dusun Anyar station and climate data at the Sopak Bayan station, respectively.

The Lokok Meniris river drains the north side of Mt. Rinjani. The river rises near Desa Bayan where the altitude is approximately 620 m and follows a northerly course for about 7 km joining the some tributaries to the proposed Embung site. Subsequently, the river flows northward about 4 km and discharges into Bali Sea. The surface of the catchment area is mostly fallow land and upland field. The catchment area at the proposed Embung site is 7.4 km^2. There is no gauging station on this river.

1.3 Geology

The proposed Embung site is mainly underlain by volcanic products of Mt. Rinjani of the Quaternary age. This volcanic products are half consolidated rock and not homogeneous, named the Lekopiko Formation. The geological formations is: andesitic breccia composed of andesitic breccia, which is mainly andesite with tuff, soft rock belonged to the Lekopiko Formation; pumice tuff composed of pumice tuff, which is tuff with many pumice and very soft rock also belonged to the Lekopiko Formation; terrace deposits composed of mainly sand and gravel forming terrace with flat to gentle slope; alluvium composed of sand, silt and gravel forming lowland; Detritus composed of soil with rock fragments and distributed at foot of slope or gentle valley; and river deposits composed of sand, silt, gravel and boulder, and distributed along the existing river bed.

1.4 Soils and Land Use

The Project area of Lokok Meniris lies on undulating plain of right bank of the Lokok Meniris river. The land slope of the area ranges from 2 to 5%.

The Soils are developed from the alluvial materials of the river and volcanic pumice. The sandy textured soils widely cover the farmland with a rapid permeability of water. Soil drainage on farmland is well to excessive. Soil depth is shallow to very deep ranging from 15 cm to more than 100 cm.

The results of the soil survey are shown in Table 1.3 on a typical soil profile out of 10 soil test pits, Table 1.4 on soil laboratory tests out of three pits out of 10 pits and Table 1.5 on the soil classification.

Most of the Project area is covered by wet paddy field. The upper 112 ha of the paddy field is generally irrigated by two irrigation canals from the Sopak weir which is located in the neiboring river basin. Besides, about 10 pump houses have been installed by P2AT and others agencies to supply irrigation water or livestock water to the lower portion of the Project area.

Upland field is mostly located in lower portion of the Project area because of water shortage for paddy production and some soil limitations.

The present land use is classified on the 1/5,000 topographic map and summarized below.

Present Land Use on the Project Area of Lokok Meniris

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	112	55		167
Upland	0	44		44
Tree crops	0	0		0
Bush/Scrub/Grassland			12	12
Residential			13	13
Cemetery			3	3
Others			0	0
Total	112	99	28	239

Source : The JICA Study Team

The present land use and soil classification of the Project area are illustrated in Figure 1.1.

1.5 Demography

The demographic condition in the Project area as of 1993 is revealed by a total population of 977 and a total number of households of 222 including farm households of 177 as shown below. The average family size is 4.4 persons. Dominant ethnics are Sasaknese mixed with a few Balinese and Javanese. The majority of inhabitants embrace Islam religion. Their education attainment is commonly primary school grade.

Present Demographic Condition

Village	Sub-Village	Total Population (person)	Total Household (No.)	Family Size (person)	Farm Household (No.)
Anyar	Telaga Banyak	471	94	5.0	92
	Lendang Mamben	506	128	4.0	85
Total		977	222	4.4	177

Source : JICA Water Use Survey

1.6 Domestic Water Use

The existing water source facilities for supplying domestic and livestock water are small Embungs, irrigation canal, public water basin and dug wells in the Project area. The present water use in each sub-village clarified under the Study is summarized below:

- In Telaga Banyak Sub-Village, all the inhabitants depend their water sources on such irrigation facilities as Loloan and Sopak Embungs as well as Sopak irrigation canal. As irrigation water distribution to this area is usually stopped between September and December, they have to carry their drinking water from and move their livestock to the other irrigation system in which water is available throughout a year. The minimum distance is about 100 m; and,

- In Lendang Mamben Sub Village, all the inhabitants normally get their drinking water at a public water basin where water is available all year round and further utilize a dug well and Sopak irrigation canal from January to August because of insufficient water supply amount and too many water users of the public water basin.

1.7 Social Infrastructures

The main access from Mataram, to the Project area is the Mataram-Bayan road which is a two-lane paved road. The proposed Embung site is linked by a gravel road with this main access. The on-going rural electrification network project is planned to be extended to the Project area soon.

Inhabitants are generally using private toilets outside their houses or the river bed for defecating purposes. There are an auxiliary hospital and an integrated health service center within the Project area.

1.8 Agriculture and Livestock

(1) Present cropping pattern and intensity

The average annual planted areas of major crops are summarized below.

Present Cropping Pattern and Intensity

Cropping Pattern	Net Area (ha)	Planted Area (ha)	Proportion of Planted Area (%)	Cropping Intensity (%)
(1) Paddy - Paddy	50.5	101.0	52.9	200
(2) Paddy - Palawija	33.5	50.0	26.2	150
(3) Upland crop - Fallow	40.0	40.0	20.9	100
Total / Average	124.0	191.0	100.0	166

Source : The JICA Land Use Survey and Inventory Survey

(2) Farming practice and farm inputs

Wet paddy is cultivated in the irrigated area for the both wet and dry seasons. On the rainfed paddy field, wet paddy is cultivated during the wet season, while Palawija crops are partly cultivated for the dry season due to shortage of water. Major Palawija crops are red onion and groundnut. On the dry upland field, groundnut is commonly grown.

As for paddy, most of the farmers carry out land preparation with an animal-drawn plough and harrow their wet paddy field once or twice every season, while this work done by

other marginal farmers depends on their own man-power. High yielding rice varieties such as IR36, IR64, Krueng Aceh, Pelita and C4 are grown. Rice seed is sown on a nursery bed which is in the ratio of one twentieth against the main paddy field. Manual weeding is usually done one to three times throughout the rice growing period. Harvesting is carried out by using a sickle and hand threshing is made by beating rice plants against a frame.

Predominant cultivation methods of Palawija crops are very primitive and local varieties are commonly used. Land preparation, planting, weeding and harvesting are done by hand.

Farm inputs and labor requirements presently used for growing these crops are given below.

Present Farm Inputs and Labor Requirements

Description	Unit	Wet Paddy	Groundnut	Red Onion
Farm Inputs				
Seed	kg/ha	50	60	2,000
Fertilizer				
Urea	kg/ha	300	50	400
TPS	kg/ha	100	100	200
KCl	kg/ha	50	25	200
Agro-chemicals	lit/ha	-	-	-
Labor Requirements				
Nursery	md/ha	3	-	-
Land preparation	md/ha	2	10	20
	ad/ha	5	-	-
Planting	md/ha	3	4	6
Transplanting	md/ha	15	-	-
Weeding	md/ha	10	4	10
Pest & disease control	md/ha	2	2	4
Farm management	md/ha	2	2	3
Harvesting	md/ha	15	10	20
Transportation	md/ha	5	5	3
Others	md/ha	4	2	4
Total	md/ha	61	39	70
	ad/ha	5	-	-

Source : The JICA Farm Economy Survey

(3) Crop yield and production

The present crop yield and production in the Project area are estimated as shown below. Unit yield of major crops remains extremely low due to shortage of irrigation water, insufficient farm input supply and traditional farming practices.

Present Crop Yield and Production

Crops	Planted Area (ha)	Unit Yield (ton/ha)	Production (ton)
Wet Paddy Field			
Irrigated			
Wet season paddy	101	3.00	303
Dry season paddy	101	2.00	202
Rainfed			
Wet season paddy	50	2.00	100
Dry season Palawija			
Onion	16	2.00	32
Groundnut	9	0.50	5
Upland Field			
Groundnut	40	1.20	48

Source: The JICA Inventory Survey

(4) Livestock population

Various kinds of livestock are raised in the Project area and their numbers are given below. Cows and buffaloes play important roles in land preparation and transportation as draft power. Other livestock are raised for self-consumption or selling to a local market.

Current Population of Livestock

Unit: head

Breeding Household	Cow	Buffalo	Horse	Goat /Sheep	Pig	Chicken/ Duck
147	1,119	113	20	944	0	2,836

Source: The JICA Water Use Survey

1.9 Irrigation Facilities

In the Project area, there exists paddy field on the right bank of Lokok Meniris river. This area has been irrigated by the existing Sopak weir situated at around 10 km upstream of the proposed Embung site, but not in the same river basin. Irrigation water taken by the weir is led by the existing canal to the irrigation area with a distance of about 12 km. Due to the allocation of surface water of the river and poor conditions of the existing facilities, the wet paddy field in the Project area has been irrigated only in the wet season. In the vicinity of the proposed Embung site, the existing irrigation canal is lined by stone masonry. General condition of the canal is still well, but some portions are filled up with sediment. Some of the related facilities, such as the checks, are already broken.

1.10 Agro-economy

(1) Farmers group

Farmers are members of Agricultural Cooperative (KUD). From its branch shop , they commonly purchase fertilizers and use credit services. They are also members of Village Youth Association. More than 80% of farmers benefited by the existing irrigation scheme established Water Users' Association (P3A/HIPPA) in 1991 and since then have operated it for the purpose of maintaining on-farm irrigation service facilities and managing irrigation water distribution.

(2) Agricultural supporting services

Agricultural extension services are provided to farmers by field extension workers (PPL) attached to a rural extension center (BPP) in Bayan. Usually, farmers receive PPL's visiting service very few because of limited budget for field operation in BPP. Some PPLs are livestock specialists to provide various services under the instructions of a specialized agricultural extension agent assigned to a district center for agricultural extension. Veterinary care services are given to breeding households through an animal health center of the Veterinary Service of the Department of Livestock. The present level of livestock extension services is similar to that of the agricultural extension services.

Credit services are available in KUD as well as in the service network of the Indonesian People's Bank (Bank Rakyat Indonesia) both handling "Credit for Farmer (KUT)" and "Income Generating Project for Marginal and Landless Farmers (P4K)". Financial sources of these credits are the Government for KUT and IFAD for P4K aiming at group financing.

Lombok Water Resources Development and Conservation Project Office (Proyek PKSA Lombok) under the NTB Provincial Public Works Service (DPUP) is responsible for new water resource development and watershed management. New development of irrigation system is the responsibility of Lombok Irrigation Project Office, while upgrading and rehabilitation works are the main task of Provincial Project Office for Rehabilitation and Upgrading of Irrigation. Operation and maintenance (O&M) works of all facilities are conducted by Provincial Project Office for Operation and Maintenance (PPO&M APBD). These project offices are under the direction of DPUP.

(3) Farmers' household economy

The results of agro-economy survey carried out in the Project area under the Study reveal that the average income and expenditure of 15 sample farmers amount to Rp. 1.81 million and Rp. 1.58 million, respectively. Some sample farmers make up for deficit in their household economy by selling their livestock. Table 1.6 shows the summary of replies of 15 respondents.

2. DEVELOPMENT NEEDS AND CONCEPTS

2.1 Development Needs and Constraints

(1) Population increase

The future population in the Project area is anticipated by referring to "Projection of Population for Kabupaten/Kotamadya in Indonesia 1990-2000" prepared by National Statistic Bureau and the Second Long Term Development Plan (PJPT II). The total number of inhabitants living in the Project area will increase from 977 persons as at 1993 to 1,081 persons in 1998, 1,185 persons in 2003, 1,285 persons in 2008, 1,375 persons in 2013 and 1,459 persons in 2018.

(2) Basic human needs (BHN)

The inhabitants in the Project area are unsatisfied with the present condition of rural infrastructures because the existing domestic water supply sources can meet half of drinking and livestock water requirements during the dry season. About 500 inhabitants have been forced to carry their drinking water at the minimum distance of 100 m for the period of four months from September to December. They also bring their cattle to the dry season water sources. The pressing need is thus to solve water shortage problems in the dry season.

(3) Economic development needs

All of 177 farm households have principally consumed their farm products for their own use and then sold the remaining amount to local markets. There is not much possibilities of developing manufacturing and service sector industries in and around the Project area so as to offer new job opportunities to farmers. It is therefore indispensable for promoting public investment in economic infrastructures, especially for irrigation water source facilities, which encourage farmers to improve their farming system and enable them to increase their agricultural production. Increasing farm outputs could clue farmers themselves to upgrade their living standard and to catch up with faster economic growth of other sectors and places.

(4) Inhabitants' Intention to Development Pattern

Inhabitants in the Project area intend to use their farm land more intensive because no expansion of land holding size can be expected. To do so, they need all year-round water source facilities from which they will be able to get sufficient irrigation water for growing the dry season crops. Those who are suffering from water shortage problems from September to December have to carry drinking water from and bring their cattle to places where water is available. They also intend to utilize such time in productive manner instead of spending for water carriage. In this connection, they need permanent water source facilities which enable them to secure stable drinking water throughout the year.

(5) Development constraints

The present constraints against social upgrade and economic development in the Project area are featured by the condition that it is very hard to utilize surface runoff of the Lokok Meniris river. The reason is that the watershed of the Lokok Meniris river is smaller in size and less in forest coverage compared with the neighboring river basins resulting in severely concentrated runoff and shorter period of available river flow. Due to such unstable situation of surface runoff, the Lokok Meniris river is not useful unless countermeasures to regulate the wet season runoff are practiced.

In order to secure water source facilities, the diversion channel from the neighboring river basin was constructed to supply domestic and irrigation water to the upstream part of

the Project area and further installed pumped wells in the downstream part of the Project area to utilize underflow water of the Lokok Meniris river. Such limited water resources have acted as the barrier to meet BHN and to promote development of intensive agriculture.

2.2 Development Concepts and Approach

(1) Development concepts

The existing gap of economic status between NTB and other Provinces is caused by insufficient fulfillment of BHN, slow pace of poverty alleviation and less concerns about a balanced investment to regional development. In harmony with the national policy to correct this economic imbalance, the development concept is formed aiming at improvement of social and economic infrastructures with the highest priority so as to meet BHN and increase agricultural outputs. Among others in the Project area, it is prerequisite to pay special attention to how to solve irrigation and domestic water shortage problems originated from hydrological characteristics of the Lokok Meniris river basin.

(2) Development strategies and approach

To overcome development constraints prevailing in the Project area, water resources seasonally available are to be regulated by means of constructing Embung as water storage on the Lokok Meniris river. Approach to development planning of the potential Embung is as follows:

- To put the first priority to supply irrigation water and the second to domestic water taking into account inhabitants' needs and intention;
- To project the future water demand for irrigation and domestic use at the target year of 2008 being the last year of Pelita VIII;
- To examine development potential of the Lokok Meniris Embung from the technical viewpoints;
- To determine the optimum development scale of the Embung;
- To make preliminary design and cost estimate; and
- To conduct investment justification from the viewpoints of economic soundness, social satisfaction and environmental impact.

2.3 Land Potential

In future, the lower area of rainfed paddy field, upland and bush/scrub land could be transformed into irrigated paddy field by constructing the potential Embung. Although the extension of irrigation area depends on the water availability, cropping plan, land suitability and economic viability, the possible extension area on the right bank of the Lokok Meniris river is estimated at 97 ha as shown below. Furthermore, in case that excessive water is available for irrigation, the dry upland on the left bank could be irrigated by installation of an aqueduct crossing the Lokok Meniris river.

Rainfed paddy field	->	Irrigated paddy field	55 ha
Rainfed upland	->	Irrigated paddy field	35 ha
Bush/scrub	->	Irrigated paddy field	7 ha

In conclusion, the future land use plan of the Project area on the right bank of the Lokok Meniris river is offered as shown below.

Future Land Use Plan on the Project Area of Lokok Meniris

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	112	55		167
Upland	0	44		44
Tree crops	0	0		0
Bush/Scrub/Grassland			12	12
Residential			13	13
Cemetery			3	3
Others			0	0
Total	112	99	28	239

Source : The JICA Study Team

There is no farmland in the impounding area of the potential Embung. The impounding area is covered by bush and river escarpment so that the land compensation is not necessary.

2.4 Agricultural and Livestock Development Plan

(1) Alternative cropping patterns

In formulating the future cropping patterns in the Project area, the following basic principles have been adopted:

- Higher benefit for farmers;
- Optimum use of irrigation water;
- Practical farming system for family labor; and,
- Crops and cropping patterns acceptable to farmers.

Wet paddy is the most predominant crop in the Project area and acceptable to farmers as they have long experience in rice cultivation. Therefore, they could easily master irrigated rice cultivation method to realize higher production and thereby large irrigation benefit under the condition of "With Project". Aiming to determine the optimum development scale of the proposed Embung, the following alternative cropping patterns are established.

Alternative Cropping Patterns

Pattern Code	Wet season		Dry season			
			First cropping		Second Cropping	
	Crop	Coverage (%)	Crop	Coverage (%)	Crop	Coverage (%)
With Project C-12	Paddy	100	Paddy	100	-	-
With Project C-21	Paddy	100	Soybean*	100	-	-
With Project C-22	Paddy	100	Soybean*	100	Red onion	100
With Project C-22	Paddy	100	Soybean*	50	Mungbean	50
			Mungbean	50	Red onion	50

Remarks : * ; Mixed with groundnut

(2) Farm input and labor requirements

Under the "With Project" condition, farmers who are depending on unreliable rainfall, river flow or irrigation water can be expected to get stable irrigation water supply. They will be able to increase farm inputs to the optimal level with less risk. Proposed farm inputs are

estimated in consideration of the present input level in advanced irrigation areas as well as data collected from BPP. Labor requirements are also expected to increase substantially in cultivation under the technical irrigation system. On the other hand, farm input and labor requirements are expected to remain at the present level under the "Without Project" condition.

Proposed Farm Input and Labor Requirements

Item	Unit	Wet Paddy	Soybean	Mungbean	Red Onion
Farm Inputs					
Seed	kg/ha	25	40	30	2,000
Fertilizer					
Urea	kg/ha	300	50	75	300
TPS	kg/ha	100	100	100	200
KCl	kg/ha	50	50	50	100
Agro-chemicals	lit/ha	2	2	2	10
Rodenticide	kg/ha	2	1	1	3
Labor	md/ha	185	70	80	250
Draft Animal	ad/ha	20	10	10	20

(3) Proposed farming practices

Proposed farming practices for wet paddy are as follows:

- High yielding rice varieties to be used under the With Project condition are IR64, Krueng Aceh, Pelita, C4 and IR36 with maturing periods of 110 to 135 days. These varieties are moderately resistant or resistant to several major rice pests and diseases. Land preparation on wet paddy field has to be done by animal ploughing and harrowing;

- Fertilizers need to be applied three times; the first application at the final stage of land preparation, and the second and third applications as top-dressing at the 20th and 37th day after transplanting, respectively. The top-dressing will be applied while water depth wet on paddy field is shallow. The phosphorous (TPS) and potassium (KCl) fertilizers have to be applied at the final stage of land preparation. The required amount of fertilizers is 60 kg/ha of N, 30 kg/ha of P and 30 kg/ha of K;

- Seed rates are 20 to 40 kg/ha for nursery. The best period for transplanting is 3 to 4 weeks after sowing, when the seedlings have 5 to 6 leaves. Ratio of the nursery bed to the main wet paddy field is about one twentieth. Planting density is about 2 to 3 plants per hill and spacing of hill is 20 cm x 20 cm;

- Weeding is required to be performed two to three times during the rice growing period according to weed growth. Irrigation water supply needs to be guaranteed during the most critical stages of the plant growth such as tillering, booting, flowering and germination stages. Timely control of insects, pest and diseases is necessitated on the basis of advice by PPLs and their assistants; and

- It is desirable to carry out harvesting when the ears are nearly ripened and are still in slight green. Harvesting is made by labors using a sickle. Harvested paddy plants need to be dried on the field for 3 to 4 days.

For growing Palawija crops under the irrigated condition, advanced farming practices similar to irrigated wet paddy cultivation and high yielding varieties are to be adopted. Land preparation will require animal-draft in order to enhance efficiency and accuracy of the work.

Proper fertilization matching with soil conditions and timely insect/disease control are also indispensable. These farming practices need to be applied for, following technical instructions of PPLs.

(4) Anticipated crop yield

It is anticipated that the future yield of proposed crops under the "With Project" condition increases to 4.5 ton/ha for wet paddy, 1.4 ton/ha for soybean, 1.1 ton/ha for mungbean and 7.5 ton/ha for red onion. These targets are estimated in due consideration of the present yield level in well established irrigation areas of Kabupaten Lombok Barat as well as introduction of high yielding varieties and advanced farming practices, stable irrigation water supply and optimum use of farm inputs. As for build-up period to attain the anticipated yield, it is also prospected that crop yield level is 60% of the target in the first year, 70 % in the second year, 80% in the third year, 90% in the fourth year and 100% from the fifth year and onward.

(5) Projected livestock population

The future livestock population in the Project area for the target year 2008/2009 is projected as shown below taking into account the actual growth rate of each livestock in Kabupaten Lombok Barat during the Pelita V period.

Projected Population of Livestock

Unit: head

Cow	Buffalo	Horse	Goat /Sheep	Pig	Chicken/ Duck
1,508	189	23	1,047	0	1,815

2.5 Water Demand

(1) Domestic water demand

The future domestic water consumption level in rural areas of NTB is set to be 60 lit/day/capita up to 1998/99 for the Pelita VI period, 70 lit/day/capita up to 2003/04 for the Pelita VII period and 80 lit/day/capita from 2004/05 and onward. The public water demand is to be 30 lit/day for 10% of the projected population, while the unaccounted-for is to be equivalent to 20% of the total water demand.

Following the projected population, the future domestic water demand is estimated as shown below. The annual domestic water demand for 2008 is projected to be 48,600 m^3.

Projected Domestic Water Demand

Item	Unit	1998	2003	2008	2013	2018
Population	person	1,081	1,185	1,285	1,375	1,459
Domestic water	'000m^3/yr.	23.7	30.3	37.5	40.2	42.6
Public water	'000m^3/yr.	1.2	1.3	1.4	1.5	1.6
Un-accounted for	'000m^3/yr.	5.0	6.3	7.8	8.3	8.8
Total demand	'000m^3/yr.	29.9	37.9	46.7	50.0	53.0

(2) Irrigation water demand

In order to optimize the development scale and delineate the beneficiary area of the Project, irrigation water demand for each proposed crop is estimated for unit irrigation area of 1 ha on the semi-monthly base taking into account crop consumptive use,

evapotranspiration, crop coefficient, effective rainfall and irrigation efficiency both for wet paddy and Palawija crops as well as land preparation water, layer replacement and percolation loss only for wet paddy. As described in Attachment 1, irrigation water demand in the Project area is calculated by referring to the standard quoted in "Irrigation Design Standard, KP-01" by DGWRD.

Tables 2.1 and 2.2 show the calculation results of evapotranspiration and effective rainfall, respectively, and Table 2.3 presents the unit irrigation water demands for each crop.

3. EXAMINATION OF EMBUNG DEVELOPMENT POTENTIAL

3.1 Topographic Condition

The Lokok Meniris Embung site was identified by PRIS of NTB through its identification study performed in 1993. Under the present Study, the possibility of developing this Embung is firstly confirmed through the inventory survey. Then topographical survey with mapping and geological investigations are carried out at the proposed Embung site, reservoir area and beneficiary area. The Meniris river and its small tributary flow through V-shaped valley on rather gentle slope of hill at the proposed Embung site. The width of valley is about 100 m and the elevation of river bed is El. 70.0 m. However, the left abutment is not sufficient in elevation with a section of about 80m so that a saddle dam would be designed for the above section in order to keep much water storage volume in the reservoir.

3.2 Geological Condition

The proposed Embung site is mainly underlain by pumice tuff and andesitic breccia, volcanic products of Mt. Rinjani. The foundation is mainly formed of andesitic breccia on the left bank and pumice tuff on the right bank. The drilling survey result shows that the coefficient of permeability varies from 5.3×10^{-4} to 2.8×10^{-5} cm/sec for andesitic breccia and from 1.2×10^{-4} to 4.4×10^{-5} cm/sec for pumice tuff. No ground water is present at any bore hole.

The reservoir is mainly underlain by pumice tuff and andesitic breccia, volcanic products of Mt. Rinjani. No major fault and landslide are recognized in the reservoir area. No major problem for water leakage assumed to be occurred in the reservoir area. Geological map and profile for this site are shown in Figures 3.1 and 3.2.

3.3 Availability of Embankment Materials

Embankment materials are available around the proposed Lokok Meniris Embung site, which can be used as impervious core, filter (sand and gravel) and random materials. Concrete aggregates are also available in and around the Project area. These materials are suitable for constructing a zone type fill dam.

The borrow area, quarry sites and sand and gravel deposits are investigated from the technical and economical view points. The following shows the summary of the selected locations and the availability of the materials.

Availability of Construction Materials

Material	Location	Description
1. Impervious soil	Arable land on the left side of the proposed site	clay and silty sand with gravel, weathered tuff-moderately soft
2. Filter material	Meniris river Koangan river	Natural alluvial sand and gravel. Available quantity is estimated to be more than 15,000 m^3
3. Random materials	(1)Reservoir area (2)Spillway, dam foundation	Soft rock with weathered tuff Weathered lahalic bressia
4. Concrete aggregates	Meniris and Koangan rivers	Alluvial deposits Quantity is estimated to be 20,000 m^3

3.4 Availability of Water Resources

(1) Catchment yield

As for the Lokok Meniris river, there is no record of discharge. Accordingly, runoff at the proposed Embung site is estimated by use of the rainfall record near the proposed site. The Dusun Anyar rainfall station which is located in the north of the Lokok Meniris Embung catchment has rainfall record of nearly consecutive 16 years and is considered to represent catchment rainfall. The climate is strongly influenced by altitude and the rainfall in the low elevated area is considerably low comparing to the high elevated area. Furthermore, most rainfall stations are located in the low elevated area. To convert the station rainfall to the catchment rainfall, thus, the adjustment coefficient of 1.5 is multiplied by use of isohyetal map. The generated catchment rainfall is given in Table 3.1. A runoff coefficient of 0.35 is adopted considering the characteristics of the catchment area and the previous hydrological analysis in the Lombok Island. Using this runoff coefficient and rainfall record at Dusun Anyar, river flow of the Lokok Meniris at proposed site is estimated.

The following conditions are considered for estimation of the half monthly discharge:

- Catchment area of the proposed Embung site is 7.4 km^2; and,
- Less than 20 mm of half monthly rainfall is ignored for estimation.

This estimation is made based on the rainfall record from 1959 to 1974. The estimated half monthly discharge is given in Table 3.2 and monthly discharge is summarized below.

Mean Monthly Discharge

Unit: 1,000 m^3

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1,455	1,169	1,081	223	147	113	8	0	52	13	114	644	5,019

(2) Floods

The flood analysis is made to determine the design discharge of the structures, such as spillway, diversion tunnel, and so on. Taking availability of the flood record and size of the catchment area into account, the rational formula is adopted to estimate the flood discharge in the Study. The formula is;

$$Q = 0.2778\ f\ r\ A$$

where, Q : Peak discharge (m3/s)
f : Runoff coefficient
r : Average rainfall intensity within time of concentration (mm/hr)
A : Catchment area (km)

1) Design rainfall

Design rainfall is estimated by the Log Pearson Type III method, which is widely used in NTB. In this Study, 15 years rainfall data of the Sopak Bayan station from 1972 to 1993 are analyzed by the method. The result of probability analysis is summarized below.

Design Rainfall

Unit : mm

Return Period	Design Rainfall
1 in 2 year	124
1 in 5 year	175
1 in 10 year	209
1 in 20 year	241
1 in 50 year	286
1 in 100 year	319
1 in 200 year	353

2) Design flood

The following is the Ruziha's formula to estimate the flood travel time:

$$T = L/V$$

$$V = 72(H/L)^{0.6}$$

where, T : Flood travel time (hr)
L : Horizontally projected length of river course (km)
H : Difference of elevation (m)
V : Velocity of flood (km/hr)

The rainfall intensity within concentration time of the flood is estimated by an empirical formula prepared by Dr. Mononobe as follows:

$$r = (R_{24}/24) \times (24/T)^{2/3}$$

where; r : Maximum average rainfall intensity within concentration time (mm/hr)
R24 : Daily rainfall (mm)
T : Time of concentration (hr)

The runoff coefficient is estimated at 0.8 considering the condition of the catchment area.

Based on the above condition, the peak floods in various return period are estimated. The result is shown in Table 3.3 and summarizes below:

Probable Flood

Unit : m^3/s

Return Period	Probable Flood
1 in 2 year	62
1 in 5 year	87
1 in 10 year	104
1 in 20 year	120
1 in 50 year	143
1 in 100 year	159
1 in 200 year	176

(3) Sediment load

There is no available data on sediment load on the Lokok Meniris river. The Technical Report I (Embung Study Program) in the Sumbawa Water Resources Development Planning Study Extension Phase in 1982 indicates that the sedimentation rate is 0.5 mm/year/km^2. Taking data availability and characteristics of the catchment area into account, 0.5 mm/year/km^2 is adopted in this Study.

(4) Water quality

On October 25, 1994, water samplings were carried out at the proposed Embung site and upstream and downstream of the site for the clarification of the water quality. The result of the test is shown in Table 3.4.

4. EMBUNG DEVELOPMENT PLAN

4.1 Optimization of Development Scale

The water balance study aims to clarify the relationship among the proposed Embung scale, irrigable area and cropping pattern. According to the water demand and procedure to be described below, the water balance study of the Lokok Meniris Embung Project is conducted.

(1) Methodology

The simulation equation is as follows:

$$W_2 = W_1 + I - L - S_P - O_D - O_L - O_I$$

where ,

I	:	inflow to reservoir at the half monthly period (m3)
L	:	water losses from the reservoir caused by evaporation during the half monthly period (m3)
SP	:	flow of water over the spillway during the half monthly period (m3)
OD	:	outflow needed for domestic water during the half monthly period (m3)
OL	:	outflow needed for livestock water during the half monthly period (m3)
OI	:	outflow needed for irrigation water during the half monthly period (m3)
W1	:	volume of water in the reservoir at the beginning of the half monthly period (m3)
W2	:	volume of water in the reservoir at the end of the half monthly period (m3)

1) Inflow

Since there is no gauging station on the Lokok Meniris river, discharge is generated from rainfall of the Dusun Anyar station.

2) Reservoir storage curve

Reservoir storage curve with surface area is shown in Figure 4.1 in relation to the elevation at the proposed Embung site.

3) Losses

Evaporation from inundation area can be estimated as "1.1 x ETo", indicating, "open water evaporation", which is employed in the Design Criteria KP-1.

4) Spill out discharge from reservoir

Spill out discharge is considered if there is any excess storage which exceeds the maximum storage capacity of dam.

5) Water Demand

The 100% dependability of the domestic water demand shall be secured by the proposed Lokok Meniris Embung.

To meet 80% dependability of irrigation water, reservoir capacity will be determined.

6) Water level of reservoir

Minimum water level is estimated at El. 82.1 m considering sedimentation volume for 25 years and 1.0 m allowance. Maximum water level for the simulation is equal to the crest elevation of spillway. Probable maximum high water level according to topography is set at El. 86.70 m.

(2) Optimum development scale

With respect to the proposed Lokok Meniris Embung, the plan with the most sizable reservoir is selected within economically reasonable range in view of maximum exploitation of the endowed water resource. The optimum development scale of Lokok Meniris Embung is decided by the limitation of topography at the proposed site. The optimum development scale is thus in line with the maximum height of 20 m and effective storage capacity of 0.165 million cubic meters (MCM). The result of the reservoir operation is shown in Figure 4.2.

4.2 Delineation of Beneficiary Area

(1) Delineation of beneficiary irrigation area

By developing available water resources of the Lokok Meniris river through construction of the proposed Lokok Meniris Embung at the optimum scale, irrigation water can be supplied to wet paddy field of 44 ha in net only for the wet season. Therefore, it is needed to delineate the beneficiary area of the proposed Embung from the existing rainfed paddy field on the right bank of the river. Taking such very limited water supply condition into account, the future cropping pattern under the "With-Project" condition is revised to the two cropping of irrigated wet season paddy and rainfed red soybean and mungbean as Palawija crops as shown below and illustrated in Figure 4.3.

Under the "Without-Project" condition, no new irrigation water source can be developed so that the future cropping pattern is to remain in the same condition of the present pattern on rainfed paddy field.

Future Cropping Pattern

Condition	Wet season			Dry Season		
	Crop	Water Supply	Area (ha)	Crop	Water Supply	Area (ha)
With Project	Paddy	Irrigated	44	Soybean	Rainfed	22
				Mungbean	Rainfed	22
Without Project	Paddy	Rainfed	44	(Fallow)		-

(2) Delineation of beneficiary area for domestic water supply

With regard to domestic water demand in the Project area, it is technically possible to convey clean water from the neighboring basin of the Putih river by installing a new pipeline system. Thus, the water source facility to be newly developed is to be utilized for supplementing irrigation water to grow the wet season paddy.

4.3 Embung Development Plan

Following the results of the geological and material surveys as well as the optimization study, the proposed development plan of Lokok Meniris Embung is determined. In terms of dam type, zone earthfill type is applied in due consideration of the foundation strength and the availability of embankment materials. As for the foundation treatment, it is

proposed to adopt the curtain grout with 800 m length considering the geological condition of the Embung site.

The main components of Lokok Meniris Embung are the main dam, spillway, river diversion conduit and water supply facility as shown in Figure 4.4. In order to provide the optimum storage capacity of 0.165 MCM in the reservoir, the full supply level (FSL) is set at El. 86.70 m. Taking overflow depth of spillway and freeboard into account, the dam height of Lokok Meniris Embung becomes 20.0 m above the river bed. In order to release the flood discharge during the construction period, a river diversion tunnel with concrete pipe of 2.6 m in diameter is provided below the dam body. The spillway is designed on the right bank of the main dam to release the flood discharge of 159.0 m^3 /sec from the catchment area of 7.4 km^2. For the purpose of supplying domestic water to the beneficiary area, such related facilities are provided as an intake structure in the reservoir, water supply pipe with diameter of 160 mm below the dam body and valve house at the downstream of the main dam.

The principal features of Lokok Meniris Embung are summarized below :

(1)	Reservoir	
	- Catchment area	2.5 km^2
	- F.S.L.	El. 86.7 m
	- Minimum operating level	El. 82.1 m
	- Effective storage capacity	165,000 m^3
	- Dead storage capacity	116,000 m^3
	- Gross storage capacity	281,000 m^3
	- Sediment deposition level	El. 81.1 m
(2)	Main dam	
	- Type	Zone type fill-dam
	- Height	20.0 m above river bed
	- Crest elevation	El. 90.0 m
	- Crest length	200 m
	- Crest width	7.0 m
	- Upstream slope	1 : 2.5
	- Downstream slope	1 : 2.0
	- Total embankment volume	80,000 m^3
	- Foundation Treatment	Curtain Grout, 800 m
(3)	Spillway	
	- Design flood (1/100 year)	160 m^3/sec
	- Type	Side-Channel
	- Crest elevation of overflow weir	El. 86.7 m
	- Width of overflow weir	40.0 m
	- Discharge capacity	160 m^3/sec
	- Overflow depth	1.5 m
	- Length	141.5 m
(4)	River diversion	
	- Design flood (1/5 year)	40 m^3/sec. (dry season)
	- Type	Tunnel
	- Diameter	2.6 m
	- Length	Tunnel Portion = 62.5 m, open = 74 m
(5)	Water supply system	
	- Inlet structure	1.0 x 1.0 m with trashracks
	- Pipe diameter	160 mm
	- Valve house	Right abutment of dam site

-	Design discharge	60 lit/sec
-	Type	Through Valve
-	Diameter	160 mm x 1 unit
-	Outlet elevation	El. 78.0 m

5. PRELIMINARY DESIGN OF FACILITIES

5.1 Preliminary Design of Embung

(1) Dam height

Resulting from the optimization study based on irrigation benefit and construction cost, the dam height is decided on the basis of "Reservoir Storage Curve" as shown in Figure 4.1.

(2) Freeboard

The freeboard of main dam is designed taking into consideration the rise of the reservoir water surface due to extraordinary flood discharge and wave uprush on the slope.

The following formula is applied for the design of the Lokok Meniris Embung.

$Hf = 0.05h + 1.0$ (m)

where, Hf : freeboard
h : height from river bed to the designed flood level.

(3) River diversion during construction

During the construction period of dam, river flow including floods has to be diverted to avoid inundation of the Embung construction site. This can be effectively and economically made by providing a random-filled cofferdam and river diversion tunnel with a diameter of 2.6 m as shown in Figure 4.4. Since the volume of flood inflows from 7.4-km^2 catchment will be quite small as compared to the storage created by constructing low cofferdams, a 5-m high cofferdam with a crest level of El. 75.0 m would suffice to contain the dry season flood inflow of 40 m^3/sec having a return period of five years.

(4) Spillway

The spillway is located on the right abutment of main dam, which is composed of side channel type overflow weir, throughway, chuteway and downstream channel. The overflow weir is designed to cope with the inflow design flood with a flood surcharge space provided above F.S.L. The design flood is determined at 100 year probable flood having a peak discharge of 160 m^3/sec.

Based on the result of comparative study on combination of overflow depth and width of the spillway, the overflow depth at 1.5 m and the width of 40.0 m are decided so as to minimize the costs of spillway and the main dam.

A non-gated ogee crest would be set at El. 86.7 m to coincide with F.S.L. Spillway bridge is provided across the crest portion of the spillway because of provision of an access road from the right to left abutments of the main dam.

(5) Water supply system

In order to supply the water to the downstream beneficiary area, the water supply system is provided to release the water of 60 lit/sec. for irrigation use. The water supply system consists of intake structure, pipe line and valve house. The intake structure is located at the inlet portion of the river diversion tunnel just above the sediment deposition level of El. 81.0 m. Fixed trashracks are provided on the intake structure. Steel pipe with a diameter of 160 mm is installed from the plug portion of river diversion tunnel to the valve house located immediately downstream of the main dam.

5.2 Preliminary Design of Irrigation Facilities

(1) Basic concept

The following basic concepts are applied for the preliminary design of irrigation facilities in line with the development strategy:

- Irrigation water impounded by the Embung is supplied firstly to the existing cropped field, irrigated or rainfed, in the beneficiary area;
- Irrigation area is defined taking into consideration the available cropped field and the effective storage capacity of Embung;
- Irrigation canals from the outlet of Embung to the head of existing cropped field is constructed in the form of open channel as much as possible from the economic viewpoint;
- Irrigation system in the existing cropped field is be developed by farmers themselves, as the irrigation system commands around 50 ha only. No consideration is taken into in terms of new land reclamation;
- Proper design of canal alignment for gravity irrigation is considered paying special attention to avoid adverse effect on environment; and,
- Drainage improvement is not required for the existing cropped field since the beneficiary area is situated on well drained land.

(2) Irrigation plan

Irrigation water taken from the reservoir is led to the valve house through the cast iron pipe provided inside the diversion tunnel driven through the right abutment of the dam. The water is discharged to the irrigation inlet box to make the open flow from the pipe pressure flow. From the irrigation inlet box, irrigation water is led to the existing irrigation canal by newly constructed open channel with masonry flume with a distance of around 300 m. Irrigation water led to the existing irrigation canal flows down to the beneficiary irrigation area with a distance of 1780 m. Within the area, irrigation water is delivered by the newly constructed irrigation canal.

General layout is shown in Figure 5.1 including the layout of irrigation canals.

(3) Design discharge and initial water level

Design discharge for canal and related structures are decided based on the irrigation water requirement and proposed cropping pattern. Peak semi-monthly base diversion requirement for the irrigation unit area of 1.0 ha is defined as a design discharge after multiplying the irrigation area. Peak diversion requirement occurs in the second half month of December for the wet season paddy and its design discharge is estimated at 60 lit/sec for the net irrigation area of 44 ha.

Initial water level at the irrigation inlet box is decided taking the elevation at the box site situated at just after the valve house of the Embung into consideration. As a result, the initial water level is El. 78.0 m at the irrigation inlet box.

(4) Irrigation facilities

Layout of canal and design of irrigation facilities are made based on the 1/5,000 topographic map prepared under the Study.

Irrigation canal to lead water to the existing canal from the Embung is constructed using masonry flumes taking into account the design discharge, steep topographic condition, construction method and available construction materials in the Project area. Canal related structures required are irrigation inlet box, turnout, cross drain and irrigation division boxes. Required irrigation facilities are summarized below.

Irrigation Facilities Requirements

Facilities	Quantities
- Valve house (included the facilities for Embung)	1 No.
- Irrigation inlet box	1 No.
- Masonry flume type canal to be constructed	1.8 km
- Masonry flume type canal to be rehabilitated	1.8 km
- Turnout	1 No.
- Cross drain	1 No.
- Irrigation division box	15 Nos.

5.3 Preliminary Design of O&M Road

No all weathered road is available in and around the Embung site. It is therefore planned to provide O&M road to the dam site aiming at smooth undertaking of O&M works after completion of the Embung. Main features are summarized below.

Main Features of O&M Road

Item	Unit	Quantities
Required length	km	0.47
Width	m	7.0
Pavement		Gravel
Cross drain	Nos.	1

6. EMBUNG CONSTRUCTION PLAN

6.1 *Construction Schedule*

(1) Basic condition

All the construction works will be carried out by a local contractor selected by local competitive bidding.

The construction plan is based on the mode of construction and the target schedule of construction works as well as local conditions such as availability of construction labor, material and equipment as well as weather and topographic conditions of the construction site.

It is assumed that 200 working days per year are available for conducting the earthfill embankment works, 270 days per year for the filter and rock embankment works and 300 days per year for concreting works in view of the daily rainfall distribution in the Project area. For each working day, 8-hour shift is applied.

(2) Construction schedule

The overall construction schedule is determined as shown in Figure 6.1 taking into account the necessary time of detailed design, bidding procedure including the time of tender evaluation and award of the contract. The major points of construction schedule are described below.

1) Mobilization and preparation works

Immediately after received the "Notice to Proceed", the contractor would commence the mobilization of construction equipment and key staff to the Project site from the beginning of November in the first year. Following this, preparatory works would be commenced at the Project site.

2) Setting out and excavation works

During the mobilization, setting out of all the structures would be commenced by the contractor at the Project site. Construction of temporary access roads such as access to the borrow area and access to major structural sites shall be stated by using equipment available at the Project site. The excavation works for the river diversion tunnel, and the Spillway would be commenced at the beginning of March in the second year.

3) Concrete works and embankment works

After completion of the concrete placing into the river diversion tunnel embankment works for the main dam shall be commenced and completed before the wet season in the second year. Concrete works for the spillway shall also be concentrated and completed before October in the second year.

4) Commencement of reservoir water impounding

Commencement of the reservoir water impounding will be done at beginning of October, 2nd year after completion of the main dam embankment and sillway construction. Considering the rainfall in November and December, 2 nd year, the Lokok Meniris reservoir would be full reservoir water condition, accordingly the water can be supplied from the reservoir to the water users from January, 3 rd year.

5) Water distribution system

Construction works for the water distribution system will be executed in parallel with the construction works of the Embung by using mainly manpower because of the work quantities for them are not so much. These works shall be completed by the end of December before supplying the reservoir water to the beneficiary area.

6.2 Construction Plan of Embung

(1) Preparatory works

The preparatory works consist of preparation of temporary buildings, construction plant and repair shop, arrangement power and water supply systems as well as communication system, construction of access and haul roads, and so on. All of these works will be conducted from November in the first year to February in the second year.

1) Temporary buildings and yards

The temporary buildings required for the construction would include office, quarters, workshop, warehouse and storage yards. These temporary buildings will be built by the contractor.

2) Water and power supply

The water required for the construction works and the daily use in the construction camp is planned to be taken from the rivers or springs near the Embung site or the wells drilled in the contractor's yard.

The electric power for the construction camp is planned to be supplied by the contractor's diesel generators.

(2) River diversion works

The river flow will be released through the river diversion tunnel during the dry season in the second year, and therefore the river diversion tunnel will be constructed in the right abutment of the main dam.

After completion of the main dam embankment works around the end of September in the second year, the river diversion tunnel shall be plugged by the concrete using concrete pump for a section of 20 m located just crossing point of the main dam axis and the tunnel.

(3) Main dam works

Following construction of the foundation excavation, curtain grouting, river diversion tunnel construction, the embankment works for the main dam will be commenced at the beginning of July in the second year. Considering a total embankment volume of 80,000 m^3 and the remaining dry season period of three months until the end of September in the second year, the daily embankment volume is to be 1,100 m^3 which is quarried from the quarry site and borrow area in the reservoir area.

(4) Spillway construction

Excavation of the spillway will be scheduled to be performed for about three months from March to May in the second year. Most of the excavated materials may be used for the

main dam embankment so that the excavated materials will be stocked on the designated area.

After completion of the spillway excavation, concrete works of weir and chuteway will be commenced. Before starting the reservoir water impounding at the beginning of October in the second year, major concrete works of the spillway shall be completed in order to release the flood discharge in the following wet season.

(5) Water supply system

The inlet structure of water supply system will be constructed at the inlet portion of the river diversion tunnel, at the beginning of October in the second year.

Steel pipe with a diameter of 160 mm is installed in the plug portion of the river diversion tunnel just crossing point between the dam axis and the tunnel. The steel pipe will be connected from the plug portion to the valve house located immediately downstream at the main dam.

Construction of the valve house and the installation of the steel pipe will be completed before the reservoir water reaches to F.S.L. of El. 86.70 m, around the end of December in the second year.

6.3 Construction Plan of Irrigation Facilities and O&M Road

Since the irrigation facilities and O&M road to be constructed are rather small and in work quantities scattering in the beneficiary area in comparison with the Embung construction works, almost all of the works except earth works for irrigation canal and road will be basically executed by man-power in parallel with the Embung. Earth works for the irrigation canal and O&M road such as clearing, stripping, excavation and embankment works will be executed by using heavy construction equipment bulldozer, excavator, compactor, and so on. All of these works will be also executed in parallel with the Embung construction works.

6.4 Institutional Arrangement for Project Implementation

(1) Responsible organization for Project implementation

In the course of Project implementation, DPUP of NTB, after getting approval from DGWRD, will direct the PKSA Lombok Project Office to commence undertaking of detailed investigation and design works of the Lokok Meniris Embung. These works will be done by the Survey and Investigation Section as well as the Technical Design Section of the said Project Office. Based on the cost estimate, DPUP of NTB will disburse budget for land acquisition and construction of Embung and related facilities to the Project Office using development budget allocated from the Central Government. Before starting construction work, land acquisition work will be carried out by the Land Acquisition Section of the Project Office. Supervision of construction works, being entrusted to a contractor through tendering, will be the responsibility of the Construction and Implementation Section of the Project Office.

(2) Technical resources input

In due consideration of the current availability of engineers and technical staff as well as the annual development target in the PKSA Lombok Project Office, it is necessary to utilize technical resources outside the Project Office to the maximum extent for enabling the Project Office to realize its target. In this connection, undertaking of detailed investigation and design works for the Lokok Meniris Embung need to be entrusted to consultants aiming

to secure smooth implementation of the Project in accordance with the implementation program made by the Project Office.

(3) Organization for O&M

After completing all of the Project works for Lokok Meniris Embung, DPUP of NTB will submit its completion report to the Minister for Public Works through DGWRD and therefrom the notice of Project completion will be transferred to the Minister for Home Affairs. After receiving the Minister's direction, the Governor of NTB Province will order DPUP NTB to take a necessary action for O&M of the said Project facilities. Following this, DPUP of NTB will direct its Provincial O&M Project Office to arrange O&M works and disburse the Provincial Government's budget to DPUP Kabupaten Lombok Barat Office.

(4) Water User's Association (P3A)

In the Project area, the existing P3A has been active since 1991. It is therefore necessitated to make the new beneficiary farmers become members of this P3A and to train them by using training materials and modules prepared by the Water User Training Program under DGWRD.

7. COST ESTIMATE

7.1 Basic Assumption of Cost Estimate

Project cost of the proposed works for developing the Lokok Meniris Embung is estimated on the basis of assumptions as follows :

- All the civil works of the Project will be executed on the contract basis. Contractor(s) will be selected through the competitive bidding;
- Project cost includes the physical contingency of 15% of the construction costs in view of the preliminary nature of the estimate. The price contingency of 20% is also included in the cost estimate taking into account the recent price escalation of construction materials in Indonesia;
- The associated costs to be financed by the Government, such as the cost for strengthening the extension services, facilities of the Water Users' Association and improvement of the social infrastructures except for those included in the proposed Project works, are not included in the cost estimate;
- The direct construction cost is estimated based on the calculated work quantities of the Project works and unit prices of the works. The unit prices of the works are estimated based on the current prices in NTB as of October 1994 and the data collected from the on-going projects in NTT and NTB. The basic prices for construction works include delivery cost of construction materials to the Project site;
- The contract tax, which is a value added tax imposed by the government at a rate of 10% against the total contract cost, is included in the estimate of the Project cost;
- Engineering service cost for the consultants in conducting detailed design and construction supervision is estimated based on such assumption as 15% of direct construction cost;
- Administration cost consists of PRWS's staff salary for construction management, vehicle running cost and other related cost only for the Project implementation. Administration cost is estimated at around 5% of the direct construction cost with reference to the recent other project costs in NTT and NTB;
- Land acquisition cost including the purchase of the Embung site, reservoir area, borrow areas, and land of pipe line, irrigation canal and permanent structures and is estimated at 0.5 % of the direct construction cost taking into consideration the present condition of the Project area based on the survey results under the Study; and,
- The currency for cost estimate is expressed in Indonesian Rupiah (Rp.) since all construction materials are available in Indonesia and the payment for construction works will be executed with Indonesian Rupiah.

7.2 Construction Cost

The Project cost, as an initial investment by the Project, is composed of direct construction cost, administration cost, engineering service cost, physical contingency,

contract tax, land acquisition cost and price contingency. The total Project cost for constructing the Lokok Meniris Embung is estimated at Rp. 4,766 million as shown in Table 7.1. Detail of direct construction cost estimated based on the calculated work quantities of the proposed Project works and unit prices of the works is shown in Table 7.2 together with work quantities of the main work items and unit prices.

The total Project cost for constructing the Lokok Meniris Embung is summarized below.

Summary of Project Cost for Lokok Meniris Embung

Unit : Rp. Million

Item		Project cost
I.	Direct construction cost	2,617
1.1	Preparatory works	125
1.2	Embung construction	2,269
1.3	Irrigation facilities	190
1.4	Domestic water supply	0
1.5	Operation & maintenance road	33
II.	Administration cost	131
III.	Engineering services	392
IV.	Physical contingencies	471
V.	Contract tax	348
VI.	Land acquisition	13
VII.	Price contingency	794
	Grand Total	4,766

7.3 Operation and Maintenance Cost

The O&M costs consist of salaries of O&M staff, cost for maintaining the Project facilities, material and labor cost for repairing works, and running cost of Project facilities. The annual O&M costs are estimated at Rp. 23.8 million, which is equivalent to 0.5 % of the project cost.

8. PROJECT JUSTIFICATION

8.1 Satisfaction of BHN

The inhabitants in Anyar Village intend to get a new domestic water source. The future domestic water demand for 1,285 beneficiary inhabitants is projected to be 37.9 MCM in the year of 2008. However, it is technically possible and financially cheap to convey clean water from the neighboring basin of the Putih river compared with the required investment in construction of a new Embung on the Lokok Meniris river.

8.2 Economic Consideration

(1) Economic cost

The financial costs are to be converted into the economic costs by applying the economic conversion factor (ECF) established by DGWRD in 1985. The ECFs applied are: 0.71 for preparatory works and all civil works including Embung, irrigation facilities, domestic water supply system and road networks; 0.75 for unskilled on-farm labor and farm labor; 0.80 for land clearing, on-farm development and operation and maintenance cost; and tertiary irrigation system development, 0.90 for design and survey works and administration; and 1.00 for O&M equipment and replacement cost.

When the financial cost is converted to the economic cost, the contract tax, land acquisition cost and price contingency are fully excepted. In this Study, only the purchasing cost of consumable and goods appropriated in the administration cost is to be converted to the economic administration cost, as the normal payment to civil servants is principally appropriated in the operation budget of the Government. As the construction cost of dam and engineering cost estimated include some allowance to cover additional cost for expatriates, 50% of the engineering cost is to be converted to the economic cost in order to make the estimated cost equal to the level of local cost.

The economic cost converted and its annual disbursement schedule are shown in Table 8.1.

(2) Economic benefit

The irrigation benefits of the Project are principally derived from increased crop production attributable to stable irrigation water supply, full utilization of available farm land resources and optimum farm input supply. Table 8.2 gives financial and economic prices of farm inputs and outputs estimated for major islands. Based on the proposed quantity of farm inputs, anticipated crop yield and economic farm gate prices, the economic crop budget is estimated as shown in Table 8.3.

The annual net incremental benefit is thus estimated to be Rp. 43.9 million. This increment benefit will accure from the first year when irrigation water can be released from the Pelangan Embung. Taking the present agricultural situation and farmers capability into account, it is assumed that five years are needed as the build-up period to attain the anticipated crop yield level. In the proposed reservoir area, there will be no production foregone in the proposed reservoir area by constructing the proposed Lokok Meniris Embung.

(3) Economic evaluation

The economic internal rate of return (EIRR) is examine as shown in Table 8.4 on costs and benefits as at August 1994. The result of economic analysis reveals that there is no economic merit developing the proposed Lokok Meniris Embung because the economic

benefit attributed to the Embung development is too small compared with the required capital cost as the topographic condition limits to enlarge the reservoir capacity of Embung resulting in new irrigation area of only 44 ha.

(4) Farm budget analysis

With the implementation of Pelangan Embung Project, the net on-farm income of farmers holding a unit farm size of 1.0 ha can be expected to increase by Rp. 1,429,915/year from Rp. 449,750/year under the "Without Project" condition with the cropping intensity of 100% to Rp. 1,879,665/year under the "With Project" condition with the cropping intensity of 200% as shown in Table 8.5 and below. Though farm budget would be improved to large extent, the number of beneficiary farmers is limited and their total payment capacity is too small to cover operation and maintenance cost of on-farm irrigation service facilities to some extent.

Farm Budget for Unit Farm Size of 1 Ha

Crop	Watering Condition	Without Project		With Project	
		Crop Intensity (%)	Income (Rp.)	Crop Intensity (%)	Income (Rp.)
Paddy	Wet/Rainfed	100.0	449,750	-	-
	Wet/Irrigated	-	-	100.0	1,009,875
Soybean	Dry/Rainfed	-	-	50.0	448,955
Mungbean	Dry/Rainfed	-	-	50.0	420,835
Total		100.0	449,750	200.0	1,879,665

8.3 Environmental Impact Assessment

Environmental impact assessment for the Project is carried out in consideration of the development objectives of the Project.

(1) Environmental Features of the Project area

The principal features of human and physical environment in the Lokok Meniris Project area are summarized as below.

Environmental Features in the Lokok Meniris Project Area

Item	Description
1. Human Environment	
Social intention	Insufficiency of reliable water sources and facilities for irrigation water and domestic use
Human use	Use of well water (shortage in the dry season)
Economic activities	Cultivation of irrigated paddy and Palawija, and livestock farming
Health and sanitation	Prevalence of waterborne intestinal diseases
2. Physical environment	
Geology/land	Volcanic products of the Quaternary
Surface/ground water	Surface water is not perennially observed
Endemic fauna and flora	None
3. Others	None

(2) Environmental impact assessment

The results of environmental impact assessment reveal that there exist no negative impacts by developing Lokok Meniris Embung in this Project area.

(3) Primary information of environmental assessment

To support environmental analysis presentation for this Project implementation on the Indonesian rule, primary information on environmental assessment is compiled in the Attachment to Volume 4.

8.4 Contribution to Women in Development

Since housewives in the Project area manage their family budgets, an increase of the farmer's income would encourage women in investing surplus in improvement and diversification of their income sources.

9. CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

On the basis of categorization of 157 candidate schemes for the Study, the Lokok Meniris Embung scheme is selected representing a typical sample scheme of which potential beneficiary area has its irrigation water source in the neighboring river basin, good farming system with the maximum extent of designed irrigation area and inhabitants' demand for further use of irrigation and domestic water. The proposed Lokok Meniris Embung site has physically irrigable land resources of 83 ha in net and the annual discharge of 5.0 MCM from its catchment area of 7.4 km^2.

The topographic condition at the proposed Embung site is the determining factor in the optimization of development scale. The maximum dam height of Lokok Meniris Embung is thus set to be 20.0 m with the total and effective storage capacities of o.281 and 0.165 MCM, respectively. Under such condition, however, 44 ha out of the physically irrigable land resources of 83 ha will be able to be provided with irrigation water only for the wet season. It can be expected to grow the dry season Palawija crops under the rainfed condition depending on available soil moisture during the early dry season. The future domestic water demand of 0.047 MCM for 1,285 inhabitants will be unable to be covered as the priority of water supply is given to the irrigated farming.

The structural components are main dam, spillway and diversion tunnel as well as irrigation water distribution system. The zoned embankment dam is constructed with the crest length of 200 m, embankment volume of 8,000 m^3 and side-channel typed spillway having design flood discharge of 159 m^3/sec and overflow weir width of 40 m. The required investment cost amounts to Rp. 4.8 billion of which direct construction cost is estimated to be 2.6 billion.

The results of feasibility study reveal that construction of the candidate Embung at the proposed site is technically sound but economically impossible because of limited storage capacity. The increasing domestic water demand of inhabitants in the Project area could be met by further trans-basin of river flow. Therefore, such type of Embung is worthless implementing from the topographic and socio-economic viewpoints.

9.2 Recommendations

To meet the future water demand in the Lokok Meniris area, it is recommended to formulate a development plan to transfer excess discharge from the neighboring river basin instead of implementing Embung development on the Lokok Meniris river.

The Study on The Embung Development Project in East Nusa Tenggara and West Nusa Tenggara

Feasibility Study on Lokok Meniris Embung Development Project

Tables

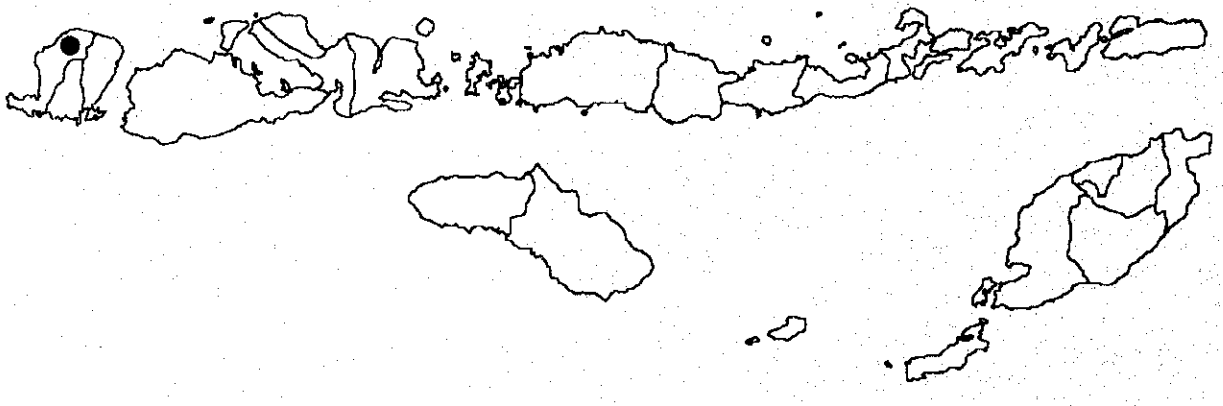


Table 1.1 Rainfall Record in Desa Anyar

DESA ANYAR (SOURCE CRIPPEN + DPU)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year
1959	74	615	467	119	17	266	34	12	0	0	6	676	2286
1960	248	338	207	117	42	38	0	0	0	6	20	300	1316
1961	401	266	134	24	135	1	0	0	0	0	121	51	1133
1962	1008	0	61	65	0	0	0	0	0	0	0	166	1300
1963	724	319	79	94	0	0	0	0	0	0	14	61	1291
1964	5	176	378	9	20	0	0	0	12	51	32	21	704
1965	350	185	299	8	0	14	6	0	0	6	0	15	883
1966	61	264	277	60	40	30	4	2	21	8	32	170	969
1967	376	300	277	60	40	30	4	2	21	8	32	170	1320
1968	376	300	277	60	40	30	4	2	21	8	32	170	1320
1969	376	300	277	60	40	30	4	2	21	8	32	170	1320
1970	148	514	80	197	89	0	0	0	176	0	43	211	1458
1971	13	336	524	5	37	34	1	0	22	12	32	19	1035
1972	167	250	408	40	34	2	0	8	0	0	0	335	1244
1973	916	233	483	38	102	0	6	0	36	5	32	163	2014
1974	764	405	209	0	0	0	5	0	2	10	80	23	1498
Max.	1008	615	524	197	135	266	34	12	176	51	121	676	2286
Mean	375	300	277	60	40	30	4	2	21	8	32	170	1318
Min.	5	0	61	0	0	0	0	0	0	0	0	15	704

Sum of monthly means

Table 1.2 Climate in Sopak Bayan

Station: Sopak Bayan
Island : Lombok
Kabupaten : Lombok Barat

Latitude : 08 15 S
Longitude : 116 26 E
Elevation : 278 m

Description	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Average	Year
Average daily maximum temperature	C	30.0	27.2	28.8	29.2	29.8	29.1	30.1	29.0	30.9	31.6	31.2	30.4	29.8	1982 - 1985
Average daily minimum temperature	C	22.1	22.9	23.8	23.2	22.6	22.1	19.8	21.8	20.3	20.8	22.5	22.2	22.0	1982 - 1985
Mean daily temperature	C	26.1	25.1	26.3	26.2	26.2	25.6	25.0	25.4	25.6	26.2	26.9	26.3	25.9	1982 - 1985
Mean daily relative humidity	%	78.0	82.0	70.0	62.0	59.0	76.0	74.0	68.0	73.0	66.0	70.0	77.0	71.0	1982 - 1985
Mean daily wind run over 24 hours	km/day	111.0	102.0	103.0	115.0	118.0	118.0	126.0	129.0	141.0	138.0	144.0	118.0	122.0	1982 - 1985
Wind speed at time of observation	m/s	1.3	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.4	1.4	1982 - 1985
Mean daily observed bright sunshine	hr/month	140.0	127.0	133.0	165.0	220.0	255.0	279.0	285.0	270.0	257.0	192.0	140.0	2,463.0	1982 - 1985
Mean daily observed bright sunshine	hr/day	4.5	4.5	4.3	5.5	7.1	8.5	9.0	9.2	9.0	8.3	6.4	4.5	6.7	1982 - 1985
Mean daily maximum possible sunshine	hr/day	12.5	12.4	12.2	12.0	11.8	11.7	11.8	11.9	12.0	12.2	12.5	12.6	12.1	1982 - 1985
Mean Solar Radiation	mm/day	16.1	16.1	15.8	14.6	13.3	12.6	12.9	13.9	15.1	15.9	16.0	16.1	14.9	1982 - 1985

Source : Reppprot (Nusatenggara, Maluku, Timor Timur) Annex 3

Table 1.3 Typical Soil Profile in the Lokok Meniris Project Area

Profile No.:	8
Soil Classification:	Typic Ustipsamments
Physiography:	Alluvial fan
Topography:	Undulating (2 - 4 %)
Land Use/Vegetation:	Unirrigated upland
Parent material:	Alluvium
Drainage:	Excessive
Groundwater Table:	> 15 m
Permeability:	Very rapid (32 cm/hr)
Land Morphology:	

Horizon	Depth (cm)	Description
Ap	0 - 19	Light brown (7.5YR 6/4, dry); loamy sand; 5 % pumice-coarse material 2mm; structureless, single grain; non sticky; non plastic; very friable; loose consistency; vew fine root; diffuse, smooth horizon boundary
AC	19 - 65	Brown (7.5YR 5/4, dry); lamy sand; 5 % pumice-coarse material 6 - 8 mm; structureless, single grain; non sticky, non plastic, friable, loose consistency; diffuse, smooth horizon boundary
C	65 - 100+	Layered punice-sandy materials

Source: Soil survey carried out by the local consultant under supervision of the JICA Study Team

Table 1.4 Results of Soil Laboratory Test in Lokok Meniris Project Area

Soil Pit	Layer	Texture			Permeability	pH	pH	Organic matter	Total N	Ava. P	CEC	Ex. Na	Ex. Ca	Ex. K	Ex. Mg	Base Saturation	EC
		Sand (%)	Silt (%)	Clay (%)	(cm/hr)	(H2O)	(KCl)	(%)	(%)	(ppm)	(me/100g)	(me/100g)	(me/100g)	(me/100g)	(me/100g)	(%)	(mS/cm)
3	Ap	70.4	16.6	13.0	30.5	6.6	5.5	1.36	0.04	4.77	19.57	0.41	6.89	1.87	1.73	56	0.10
	Bw	71.7	13.3	15.0	22.2	6.7	5.4	1.15	0.08	4.14	19.44	0.49	5.48	1.74	2.03	50	0.08
	C	66.4	12.6	21.0		7.1	5.9	1.16	0.09	2.05	20.25	2.20	7.87	1.88	2.17	70	0.08
8	Ap	80.4	8.8	10.8	32.3	6.5	5.5	0.96	0.04	2.87	7.57	0.32	3.28	0.71	0.71	66	0.08
	AC	84.4	4.8	10.8	30.2	7.0	5.3	0.15	0.05	2.60	7.54	0.12	3.67	0.78	0.65	69	0.02
	C	81.7	7.3	10.0		6.9	5.4	0.08	0.05	2.65	6.76	0.26	3.19	0.60	0.61	69	0.02
9	Ap	86.4	2.6	11.0	26.7	6.8	5.6	0.38	0.03	2.06	8.97	0.51	4.05	0.95	0.86	71	0.06
	B	82.4	5.3	12.0	31.2	6.7	5.7	1.14	0.05	2.12	7.88	0.33	3.33	0.67	0.84	66	0.06
	C	82.4	4.6	13.0		7.0	5.7	0.15	0.04	2.17	7.53	0.36	3.16	0.73	0.64	65	0.04

Source: Soil survey carried out by the local contractor under supervision of the JICA Team

Table 1.5 Soil Classification in the Lokok Meniris Project Area

Land Unit	Description	Physiography	Topography	Potential Suitability			Area	
				Paddy	Soybean	Maize	(ha)	(%)
I	Typic Ustropepts deep; coarse loamy; neutral; moderate CEC; rapid permeability; well drainage	Mountain foot slope	Flat-undulating (0-8%)	S1/S3	S2/S3	S2/S3	80	33%
II	Lithic Ustipsamments shallow; sandy; neutral; low-moderate CEC; very rapid permeability; well drainage	Mountain foot slope	Undulating (6-8%)	S3	S2	S3	14	6%
III	Typic Ustipsamments deep; sandy; neutral; low-moderate CEC; very rapid permeability; well drainage	Alluvial fan	Undulating (0-8%)	S2/S3	S2/S3	S2/S3/N	136	57%
IV	Lithic Ustipsamments deep; loamy sandy; neutral; moderate CEC; rapid permeability; well drainage	Alluvial fan	Undulating (2-4%)	S3	S2	S3	9	4%
#	Unclassified						0	0%
	Total						239	100%

Source: Soil survey carried out by the local consultant under supervision of the JICA Team

Table 1. 6 Summary of Farm Household Economic Survey in the Lokok Meniris Project Area

	Item	Unit	Respond't No. 1	Respond't No. 2	Respond't No. 3	Respond't No. 4	Respond't No. 5	Respond't No. 6	Respond't No. 7	Respond't No. 8	Respond't No. 9	Respond't No. 10	Respond't No. 11	Respond't No. 12	Respond't No. 13	Respond't No. 14	Respond't No. 15	Average
1	Sex and Age		Male 50	Male 50	Male 40	Male 45	Male 26	Male 50	Male 45	Male 30	Male 35	Male 40	Male 48	Male 50	Male 40	Male 42	Male 50	Male 43
2	No. of Family Member		M-1/F-5	M-4/F-1	M-1/F-2	M-5/F-3	M-0/F-2	M-3/F-1	M-4/F-1	M-3/F-2	M-2/F-1	M-0/F-1	M-0/F-3	M-2/F-2	M-2/F-1	M-0/F-3	M-0/F-3	M-2/F-2
3	Type of Side Job		Seller	None	None	None	None	None	Carpenter	None	Civil Ser.	None	None	None	Worker	Seller	None	
4	Own Farmland	ha	0.60	0.50	1.37	2.84	0.29	0.75	0.60	0.50	1.00	1.00	0.56	1.50	0.50	0.38	0.65	0.87
	Rented Farmland	ha	0.00	0.00	0.00	0.00	0.00	0.00	1.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
	Yield Division	ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(Paddy field)	ha	0.30	0.50	1.35	2.75	0.25	0.75	2.35	0.50	1.00	1.00	0.50	1.50	0.50	0.38	0.65	0.95
5	Cropped Area	ha	0.75	0.80	2.95	4.54	0.48	1.83	6.00	1.82	2.70	1.70	1.20	2.70	1.70	1.85	0.80	2.12
	(Paddy)	ha	0.25	0.10	1.00	2.00	0.20	0.70	2.00	0.48	0.90	0.75	0.45	1.35	0.48	0.35	0.50	0.77
	(Palawija)	ha	0.50	0.70	1.95	2.54	0.28	1.13	4.00	1.34	1.80	0.95	0.75	1.35	1.22	1.50	0.30	1.35
	(Others)	ha	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	Cow/Buffalo	head	4	2	2	7	2	3	4	3	3	3	2	3	3	3	4	3
	Horse	head	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Goat/Sheep	head	0	0	0	4	0	0	0	0	6	0	0	0	0	0	0	1
	Pig	head	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Chicken/Duck	head	24	20	37	22	8	36	35	18	18	17	18	28	20	39	38	25
7	Gross Income	Rp.'000/yr	1,667.5	817.5	2,730.0	6,853.0	700.0	2,300.0	15,385.0	1,710.0	4,590.0	2,550.0	1,012.5	2,162.5	2,050.0	2,360.4	1,550.0	3,229.2
	(Crop)	Rp.'000/yr	667.5	817.5	2,730.0	6,453.0	700.0	2,000.0	13,025.0	1,410.0	1,800.0	2,200.0	1,012.5	1,862.5	1,450.0	1,040.4	1,250.0	2,561.2
	(Livestock)	Rp.'000/yr	400.0	0.0	0.0	400.0	0.0	300.0	700.0	300.0	390.0	350.0	0.0	300.0	300.0	300.0	300.0	269.3
	(Side job)	Rp.'000/yr	600.0	0.0	0.0	0.0	0.0	0.0	1,660.0	0.0	2,400.0	0.0	0.0	0.0	300.0	1,020.0	0.0	398.7
	(Miscellaneous)	Rp.'000/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	Expenditure	Rp.'000/yr	1,874.4	1,452.2	1,385.2	1,927.0	1,029.3	2,144.0	3,766.7	1,706.0	2,084.5	1,011.8	1,302.1	1,326.3	1,393.6	1,694.6	1,125.0	1,681.5
	(Food/drink)	Rp.'000/yr	1,422.0	864.0	614.4	720.0	672.0	1,050.0	1,692.0	948.0	954.0	336.0	828.0	354.0	720.0	912.0	492.0	838.6
	(Living)	Rp.'000/yr	107.2	245.0	201.0	257.0	127.0	591.0	525.0	193.0	268.0	171.0	219.0	219.0	280.0	236.0	267.0	260.4
	(Education)	Rp.'000/yr	79.2	0.0	0.0	72.0	0.0	0.0	78.0	78.0	72.0	0.0	0.0	0.0	78.0	78.0	0.0	35.7
	(Production)	Rp.'000/yr	266.0	343.2	569.8	878.0	230.3	503.0	1,471.7	487.0	790.5	504.8	255.1	753.3	315.6	468.6	366.0	546.9
9	Surplus/Deficit	Rp.'000/yr	-206.9	-634.7	1,344.8	4,926.0	-329.3	156.0	11,618.3	4.0	2,505.5	1,538.2	-289.6	836.2	656.4	665.8	425.0	1,547.7
10	Saving	Rp.'000/yr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source : JICA Agro-economic Survey

Table 2.1 Estimated Evapotranspiration in Lokok Meniris Scheme

Site : Lokok Meniris
Meteororogical Station : Sopak Bayan

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean	C	26.10	25.10	26.30	26.20	26.20	25.60	25.00	25.40	25.60	26.20	26.90	26.30
RH mean	%	78.00	82.00	70.00	62.00	59.00	76.00	74.00	68.00	73.00	66.00	70.00	77.00
U km/day	km/day	111.00	102.00	103.00	115.00	118.00	118.00	126.00	129.00	141.00	138.00	144.00	118.00
ea	mbar	33.60	31.70	34.02	33.81	33.81	32.65	31.51	32.27	32.65	33.81	35.28	34.02
RH/100		0.78	0.82	0.70	0.62	0.59	0.76	0.74	0.68	0.73	0.66	0.70	0.77
ed	mbar	26.21	25.99	23.81	20.96	19.95	24.81	23.32	21.94	23.83	22.31	24.70	26.20
(ea-ed)	mbar	7.39	5.71	10.21	12.85	13.86	7.84	8.19	10.33	8.82	11.50	10.58	7.82
f(u)		0.57	0.55	0.55	0.58	0.59	0.59	0.61	0.62	0.65	0.64	0.66	0.59
(1-W)		0.25	0.26	0.25	0.25	0.25	0.26	0.26	0.26	0.26	0.25	0.24	0.25
(1-W)f(u)(ea-ed)	mm/day	1.05	0.81	1.39	1.86	2.03	1.18	1.30	1.64	1.46	1.84	1.69	1.14
Ra	mm/day	16.40	16.30	15.50	14.20	12.80	12.00	12.40	13.50	14.80	15.90	16.20	16.20
n	hr/day	4.50	4.50	4.30	5.50	7.10	8.50	9.00	9.20	9.00	8.30	6.40	4.50
N	hr/day	12.60	12.40	12.10	11.80	11.60	11.50	11.60	11.80	12.00	12.30	12.60	12.70
(0.25+0.50n/N)		0.43	0.43	0.43	0.48	0.56	0.62	0.64	0.64	0.63	0.59	0.50	0.43
Rs	mm/day	7.03	7.03	6.63	6.86	7.12	7.43	7.91	8.64	9.25	9.34	8.16	6.92
Rns	mm/day	5.62	5.63	5.30	5.49	5.69	5.95	6.33	6.91	7.40	7.47	6.53	5.54
f(T)		15.90	15.65	15.94	15.94	15.94	15.80	15.65	15.75	15.80	15.94	16.06	15.94
f(ed)		0.11	0.11	0.12	0.13	0.14	0.12	0.12	0.13	0.12	0.13	0.12	0.11
f(n/N)		0.42	0.43	0.42	0.52	0.65	0.77	0.80	0.80	0.78	0.71	0.56	0.42
Rnl=f(T)f(ed)f(n/N)	mm/day	0.74	0.75	0.81	1.12	1.45	1.41	1.55	1.64	1.49	1.45	1.05	0.74
Rn =Rns-Rnl		4.88	4.88	4.49	4.37	4.24	4.54	4.78	5.27	5.91	6.02	5.48	4.80
W		0.75	0.74	0.75	0.75	0.75	0.75	0.74	0.74	0.75	0.75	0.76	0.75
W Rn		3.66	3.61	3.38	3.28	3.19	3.38	3.53	3.91	4.41	4.52	4.15	3.61
c		1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10
Eto	mm/day	5.19	4.86	5.24	5.65	5.74	5.01	5.32	6.11	6.46	7.00	6.43	5.22

Source : JICA Study Team estimation by Modified Penman Method based on the meteorological data at the Sopak Bayan station.

Table 2.2 Effective Rainfall in Lolok Meniris Project

Site : Lokok Meniris
Meteorological Station : Dusun Anyar

Month	Evapotrans-piration (ETo)	Average Rainfall		Annual-base Dependable Rainfall	Effective Rainfall	
					Paddy	Palawija
	[1] (mm)	[2] (mm)	[3] (%)	[4] (mm)	[5] (mm)	[6] (mm)
January	161	375	28.4%	284	199	137
February	136	300	22.7%	227	159	126
March	162	277	21.0%	210	147	137
April	170	60	4.5%	45	32	38
May	178	40	3.0%	30	21	27
June	150	30	2.3%	23	16	19
July	165	4	0.3%	3	2	0
August	189	2	0.2%	2	1	0
September	194	21	1.6%	16	11	14
October	202	8	0.6%	6	4	0
November	193	32	2.4%	24	17	21
December	162	170	12.9%	129	90	93
Total	2,062	1,319	100.0%	1,000	700	610

Note ;

[1] : Estimated by Modified Penman Method based on Sopak Bayan station
[2] : Rainfall data in station compiled by DPU+Crippen (1959-1974)
[3] : Percentage of monthly rainfall to annual rainfall, calculated from column [2]
[4] : 1000 mm (Calculated 80 % dependable annual rainfall) x [3]
[5] : [4] x 0.70
[6] : Derived by USDA SCS Method introduced by Design Criteria KP-01, where effective storage is assumed 75 mm

Source : JICA Study Team estiamtion based on the rainfall data at the Dusar Anyar statin.

Table 2.3 Irrigation Water Requirement in Lokok Meniris Project (1/4)

Site : Lokok Meniris
Crops : Wet Season Paddy

Item		Month (days)	Jan. 1 (15)	Jan. 2 (16)	Feb. 1 (14)	Feb. 2 (14)	Mar. 1 (15)	Mar. 2 (16)	Apr. 1 (15)	Apr. 2 (15)	May 1 (15)	May 2 (16)	Jun. 1 (15)	Jun. 2 (15)	Jul 1 (15)	Jul 2 (16)	Aug. 1 (15)	Aug. 2 (16)	Sep. 1 (15)	Sep. 2 (15)	Oct. 1 (15)	Oct. 2 (16)	Nov. 1 (15)	Nov. 2 (15)	Dec. 1 (15)	Dec. 2 (16)	Annual
I. Evapotranspiration (Eto)		mm/day	5.19	5.19	4.86	4.86	5.24	5.24	5.65	5.65	5.74	5.74	5.01	5.01	5.32	5.32	6.11	6.11	6.46	6.46	7.00	7.00	6.43	6.43	5.22	5.22	
		mm	78	83	68	68	79	84	85	85	86	92	75	75	80	85	92	98	97	97	105	112	96	96	78	84	2,077
II. Wet Season Paddy																											
(1) Proposed cropping pattern / Crop coefficient																											
- WP-1			1.10	1.10	1.05	1.05	0.95	0.00																	LP	LP	
- WP-2			LP	1.10	1.10	1.05	1.05	0.95	0.00																	LP	
- WP-3			LP	LP	1.10	1.10	1.05	1.05	0.95	0.00																	
(2) Crop consumptive use (Etc)																											
- WP-1		mm	86	91	71	71	75	0																			395
- WP-2		mm		91	75	71	83	80	0																		400
- WP-3		mm			75	75	83	88	81	0																	401
(3) Land preparation (IR)																											
- WP-1		mm																							192	205	397
- WP-2		mm	192																							205	397
- WP-3		mm	192	205																							397
(4) Percolation																											
- WP-1		mm	30	32	28	28	30																				
- WP-2		mm		32	28	28	30	32																			
- WP-3		mm			28	28	30	32	30																		
(5) Water layer replacement (RW)																											
- WP-1		mm		50		50																					
- WP-2		mm			50		50																				
- WP-3		mm				50		50																			
(6) Effective rainfall (ER)		mm	96	103	80	79	71	76	16	16	10	11	8	8	1	1	0	1	5	6	2	2	8	9	44	46	699
(7) Field water requirement																											
- WP-1		mm	20	70	19	70	34	0																	148	159	521
- WP-2		mm	96	20	73	20	92	36	0																	159	496
- WP-3		mm	96	102	23	74	42	94	95	0																	525
(8) Diversion requirement		mm	109	99	59	84	86	67	48	0															76	163	790
		m3/ha	1,090	990	590	840	860	670	480	0															760	1,630	7,910

Source : JICA Study Team estimate based on the meteorological data at the Sopac Bayan and Dusun Anyar station

Table 2.3 Irrigation Water Requirement in Lokok Meniris Project (2/4)

Site : Lokok Meniris
Crops : Dry Season Paddy

Item		Month (days)	Jan. 1 15	Jan. 2 16	Feb. 1 14	Feb. 2 14	Mar. 1 15	Mar. 2 16	Apr. 1 15	Apr. 2 15	May 1 15	May 2 16	Jun. 1 15	Jun. 2 15	Jul 1 15	Jul 2 16	Aug. 1 15	Aug. 2 16	Sep. 1 15	Sep. 2 15	Oct. 1 15	Oct. 2 16	Nov. 1 15	Nov. 2 15	Dec. 1 15	Dec. 2 16	Annual
I. Evapotranspiration (Eto)		mm/day	5.19	5.19	4.86	4.86	5.24	5.24	5.65	5.65	5.74	5.74	5.01	5.01	5.32	5.32	6.11	6.11	6.46	6.46	7.00	7.00	6.43	6.43	5.22	5.22	
		mm	78	83	68	68	79	84	85	85	86	92	75	75	80	85	92	98	97	97	105	112	96	96	78	84	2,077
II. Wet Season Paddy																											
(1) Proposed cropping pattern / Crop coefficient																											
- DP-1										LP	LP	1.10	1.10	1.05	1.05	0.95	0.00										
- DP-2											LP	LP	1.10	1.10	1.05	1.05	0.95	0.00									
- DP-3												LP	LP	1.10	1.10	1.05	1.05	0.95	0.00								
(2) Crop consumptive use (Etc)																											
- DP-1		mm										101	83	79	84	81	0										427
- DP-2		mm											83	83	84	89	87	0									426
- DP-3		mm												83	88	89	96	93	0								449
(3) Land preparation (IR)																											
- DP-1		mm								197	198																395
- DP-2		mm									198	211															409
- DP-3		mm										211	189														400
(4) Percolation																											
- DP-1		mm										32	30	30	30	32	0										
- DP-2		mm											30	30	30	32	30	0									
- DP-3		mm												30	30	32	30	32	0								
(5) Water layer replacement (RW)																											
- DP-1		mm											50		50												
- DP-2		mm												50		50											
- DP-3		mm													50		50										
(6) Effective rainfall (ER)		mm	96	103	80	79	71	76	16	16	10	11	8	8	1	1	0	1	5	6	2	2	8	9	44	46	699
(7) Field water requirement																											
- DP-1		mm								181	188	122	155	101	163	112	0										1,021
- DP-2		mm									188	200	105	155	113	170	117	0									1,048
- DP-3		mm										200	181	105	167	120	176	124	0								1,073
(8) Diversion requirement		mm								93	193	268	226	185	227	207	150	64	0								1,611
		m3/ha								930	1,930	2,680	2,260	1,850	2,270	2,070	1,500	640	0								16,130

Source : JICA Study Team estimate based on the meteorological data at the Sopac Bayan and Dusun Anyar station

Table 2.3 Irrigation Water Requirement in Lokok Meniris Scheme (3/4)

Site : Lokok Meniris
Crops : Palawija (1/2) : Soybeans and Mungbeans

Item		Jan. 1	Jan. 2	Feb. 1	Feb. 2	Mar. 1	Mar. 2	Apr. 1	Apr. 2	May 1	May 2	Jun. 1	Jun. 2	Jul 1	Jul 2	Aug. 1	Aug. 2	Sep. 1	Sep. 2	Oct. 1	Oct. 2	Nov. 1	Nov. 2	Dec. 1	Dec. 2	Annual
	Month (days)	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	
		15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	
I. Evapotranspiration (Eto)	mm/day	5.19	5.19	4.86	4.89	5.24	5.24	5.65	5.65	5.74	5.74	5.01	5.01	5.32	5.32	6.11	6.11	6.46	6.46	7.00	7.00	6.43	6.43	5.22	5.22	
	mm	78	83	68	68	79	84	85	85	86	92	75	75	80	85	92	98	97	97	105	112	96	96	78	84	2,077
II. Palawija(1), (2) : Soybeans and Mungbeans								**Soybeans**										**Mungbeans**								
(1) Proposed cropping pattern / Crop coefficient(Kc)								0.50	0.75	1.00	1.00	0.82	0.23					0.45	0.75	1.05	0.30					
- Pwj(1),(2)-1									0.50	0.75	1.00	1.00	0.82	0.23					0.45	0.75	1.05	0.30				
- Pwj(1),(2)-2										0.50	0.75	1.00	1.00	0.82	0.23					0.45	0.75	1.05	0.30			
- Pwj(1),(2)-3																										
(2) Crop consumptive use(Etc)																										
- Pwj(1),(2)-1	mm							42	65	92	75	62	18					44	79	118	29					
- Pwj(1),(2)-2	mm								43	69	75	75	65	20					47	84	101	29				
- Pwj(1),(2)-3	mm									46	56	75	80	70	21					50	72	101	23			
(3) Effective rainfall (ER)	mm	66	71	63	63	66	71	19	19	13	14	10	9	0	0	0	0	7	7	0	0	10	11	45	48	612
(4) Field water requirement																										
- Pwj(1),(2)-1	mm							23	52	78	65	53	18					37	79	118	19					541
- Pwj(1),(2)-2	mm								30	55	65	66	65	20					47	84	91	18				542
- Pwj(1),(2)-3	mm									32	46	66	80	70	21					50	62	90	0			518
(5) Diversion requirement	mm							16	54	110	118	123	109	60	14			24	84	168	115	72	0			1,067
	m3/ha							160	540	1,100	1,180	1,230	1,090	600	140			240	840	1,680	1,150	720	0			10,670
III. Palawija (3) : Red onion																		**Red onion**								
(1) Proposed cropping pattern / Crop coefficient(Kc)																		0.50	0.60	0.95	0.75					
- Pwj(3)-1																			0.50	0.60	0.95	0.75				
- Pwj(3)-2																				0.50	0.60	0.95	0.75			
- Pwj(3)-3																										
(2) Crop consumptive use(Etc)																										
- Pwj(3)-1	mm																	48	63	106	72					
- Pwj(3)-2	mm																		53	67	92	72				
- Pwj(3)-3	mm																			56	58	92	59			
(3) Effective rainfall (ER)	mm	66	71	63	63	66	71	19	19	13	14	10	9	0	0	0	0	7	7	0	0	10	11	45	48	612
(4) Field water requirement																										
- Pwj(3)-1	mm																	41	63	106	62					273
- Pwj(3)-2	mm																		53	67	82	61				263
- Pwj(3)-3	mm																			56	48	81	14			198
(5) Diversion requirement	mm																	28	77	153	128	95	9			489
	m3/ha																	280	770	1,530	1,280	950	90			4,900

Source : JICA Study Team estimate based on the meteorological data at the Sopac Bayan and Dusum Anyar station

Table 2.3 Irrigation Water Requiremrnt in Lokok Meniris Project (4/4)

Site : Lokok Meniris
Crops : Palawija (2/2) : Mungbeans

Item		Jan. 1	Jan. 2	Feb. 1	Feb. 2	Mar. 1	Mar. 2	Apr. 1	Apr. 2	May 1	May 2	Jun. 1	Jun. 2	Jul 1	Jul 2	Aug. 1	Aug. 2	Sep. 1	Sep. 2	Oct. 1	Oct. 2	Nov. 1	Nov. 2	Dec. 1	Dec. 2	Annual
	Month (days)	15	16	14	14	15	16	15	15	15	16	15	15	15	16	15	16	15	15	15	16	15	15	15	16	
I. Evapotranspiration (Eto)	mm/day	5.19	5.19	4.86	4.89	5.24	5.24	5.65	5.65	5.74	5.74	5.01	5.01	5.32	5.32	6.11	6.11	6.46	6.46	7.00	7.00	6.43	6.43	5.22	5.22	
	mm	78	83	68	68	79	84	85	85	86	92	75	75	80	85	92	98	97	97	105	112	96	96	78	84	2.077
II. Palawija(4) : Mungbeans																										
(1) Proposed cropping pattern / Crop coefficient(Kc)								**Mungbeans**																		
- Pwj(4)-1									0.45	0.75	1.05	0.30														
- Pwj(4)-2										0.45	0.75	1.05	0.30													
- Pwj(4)-3											0.45	0.75	1.05	0.30												
(2) Crop consumptive use(Etc)																										
- Pwj(4)-1	mm								38	65	96	23														
- Pwj(4)-2	mm									39	69	79	23													
- Pwj(4)-3	mm										41	56	79	24												
(3) Effective rainfall (ER)	mm	66	71	63	63	66	71	19	19	13	14	10	9	0	0	0	0	7	7	0	0	10	11	45	48	612
(4) Field water requirement																										
- Pwj(4)-1	mm								19	52	82	13														166
- Pwj(4)-2	mm									26	55	69	14													163
- Pwj(4)-3	mm										27	46	70	24												168
(5) Diversion requirement	mm								13	52	110	85	56	16												331
	m3/ha								130	520	1,100	850	560	160												3.320

Source : JICA Study Team estimate based on the meteorological data at the Sopac Bayan and Dusum Anyar station

Table 3.1 Estimated Catchment Rainfall at Lokok Meniris Embung SIte

Unit : mm

	Jan		Feb		Mar.		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Annual
year	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
1960	56	56	462	462	351	351	90	90	14	14	200	200	26	26	9	9	0	0	0	0	5	5	507	507	3.440
1961	186	186	254	254	156	156	89	89	32	32	29	29	0	0	0	0	0	0	5	5	15	15	225	225	1.982
1962	302	302	200	200	101	101	18	18	102	102	2	2	0	0	0	0	0	0	0	0	92	92	39	39	1.712
1963	756	756	0	0	47	47	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	125	125	1.956
1964	543	543	240	240	60	60	71	71	0	0	0	0	0	0	0	0	0	0	0	0	11	11	47	47	1.944
1965	5	5	132	132	284	284	8	8	15	15	0	0	0	0	0	0	9	9	39	39	24	24	17	17	1.066
1966	263	263	140	140	225	225	6	6	0	0	11	11	5	5	0	0	0	0	5	5	0	0	12	12	1.334
1967	47	47	198	198	209	209	45	45	30	30	23	23	3	3	2	2	17	17	6	6	24	24	128	128	1.464
1968	282	282	225	225	209	209	45	45	30	30	23	23	3	3	2	2	17	17	6	6	24	24	128	128	1.988
1969	282	282	225	225	209	209	45	45	30	30	23	23	3	3	2	2	17	17	6	6	24	24	128	128	1.988
1970	282	282	225	225	209	209	45	45	30	30	23	23	3	3	2	2	17	17	6	6	24	24	128	128	1.988
1971	111	111	386	386	60	60	149	149	68	68	0	0	0	0	0	0	132	132	0	0	33	33	159	159	2.196
1972	11	11	252	252	393	393	5	5	29	29	26	26	2	2	0	0	17	17	9	9	24	24	15	15	1.566
1973	126	126	188	188	306	306	30	30	26	26	2	2	0	0	6	6	0	0	0	0	0	0	252	252	1.872
1974	687	687	176	176	363	363	29	29	77	77	0	0	5	5	0	0	27	27	5	5	24	24	123	123	3.032
1975	573	573	305	305	158	158	0	0	0	0	0	0	5	5	0	0	2	2	8	8	60	60	18	18	2.258
Mean	282	282	226	226	209	209	45	45	30	30	23	23	3	3	1	1	16	16	6	6	24	24	128	128	1.987

Table 3.2 Estimated Discharge at Lokok Meniris Embung Site

Unit : 1000 m3

year	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Annual
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	
1960	145	145	1,197	1,197	909	909	233	233	0	0	518	518	67	67	0	0	0	0	0	0	0	0	1,313	1,313	8,764
1961	482	482	658	658	404	404	231	231	83	83	75	75	0	0	0	0	0	0	0	0	0	0	583	583	5,032
1962	782	782	518	518	262	262	0	0	264	264	0	0	0	0	0	0	0	0	0	0	238	238	101	101	4,330
1963	1,958	1,958	0	0	122	122	130	130	0	0	0	0	0	0	0	0	0	0	0	0	0	0	324	324	5,068
1964	1,406	1,406	622	622	155	155	184	184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	122	122	4,978
1965	0	0	342	342	736	736	0	0	0	0	0	0	0	0	0	0	0	0	101	101	62	62	0	0	2,482
1966	681	681	363	363	583	583	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3,254
1967	122	122	513	513	541	541	117	117	78	78	60	60	0	0	0	0	0	0	0	0	62	62	332	332	3,650
1968	730	730	583	583	541	541	117	117	78	78	60	60	0	0	0	0	0	0	0	0	62	62	332	332	5,006
1969	730	730	583	583	541	541	117	117	78	78	60	60	0	0	0	0	0	0	0	0	62	62	332	332	5,006
1970	730	730	583	583	541	541	117	117	78	78	60	60	0	0	0	0	0	0	0	0	62	62	332	332	5,006
1971	287	287	1,000	1,000	155	155	386	386	176	176	0	0	0	0	0	0	342	342	0	0	85	85	412	412	5,686
1972	0	0	653	653	1,018	1,018	0	0	75	75	67	67	0	0	0	0	0	0	0	0	62	62	0	0	3,750
1973	326	326	487	487	793	793	78	78	67	67	0	0	0	0	0	0	0	0	0	0	0	0	653	653	4,808
1974	1,779	1,779	456	456	940	940	75	75	199	199	0	0	0	0	0	0	70	70	0	0	62	62	319	319	7,800
1975	1,484	1,484	790	790	409	409	0	0	0	0	0	0	0	0	0	0	0	0	0	0	155	155	0	0	5,676
Mean	728	728	584	584	541	541	112	112	74	74	56	56	4	4	0	0	26	26	6	6	57	57	322	322	5,019
	1,455		1,169		1,081		223		147		113		8		0		52		13		114		644		

Table 3.3 Probable Flood Discharge at Lokok Meniris Embung Site

Characteristics of the catchment area								
Catchment Area	(km2)	7.40						
Eelevation at Dam Site (1)	(m)	80						
Maximum elevation in the catchment area (2)	(m)	620						
Height (3)=(2)-(1)	(h)	540						
Length of Catchment Area (l)	(m)	7,000						
Flow velocity	W2 (km/hr)	15.48						
Time of concentration	T2 (hrs)	0.45						
Probable Flood Discherge								
Return Period	(years)	2	5	10	20	50	100	200
Rainfall	(mm/day)	124	175	209	241	286	319	353
Rainfall intensity within the time of concentration	(mm)	38	53	63	73	87	97	107
Probable Flood Discharge	(m3/s)	62	87	104	120	143	159	176
Specific Discharge	(m3/s/km2)	8	12	14	16	19	22	24

To estimate design rainfall, the Log Pearson III method is adopted.
The rational method is adopted for estimation of the design flood discharge.
C = 0.8 is used to estimate designed flood discharge by the rational method.

Table 3.4 Result of Water Quality Test in Lokok Meniris Embung Site

DESCRIPTION	UNIT	1 Upstream of proposed embung	2 Embung Site	3 Embung Site	4 downstream of proposed embung	Max. Limit of B Class by GR. NO. 20/1990
I. PHYSICS						
1 Temperature	C	30.00	25.00	21.00	30.00	Normal water temperature
2 Dissolved solid matter	mg/liter	87.00	116.00	61.00	144.00	1000
3 Electric Conductivety	umhos/cm	118.00	158.00	83.00	145.00	-
II. CHEMISTRY						
a. Unorganic chemistry						
1 Mercury	mg/liter	0.00	0.00	0.00	0.00	0.001
2 Ammonia	mg/liter	0.00	0.00	0.00	0.09	0.5
3 Aroenic	mg/liter	-	-	-	-	0.05
4 Barium	mg/liter	-	-	-	-	5
5 Ferro	mg/liter	0.00	0.00	0.00	0.00	1
6 Fluoride	mg/liter	0.10	0.00	0.08	0.03	1.5
7 Cadmium	mg/liter	0.00	0.00	0.00	0.00	0.005
8 Chloride	mg/liter	19.10	32.60	22.00	23.40	600
9 Chronium, valense-6	mg/liter	0.00	0.00	0.00	0.00	0.05
10 Manganese	mg/liter	0.00	0.00	0.00	0.00	0.5
11 Nitrate, N	mg/liter	0.00	0.00	0.00	0.00	10
12 Nitric, N	mg/liter	0.00	0.00	0.00	0.08	1
13 Dissolved Oxygen	mg/liter	6.98	7.82	8.79	2.26	*
14 pH	-	8.00	7.40	7.00	6.80	5-9
15 Selenium	mg/liter	-	-	-	-	0.01
16 Zinc	mg/liter	0.00	0.00	0.00	0.00	5
17 Cyanide	mg/liter	0.00	0.00	0.00	0.00	0.1
18 Sulphate	mg/liter	14.20	15.00	12.50	14.20	400
19 Sulfide, H2S	mg/liter	0.00	0.00	0.00	0.00	0.1
20 Copper	mg/liter	0.00	0.00	0.00	0.00	1
21 Lead	mg/liter	0.00	0.00	0.01	0.00	0.1
b. Organic Chemistry						
1 Aldrin and Dieldrin	mg/liter	0.00	0.00	0.00	0.00	0.017
2 Chlordane	mg/liter	0.00	0.00	0.00	0.00	0.003
3 DDT	mg/liter	0.00	0.00	0.00	0.00	0.042
4 Endrine	mg/liter	0.00	0.00	0.00	0.00	0.001
5 Fenol	mg/liter	0.00	0.00	0.00	0.00	0.001
6 Heptachlor and Heptachlor Epoxide	mg/liter	-	-	-	-	0.018
7 Carbon Cloroform Ektract	mg/liter	-	-	-	-	0.5
8 Lindane	mg/liter	0.00	0.00	0.00	0.00	0.056
9 Methoxychlor	mg/liter	-	-	-	-	0.035
10 Oil and Fat	mg/liter	0.00	0.00	0.00	0.00	Nil
11 Organofosphate and Carbomate	mg/liter	0.00	0.00	0.00	0.00	0.1
12 PCB	mg/liter	-	-	-	-	Nil
13 Senyawa atife biru (Sulfaktan)	mg/liter	0.05	0.04	0.00	0.00	0.5
14 Toxaphene	mg/liter	0.00	0.00	0.00	0.00	0.005
III MICRO BIOLOGY						
1 Coliform tinja	per 100 ml	96	38	21	27	2,000
2 Total Coliform	per 100 ml	96	38	21	27	10,000

NOTE:
* = The water level shall be more than or equal to 6.
mg = miligram
ml = Milimeter
Bq = Bequerel

Heavy metals are classified into dissolved matter.

Source : JICA's Water Quality Test

Table 7.1 Summary of Construction Cost in Lokok Meniris Project

Item	Amount (Rp. million)
I. Direct Construction Cost	
1.1 Preparatory Works	125
1.2 Embung Construction	
1) Main dam	895
2) Spillway	1,085
3) Diversion Tunnel	83
4) Seepage protection works	0
5) Miscellaneous	206
Sub-total of 1.2	2,269
1.3 Irrigation Facilities	190
1.4 Domestic Water Supply	0
1.5 Embung Operation and Maintenance Road	33
Sub-total of I.	2,617
II. Administration Cost	131
III. Engineering Services	392
Sub-total of I, II & III	3,140
IV. Physical Contingency	471
Sub-total of I, II, II, & IV	3,611
V. Contract Tax	348
VI. Land Acquisition Cost	13
Sub-total I, II, III, IV, V & VI	3,972
VII. Price Contingency	794
GRAND TOTAL	4,766

Table 7.2 Direct Construction Cost in Lokok Meniris Project (1/2)

Item	Unit	Unit Price Rp.	Quantity	Total 1000 Rp.
I. Dam				
1. Main Dam				
1.1 Earth/stone works				
1) Clearing	m2	400	7,700	3,080
2) Excavation, common	m3	3,500	700	2,450
, weathered rock	m3	7,500	22,300	167,250
, rock	m3	11,500	3,800	43,700
3) Embankment, impervious soil	m3	8,000	11,600	92,800
, filter	m3	12,000	6,900	82,800
, transition	m3	12,000	0	0
, random material	m3	6,000	61,000	366,000
4) Stone masonry	m3	80,000	0	0
5) Rip-rap protection	m3	15,000	2,500	37,500
1.2 Grouting	m	71,000	800	56,800
1.3 Other miscellaneous works				42,619
Sub-total of 1.				894,999
2. Spillway				
2.1 Earth works				
1) Clearing	m2	400	4,300	1,720
2) Excavation, common soil	m3	3,500	300	1,050
, weathered rock	m3	7,500	7,800	58,500
, rock	m3	11,500	2,000	23,000
3) Backfill	m3	5,200	1,100	5,720
2.2 Concrete works				
1) Concrete - A	m3	250,000	190	47,500
2) Concrete - B	m3	170,000	3,540	601,800
3) Reinforcement bar	ton	1,500,000	10	15,000
4) Form	m2	15,000	18,600	279,000
2.3 Other miscellaneous works	L.S			51,665
Sub-total of 2.				1,084,955
3. Diversion Tunnel				
3.1 Earth works				
1) Clearing	m2	400	600	240
2) Excavation	m3	11,500	2,000	23,000
3) Backfill	m3	5,200	0	0
3.2 Concrete works				
1) Concrete - A	m3	250,000	130	32,500
2) Concrete - B	m3	170,000	0	0
3) Reinforcement bar	ton	1,500,000	7	10,500
4) Form	m2	15,000	600	9,000
3.3 Other miscellaneous works	L.S			7,524
Sub-total of 3.				82,764
4. Miscellaneous & Others				206,272
Total - I.				2,268,989

Table 7.2 Direct Construction Cost in Lokok Meniris Project (2/2)

Item	Unit	Unit Price Rp.	Quantity	Total 1000 Rp.
II. Irrigation Facilities				
1. Canal works (including the rehabilitation works)				
1.1 Earth works				
1) Clearing	m2	400	8,600	3,440
2) Excavation	m3	5,000	1,500	7,500
3) Embankment	m3	6,300	2,000	12,600
1.2 Stone masonry	m3	80,000	1,600	128,000
Sub-total of 1.				151,540
2. Related structures				
2.1 Turnout	nos.	2,600,000	1	2,600
2.2 Syphon	nos.	5,500,000	0	0
2.3 Aqueduct	nos.	6,000,000	0	0
2.3 Cross drain	nos.	4,700,000	1	4,700
2.4 Irrigation division box	nos.	900,000	15	13,500
2.5 Division box for livestock	nos.	1,200,000	0	0
Sub-total of 2.				20,800
3. Miscellaneous & Others	L.S			17,234
Total - II				189,574
III. Dam Operation and Maintenance Road				
1. Road Works				
1.1 Earth works				
1) Clearing	m2	400	4,300	1,720
2) Excavation	m3	5,000	600	3,000
3) Embankment	m3	6,300	1,800	11,340
4) Pavement (gravel / lime stone)	m3	15,000	600	9,000
2. Related structures				
2.1 Cross drain	nos.	4,700,000	1	4,700
3. Miscellaneous and others	L.S			2,976
Total - III				32,736
GRAND TOTAL				2,491,299

Table 8.1 Economic Construction Costs and Annual Disburement Schedule

Lokok Meniris Project (Unit : Rp. million)

	Item	SCF	Total cost	1st year	2nd year
1	Direct Construction Cost		1,711	44	1,667
	1) Preparatory Works	0.71	89	44	45
	2) Dam Construction				
	- Main dam	0.71	635	0	635
	- Spillway	0.71	770	0	770
	- Diversion tunnel	0.71	59	0	59
	- Seepage protection works	0.71	0	0	0
	Sub-total		1,464	0	1,464
	3) Irrigation Facilities	0.71	135	0	135
	4) Domestic Water Supply System	0.71	0	0	0
	5) Dam O & M Road	0.71	23	0	23
2	Administration Cost	0.90	118	3	115
3	Engineering Services	0.90	163	81	82
4	Physical Contingency		257	7	250
	Total		2,249	135	2,114

Note : Standard Conversion Factors (SFC). Source ; Pedoman Pengamatan dan Evaluasi Proyek-Proyek Pengairan, Direktorato Jeneral Pengairan, 1985

Table 8.2 Financial and Economic Prices of Farm Inputs and Outputs in NTB

Item		Unit	Lombok		Sumbawa	
			Financial Price *1	Economic Price *2	Financial Price *1	Economic Price *2
1 Farm Products						
Paddy *3		kg	280	397	260	394
Maize *3		kg	200	220	200	215
Mungbeans *3		kg	1,000	906	1,000	901
Soybeans *3		kg	900	647	900	642
Red onion *4		kg	900	704	800	699
Tobacco *5		kg	900	522	900	521
2 Seeds						
Paddy	Certified	kg	605	605	605	605
	Own	kg	-	325	-	325
Maize	Certified	kg	922	922	922	922
	Own	kg	-	297	-	297
Mungbeans	Certified	kg	1,383	1,383	1,383	1,383
	Own	kg	-	893	-	893
Soybeans	Certified	kg	617	617	617	617
	Own	kg	-	606	-	606
Red onion		kg	850	850	850	850
Tobacco		kg	25,000	25,000	25,000	25,000
3 Fertilisers						
Urea		kg	350	414	350	419
TSP		kg	400	486	400	491
KCl		kg	400	416	400	421
4 Agro-chemicals						
Insecticides	Liquid type	lit	10,000	10,000	10,000	10,000
	Powder type	kg	3,000	3,000	3,000	3,000
Rodenticides		kg	5,500	5,500	5,500	5,500
5 Labour						
Hired labour *6		man-day	3,000	2,250	2,500	1,875
Family labour		man-day	-	2,250	-	1,875
6 Draft Animal						
Hired		head-day	6,000	6,000	5,000	5,000
Own		head-day	-	6,000	-	5,000
7 Farm Machinery						
Tractor		ha	250,000	250,000	200,000	200,000

Remarks : *1 ; As of 1994

*2 ; Projected prices in 2005 at 1994 constant prices

*3 ; Dry grain

*4 ; Fresh

*5 ; Fresh leaves

*6 ; Economic conversionfactor is 0.75.

Table 8.3 Economic Crop Budget per Ha

Lokok Meniris Project

Item		Q'ty of Unit	Value (Rp.)	Without Project: Paddy (Rainfed) Q'ty	Without Project: Paddy (Rainfed) Am't (Rp.)	With Project: Paddy (Irrigated) Q'ty	With Project: Paddy (Irrigated) Am't (Rp.)	With Project: Soybean (Rainfed) Q'ty	With Project: Soybean (Rainfed) Am't (Rp.)	With Project: Mungbean (Rainfed) Q'ty	With Project: Mungbean (Rainfed) Am't (Rp.)
1 Gross Production Value											
Paddy		kg	397	2,000	794,000	4,500	1,786,500	0	0	0	0
Soybean		kg	647	0	0	0	0	1,100	711,700	0	0
Mungbean		kg	906	0	0	0	0	0	0	950	860,700
2 Production Cost											
Seed											
Paddy	Certified	kg	605	0	0	25	15,125	0	0	0	0
	Own	kg	325	50	16,250	0	0	0	0	0	0
Soybean	Certified	kg	617	0	0	0	0	20	12,340	0	0
	Own	kg	606	0	0	0	0	20	12,120	0	0
Mungbean	Certified	kg	1,383	0	0	0	0	0	0	10	13,830
	Own	kg	893	0	0	0	0	0	0	20	17,860
Fertiliser											
Urea		kg	414	150	62,100	300	124,200	40	16,560	60	24,840
TSP		kg	486	50	24,300	100	48,600	80	38,880	80	38,880
KCl		kg	416	0	0	50	20,800	40	16,640	40	16,640
Agro-chemicals											
Insecticide	Lquid	lit	10,000	0.5	5,000	2.0	20,000	1.5	15,000	2.0	20,000
	Powder	kg	3,000	0.0	0	0.0	0	0.0	0	0.0	0
Rodenticide		kg	5,500	0.5	2,750	2.0	11,000	0.5	2,750	1.0	5,500
Labor											
Family		md	2,250	65	146,250	172	387,000	60	135,000	80	180,000
Hired		md	2,250	10	22,500	13	29,250	0	0	0	0
Draft Animal											
Family		ad	6,000	10	60,000	20	120,000	10	60,000	10	60,000
Hired		ad	6,000	0	0	0	0	0	0	0	0
Tractor		ha	250,000	0	0	0	0	0	0	0	0
Total production cost					339,150		775,975		309,290		377,550
3 Net Production Value					454,850		1,010,525		402,410		483,150

Table 8.4 Economic Costs and Benefits Flow

Lokok Meniris Project Unit : Million Rp.

Year	Cost				Benefit			Increment
	Capital	Replace	O&M	Total	Irrigation	Negative	Total	
1.	135	0	0	135	0	0	0	-135
2.	2,114	0	0	2,114	0	0	0	-2,114
3.	0	0	0	0	26	0	26	26
4.	0	0	9	9	31	0	31	22
5.	0	0	9	9	35	0	35	26
6.	0	0	9	9	40	0	40	31
7.	0	0	9	9	44	0	44	35
8.	0	0	9	9	44	0	44	35
9.	0	0	9	9	44	0	44	35
10.	0	0	9	9	44	0	44	35
11.	0	0	9	9	44	0	44	35
12.	0	0	9	9	44	0	44	35
13.	0	0	9	9	44	0	44	35
14.	0	0	9	9	44	0	44	35
15.	0	0	9	9	44	0	44	35
16.	0	0	9	9	44	0	44	35
17.	0	0	9	9	44	0	44	35
18.	0	0	9	9	44	0	44	35
19.	0	0	9	9	44	0	44	35
20.	0	0	9	9	44	0	44	35
21.	0	0	9	9	44	0	44	35
22.	0	0	9	9	44	0	44	35
23.	0	0	9	9	44	0	44	35
24.	0	0	9	9	44	0	44	35
25.	0	0	9	9	44	0	44	35
26.	0	0	9	9	44	0	44	35
27.	0	0	9	9	44	0	44	35

EIRR = #NUM! %

Table 8.5 Financial Crop Budget per Ha

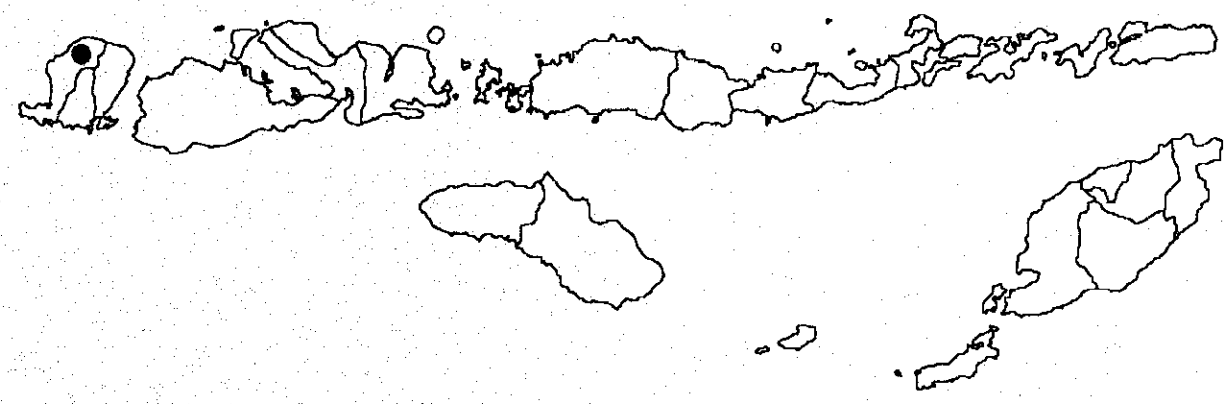
Lokok Meniris Project

Item		Q'ty of Unit	Value (Rp.)	Without Project: Paddy (Rainfed) Q'ty	Without Project: Paddy (Rainfed) Am't (Rp.)	With Project: Paddy (Irrigated) Q'ty	With Project: Paddy (Irrigated) Am't (Rp.)	With Project: Soybean (Rainfed) Q'ty	With Project: Soybean (Rainfed) Am't (Rp.)	With Project: Mungbean (Rainfed) Q'ty	With Project: Mungbean (Rainfed) Am't (Rp.)
1 Gross Production Value											
Paddy		kg	280	2,000	560,000	4,500	1,260,000	0	0	0	0
Soybean		kg	900	0	0	0	0	1,100	990,000	0	0
Mungbean		kg	1,000	0	0	0	0	0	0	950	950,000
2 Production Cost											
Seed											
Paddy	Certified	kg	605	0	0	25	15,125	0	0	0	0
	Own	kg	0	50	0	0	0	0	0	0	0
Soybean	Certified	kg	617	0	0	0	0	20	12,340	0	0
	Own	kg	0	0	0	0	0	20	0	0	0
Mungbean	Certified	kg	1,383	0	0	0	0	0	0	10	13,830
	Own	kg	0	0	0	0	0	0	0	20	0
Fertiliser											
Urea		kg	350	150	52,500	300	105,000	40	14,000	60	21,000
TSP		kg	400	50	20,000	100	40,000	80	32,000	80	32,000
KCl		kg	400	0	0	50	20,000	40	16,000	40	16,000
Agro-chemicals											
Insecticide	Lquid	lit	10,000	0.5	5,000	2.0	20,000	1.5	15,000	2.0	20,000
	Powder	kg	3,000	0.0	0	0.0	0	0.0	0	0.0	0
Rodenticide		kg	5,500	0.5	2,750	2.0	11,000	0.5	2,750	1.0	5,500
Labor											
Family		md	0	65	0	172	0	60	0	80	0
Hired		md	3,000	10	30,000	13	39,000	0	0	0	0
Draft Animal											
Family		ad	0	10	0	20	0	10	0	10	0
Hired		ad	6,000	0	0	0	0	0	0	0	0
Tractor		ha	250,000	0	0	0	0	0	0	0	0
Total production cost					110,250		250,125		92,090		108,330
3 Net Production Value					449,750		1,009,875		897,910		841,670

The Study on The Embung Development Project in East Nusa Tenggara and West Nusa Tenggara

Feasibility Study on Lokok Meniris Embung Development Project

Figures



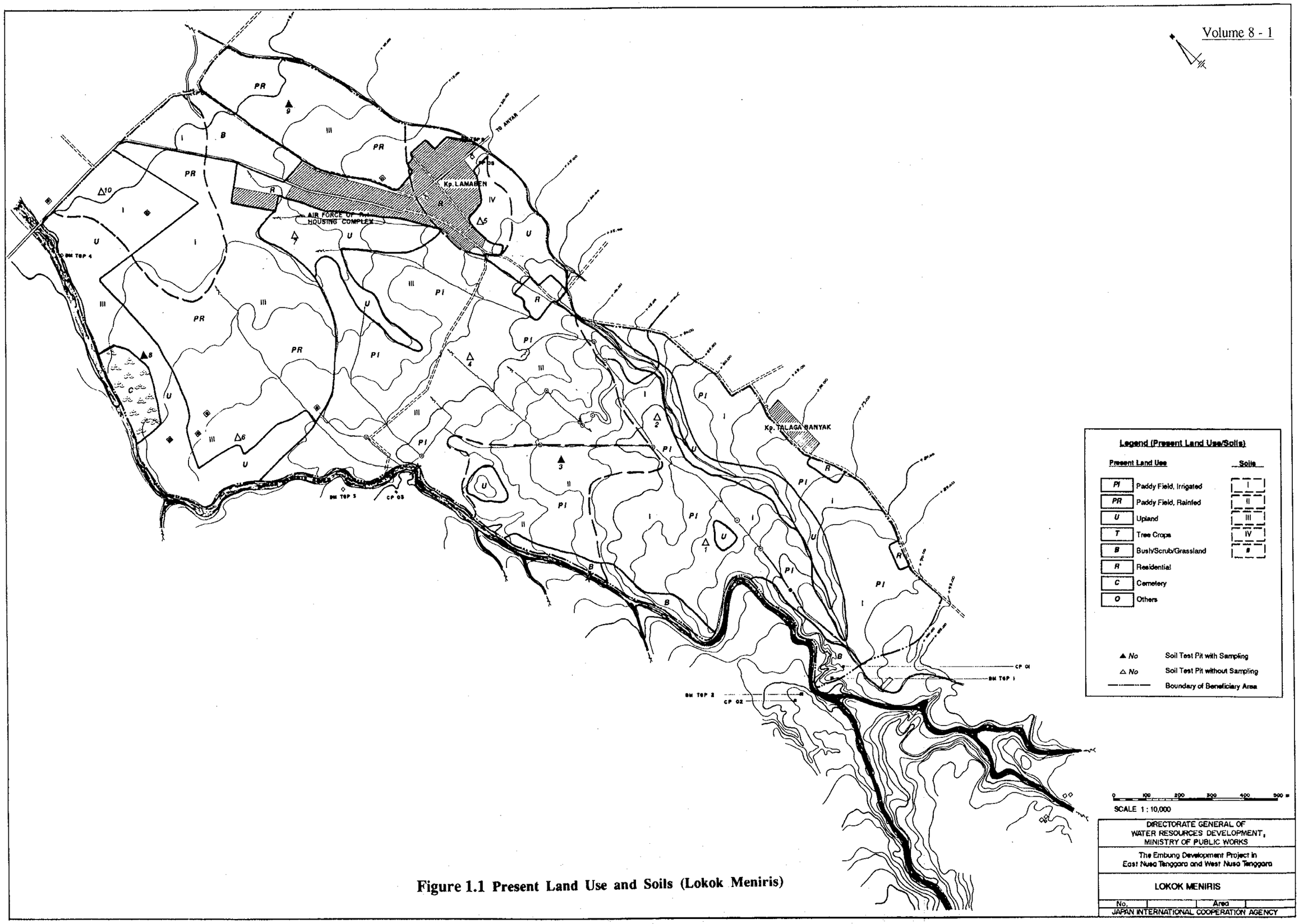


Figure 1.1 Present Land Use and Soils (Lokok Meniris)

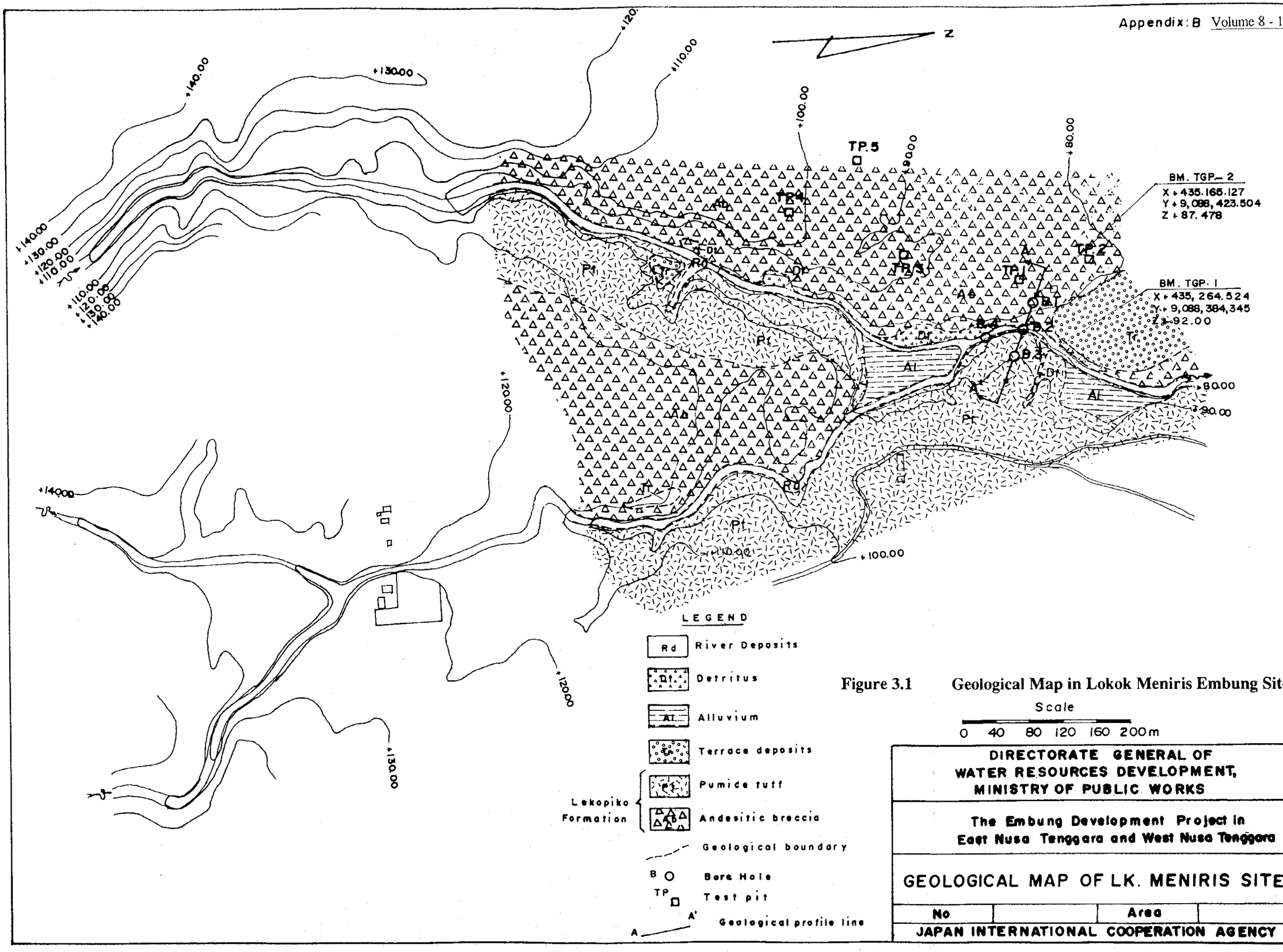


Figure 3.1 Geological Map in Lokok Meniris Embung Site

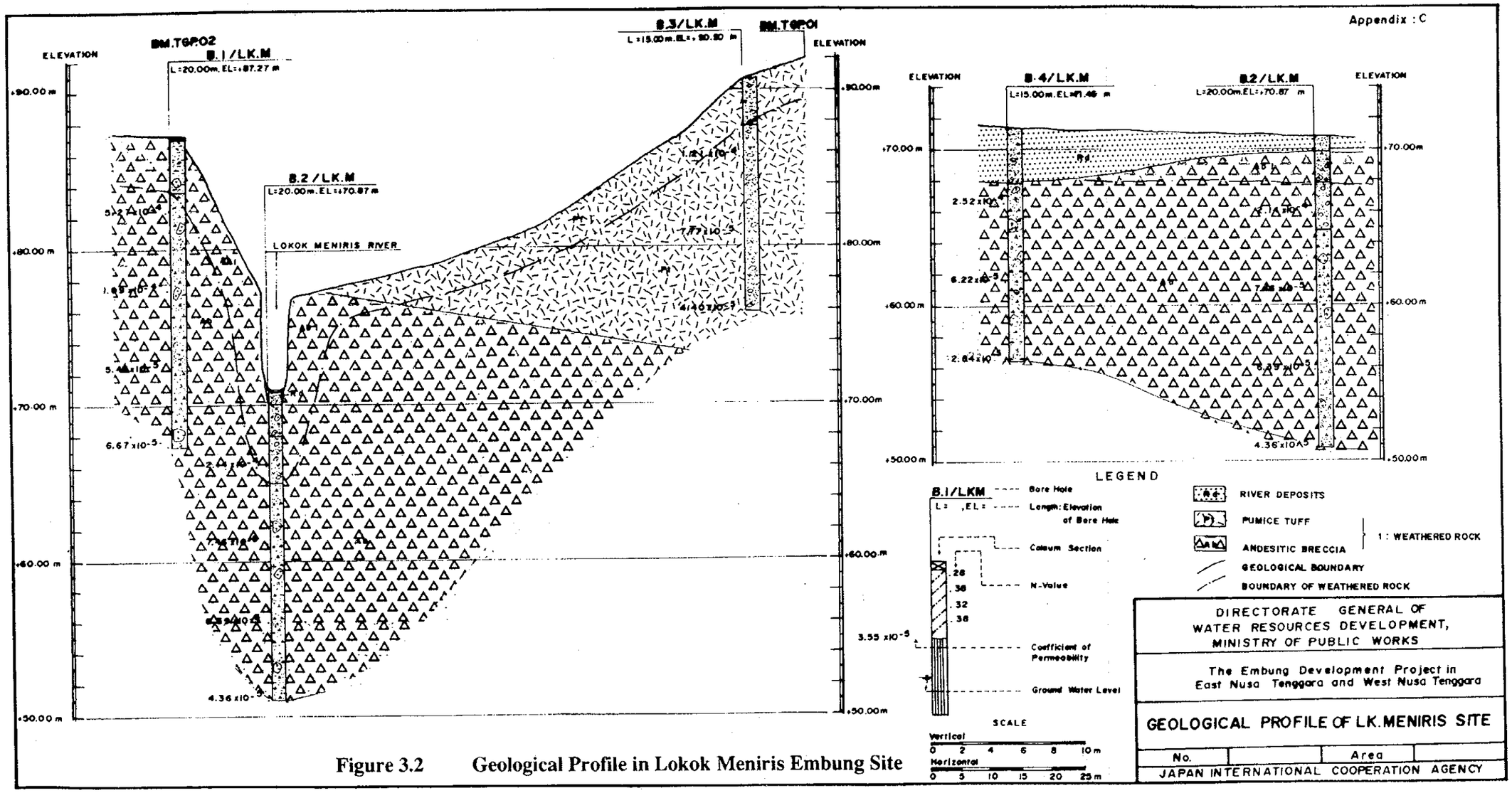


Figure 3.2 Geological Profile in Lokok Meniris Embung Site

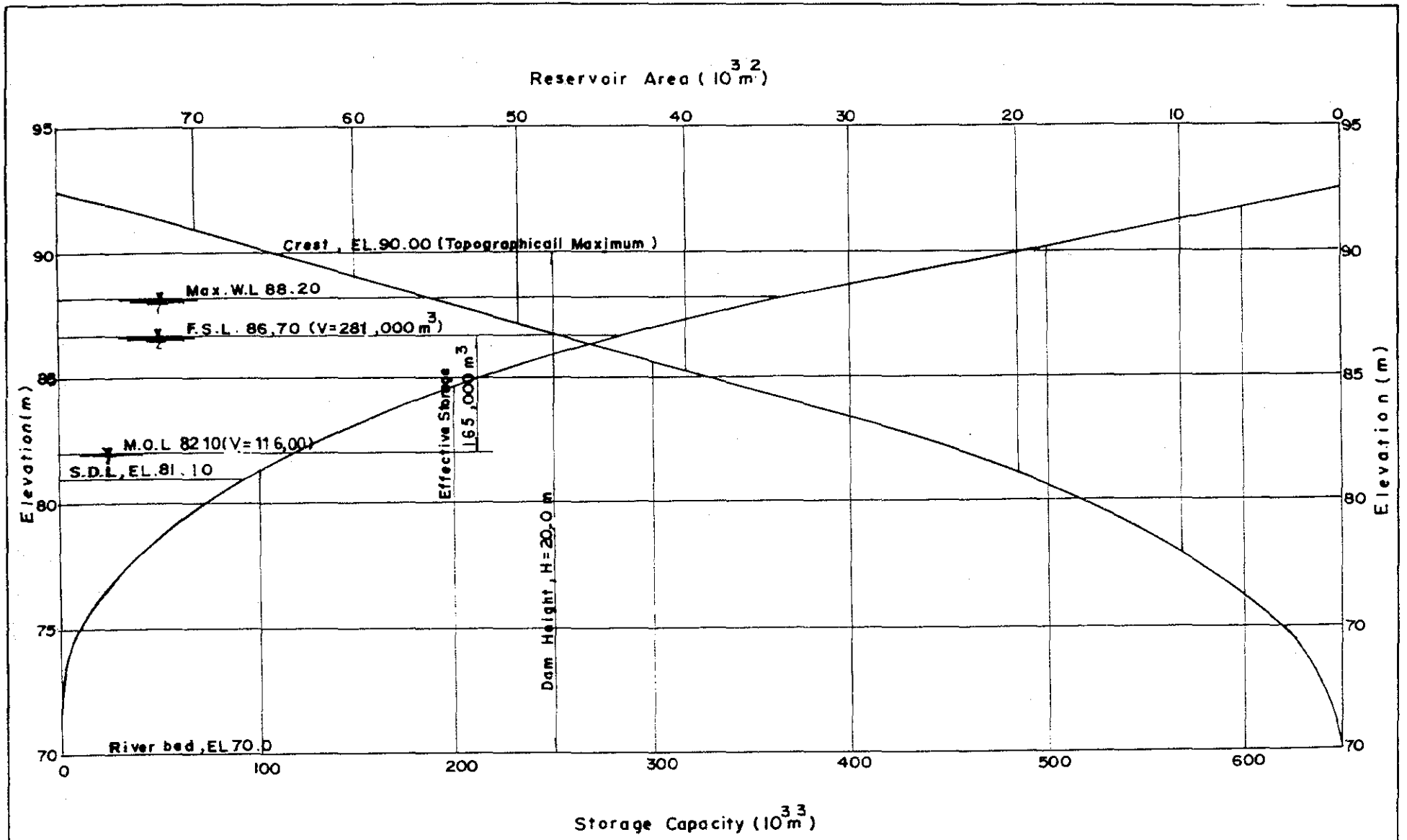


Figure 4.1 Reservoir Storage Curve in Lokok Meniris Embung

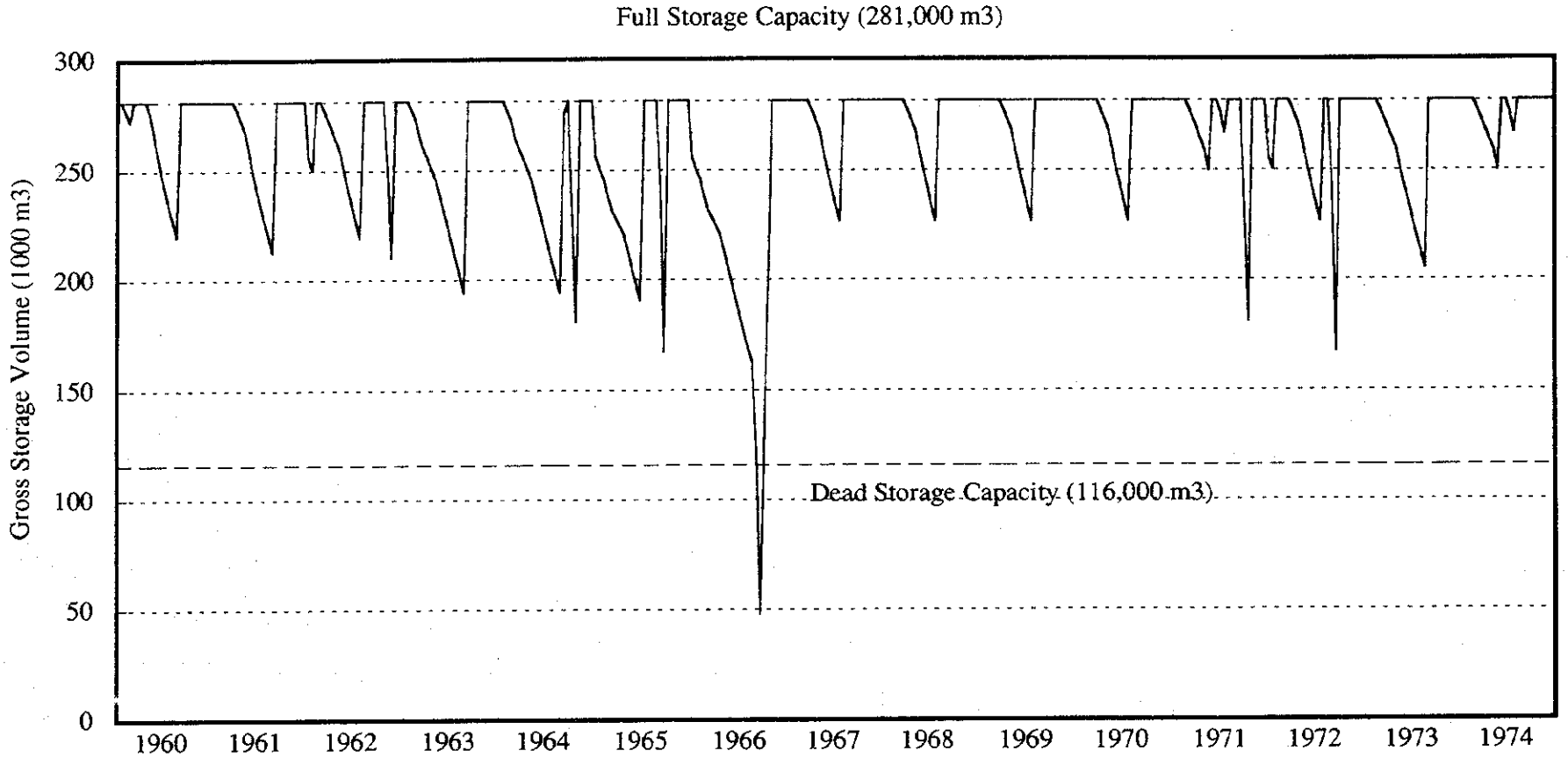


Figure 4.2 Result of Reservoir Operation in Lokok Meniris Embung

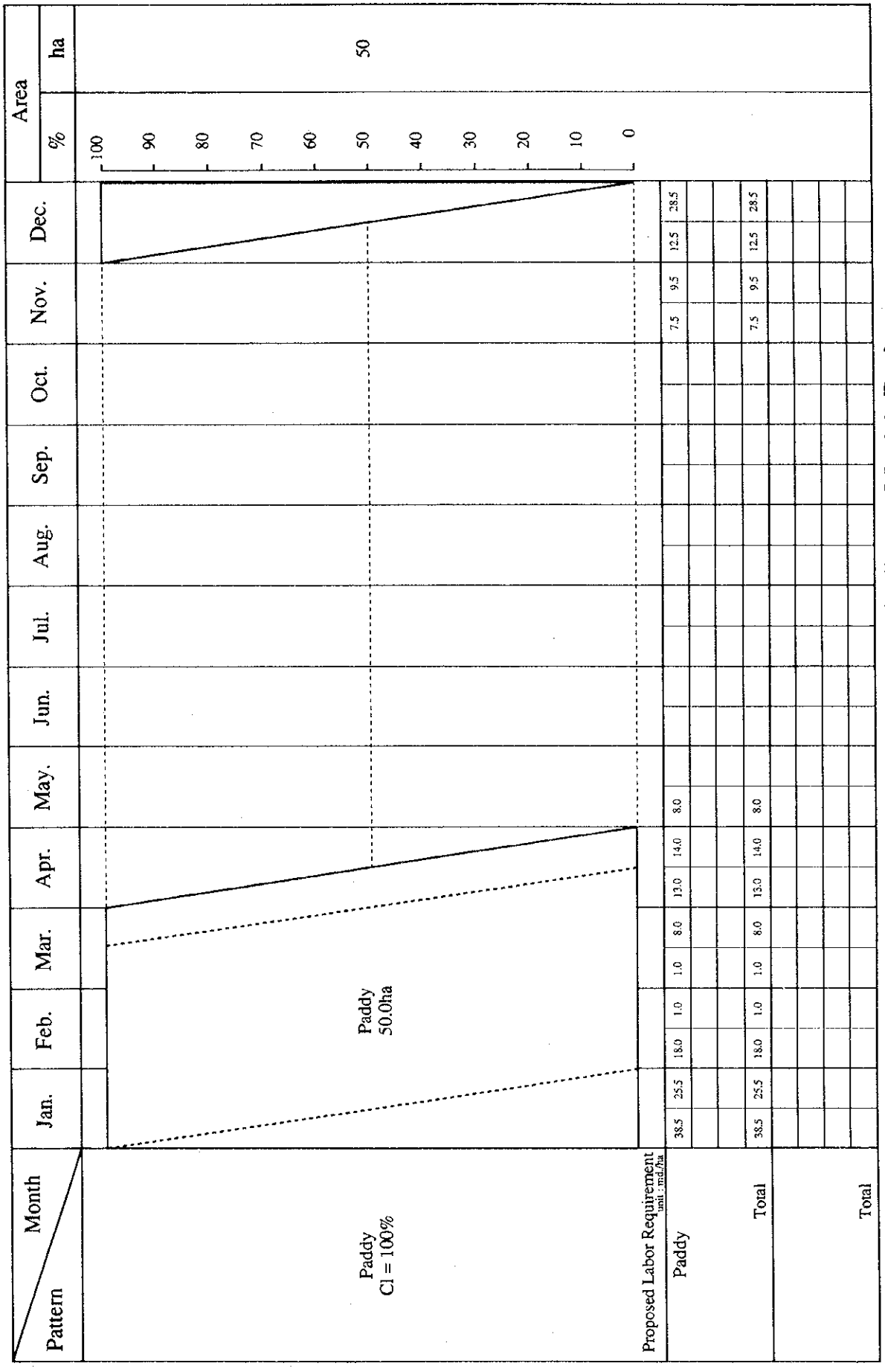
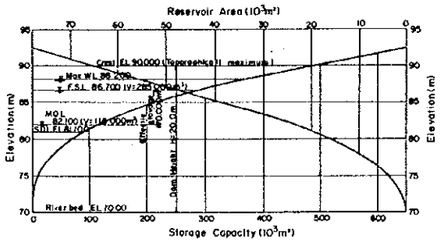
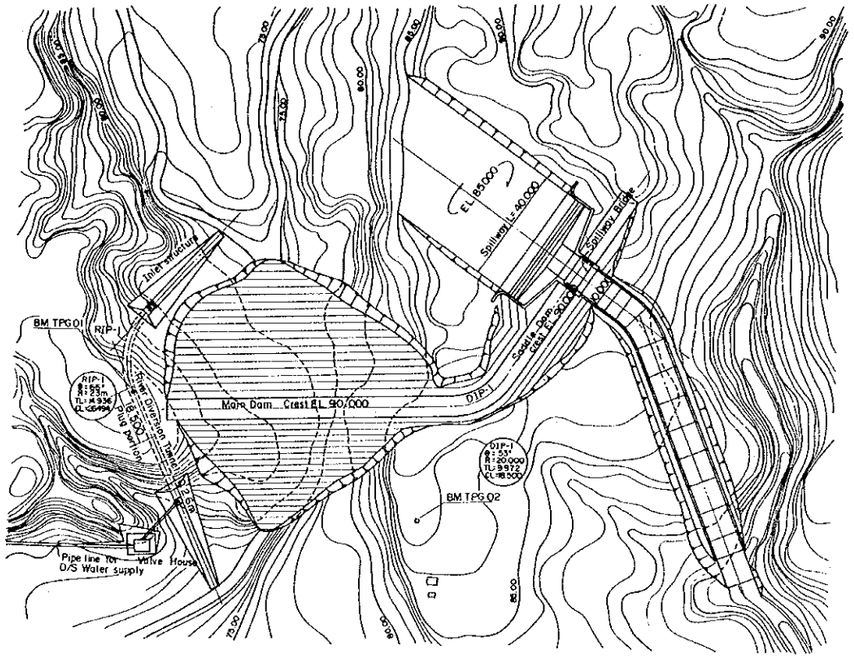


Figure 4.3 Proposed Cropping Pattern for Lokok Meniris Project

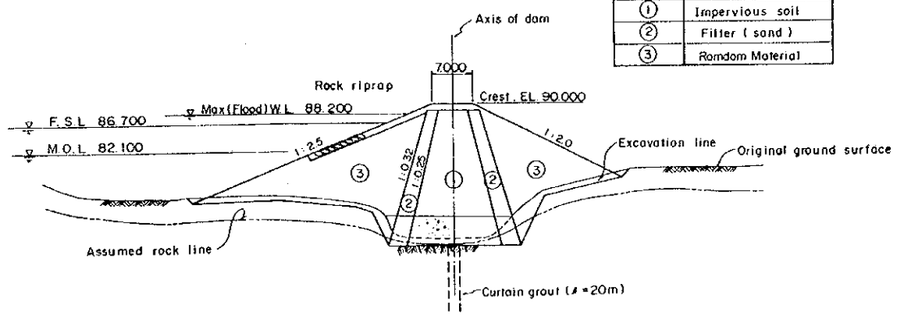


RESERVOIR STORAGE CURVE AT LOKOK MENIRIS



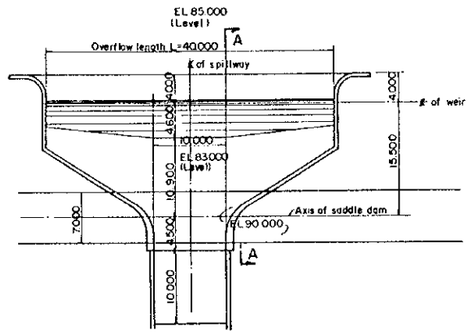
PLAN Scale A

Zone	Materials
①	Impervious soil
②	Filter (sand)
③	Ramdom Material



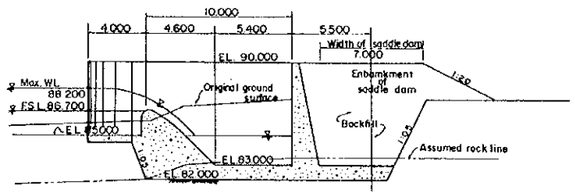
MAXIMUM CROSS SECTION

Scale B



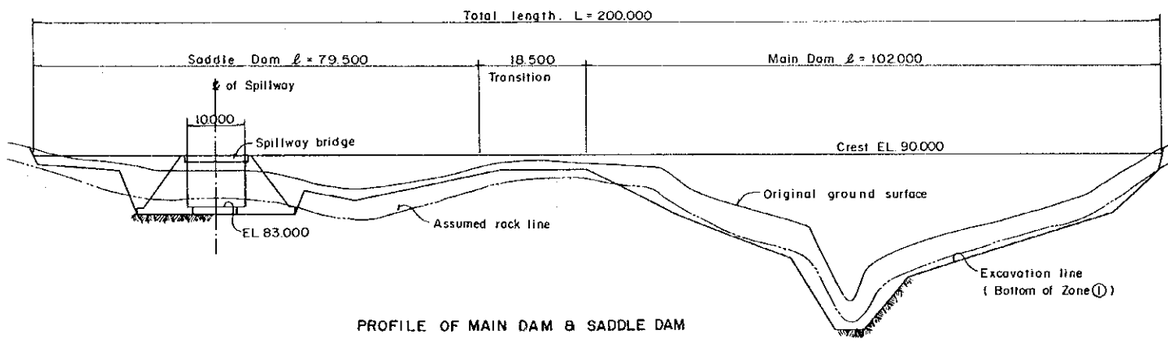
DETAIL OF OVERFLOW WEIR

Scale C



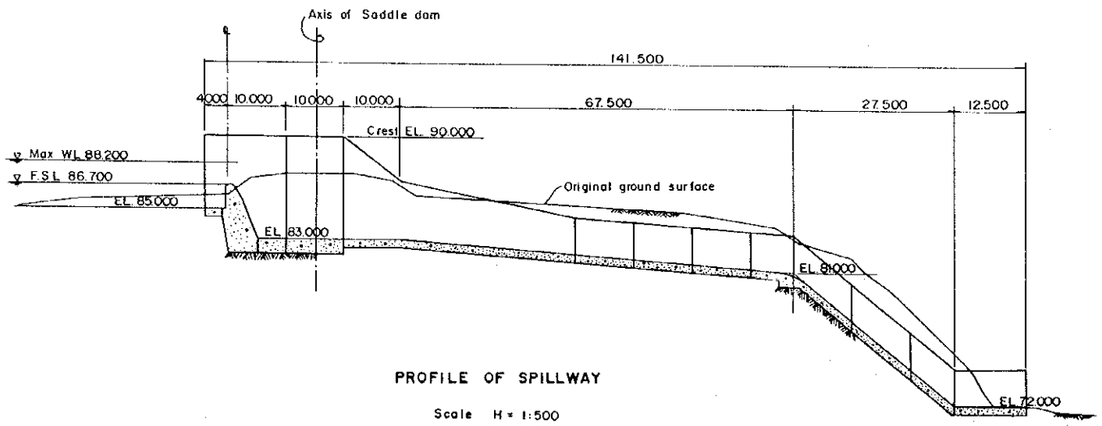
SECTION A-A

Scale D



PROFILE OF MAIN DAM & SADDLE DAM

Scale H = 1:500
V = 1:400



PROFILE OF SPILLWAY

Scale H = 1:500
V = 1:200

Scale A 0 20 40 60 80 100m

Scale B 0 10 20 30 40 50m

Scale C 0 10 20 30 40m

Scale D 0 5 10 15 20m

DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT, MINISTRY OF PUBLIC WORKS

The Embung Development Project in East Nusa Tenggara and West Nusa Tenggara

GENERAL PLAN OF LOKOK MENIRIS EMBUNG

No. | Area

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 4.4 General Plan of Lokok Meniris Embung

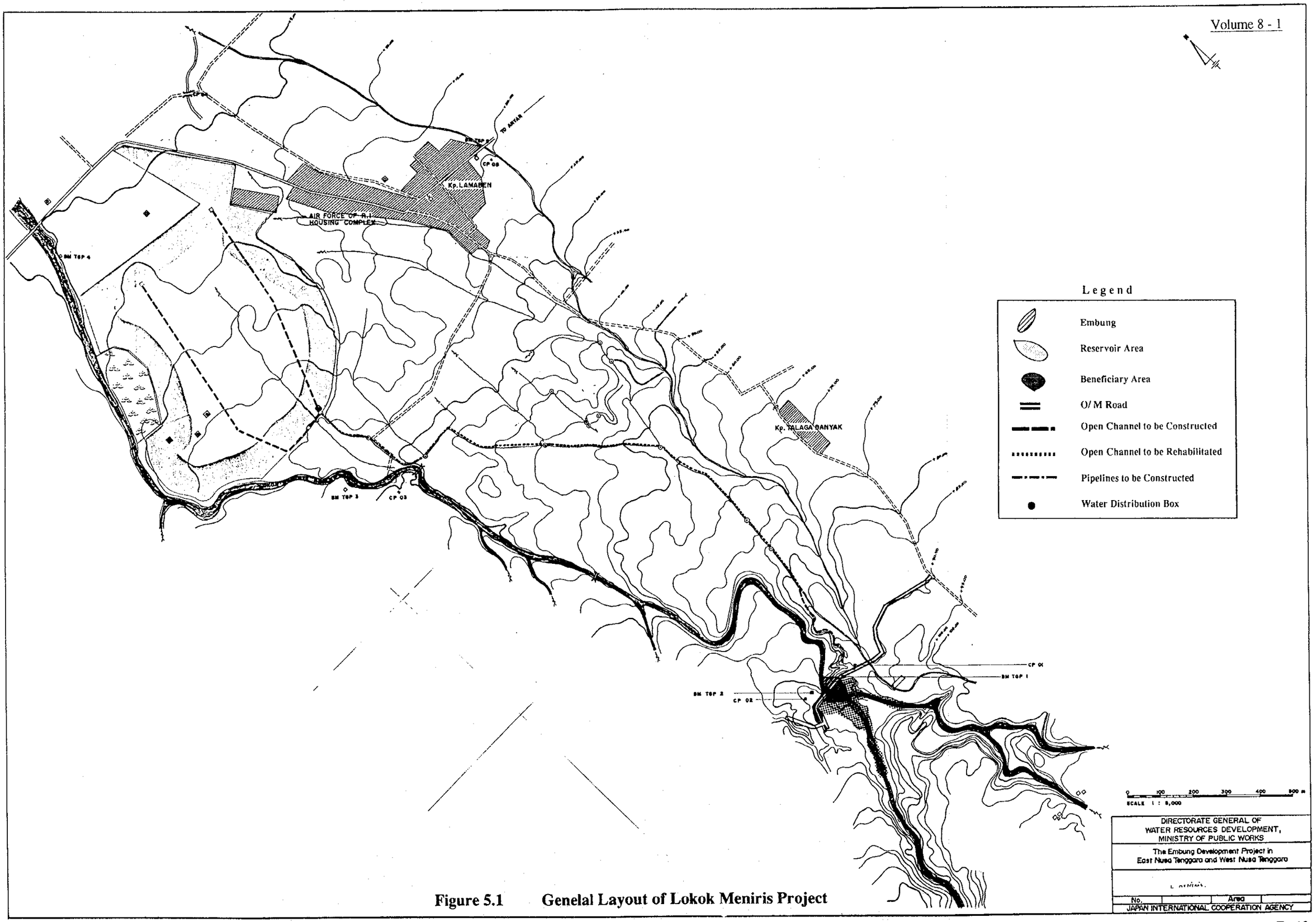


Figure 5.1 Genelal Layout of Lokok Meniris Project

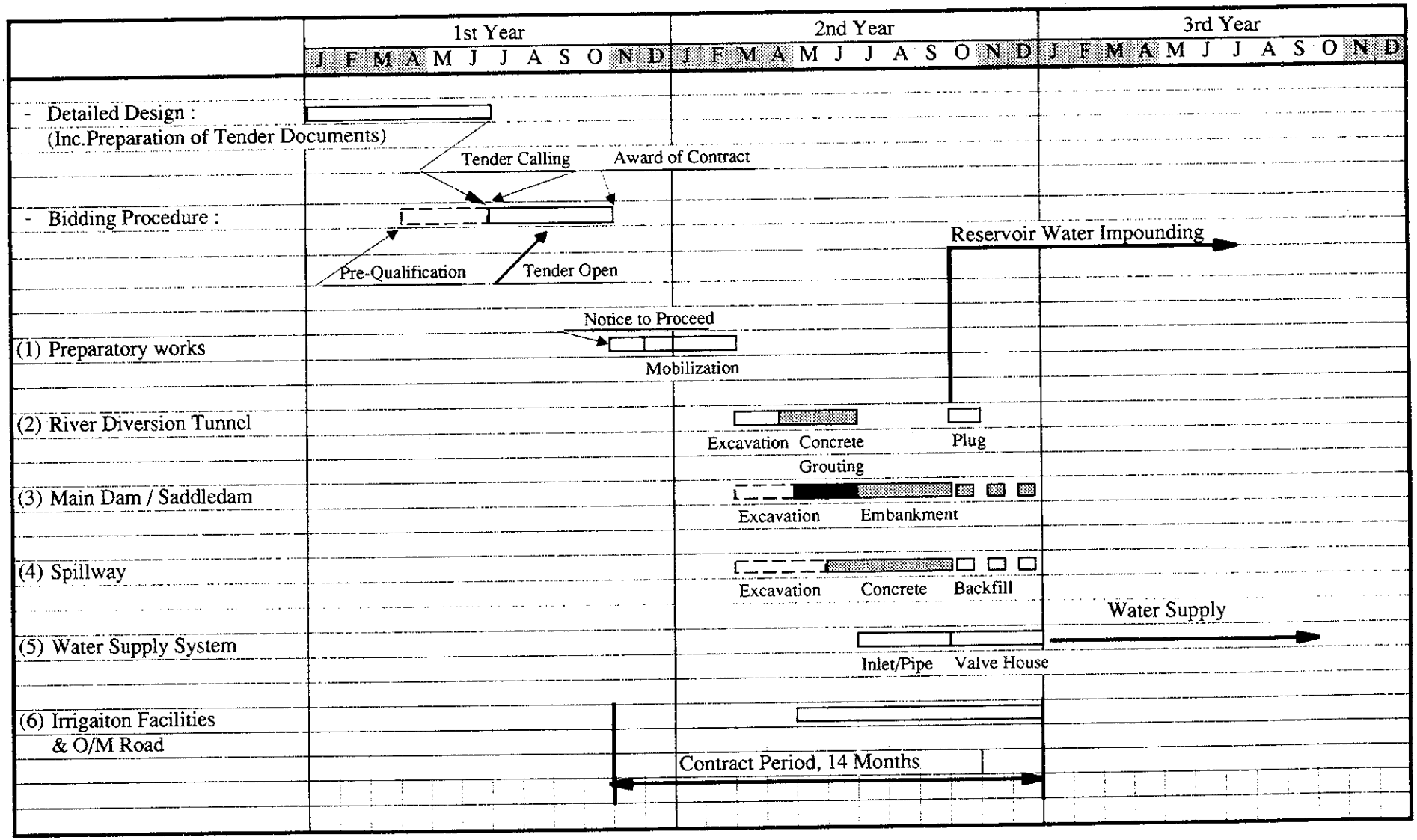


Figure 6.1 Construction Time Schedule for Lokok Meniris Project

Japan International
Cooperation Agency
(JICA)

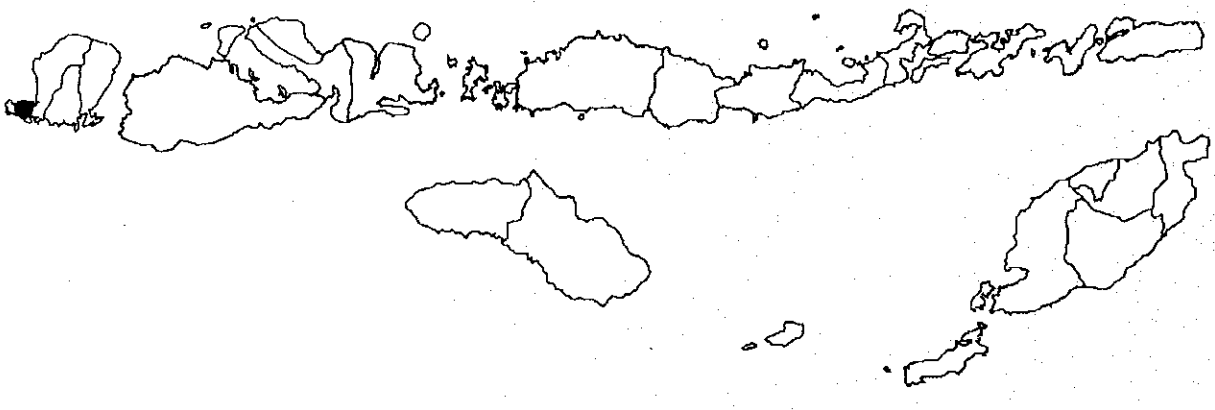
Directorate General of
Water Resources Development,
Ministry of Public Works

The Study
on
The Embung Development Project
(Small Scale Imponding Pond Development Project)
in
East Nusa Tenggara and West Nusa Tenggara
in
The Republic of Indonesia

Final Report

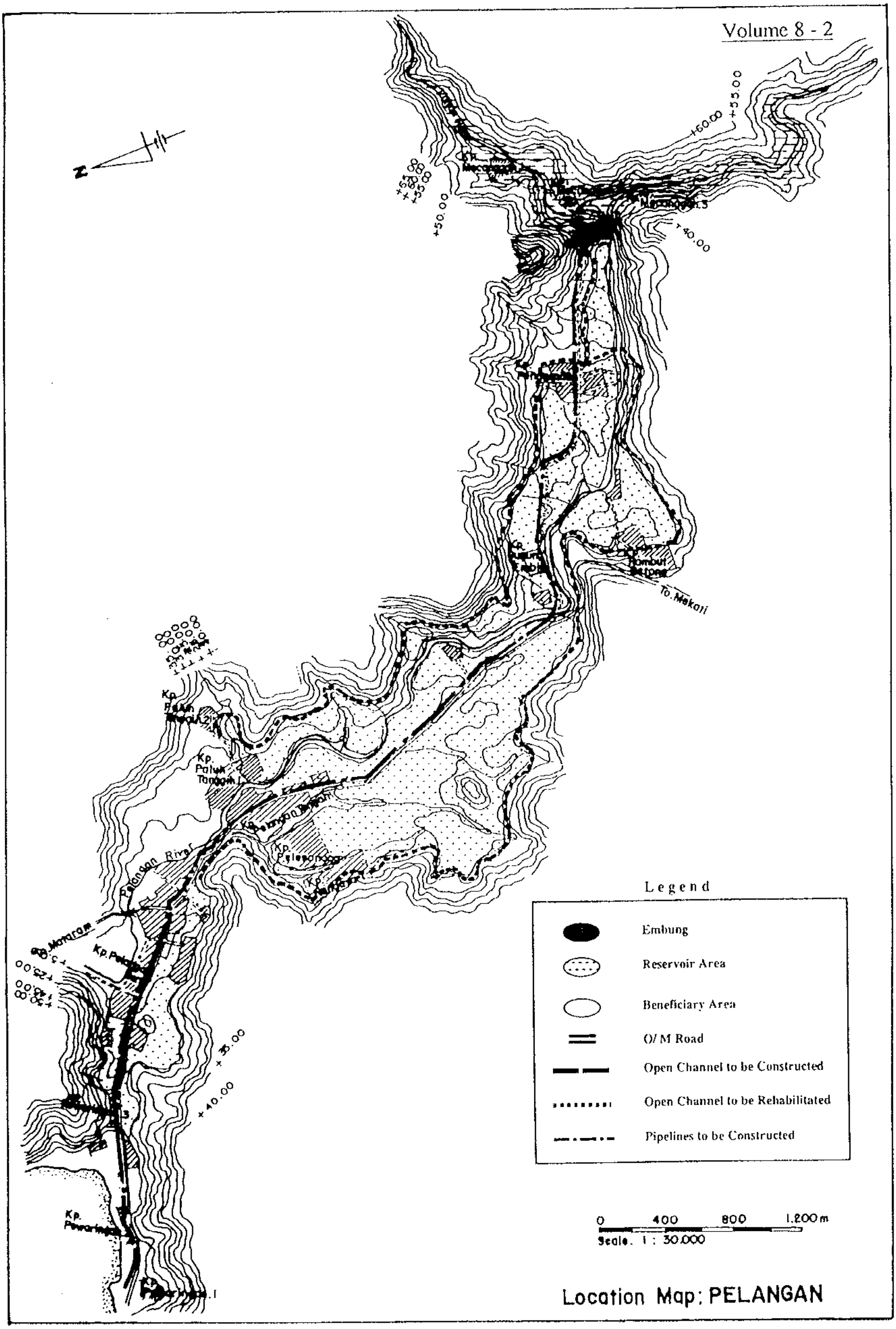
Volume 8-2

Feasibility Study
on
Pelangan Embung Development Project

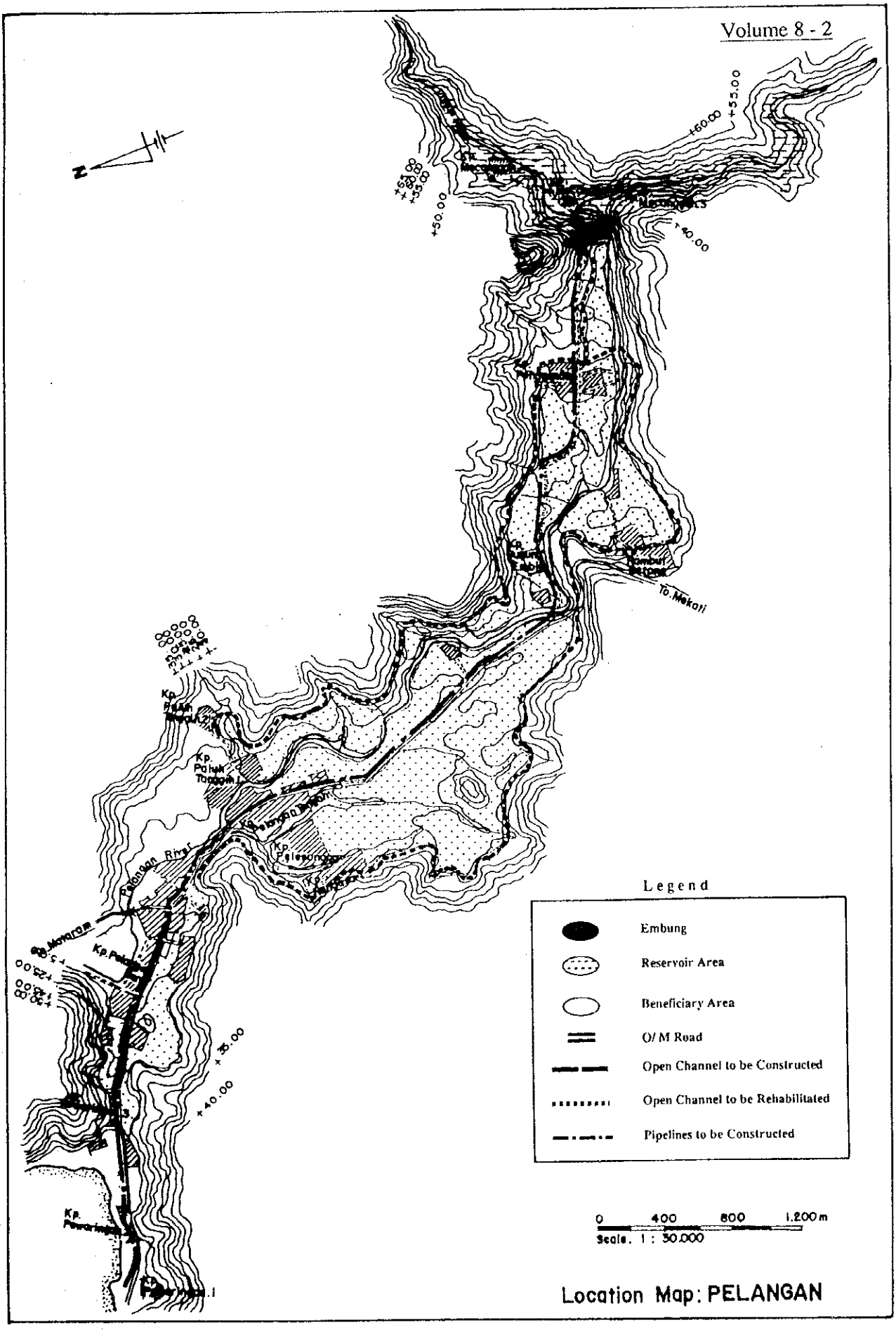


May 1995

Nippon Koei Co., Ltd.



Location Map: PELANGAN



Location Map: PELANGAN

THE STUDY
ON
THE EMBUNG DEVELOPMENT PROJECT
(SMALL SCALE IMPOUNDING POND DEVELOPMENT PROJECT)
IN
EAST NUSA TENGGARA AND WEST NUSA TENGGARA
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT

VOLUME 8-2

FEASIBILITY STUDY
ON
PELANGAN EMBUNG DEVELOPMENT PROJECT

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1. PRESENT SITUATION OF THE PROJECT AREA

1.1 Location and Topography

The Project area is located in Kecamatan Sekotong Tengah Kabupaten Lombok Barat western part of Lombok island. The proposed Embung site is Mecanggah village and about 5.5 km from Pelangan Barat Village through the provincial road at a distant of 75 km from Mataram, the capital of Nusa Tenggara Barat (NTB) Province.

Topographical condition of the catchment area is rather steep slope on the mountainous zone covered by forest. The Project area is located on the both sides of the Pelangan river, which extends about 6 km from the proposed Embung site to coastal area.

Major residential village in the Project area is Pelangan Timur, Tengah and Pelangan Barat in the downstream of the proposed Embung site, and Mecanggah in the reservoir area.

1.2 Climate and Hydrology

The nearest climate station and rainfall stations from the proposed Embung site are Rembiga and Sekotong, respectively. The wet season usually starts from November and ends March in the Project area with the average annual rainfall of 1,340 mm. Mean annual temperature is 26.3 °C with the average maximum temperature of 30.8 °C and the average minimum temperature of 21.8 °C. Mean relative humidity is 80.0%. Average sunshine hours are 5 hr/day during the wet season and increase to 6 to 7 hr/day in the dry season. Winds are stronger from June to September and weaker from December to March with the average wind velocity of 9.1 km/hr. Tables 1.1 and 1.2 show monthly rainfall record at the Sekotong station and climate data at the Rembiga station, respectively.

The Kali Pelangan river drains the Peninsular southwest of the Lombok Island. The river consists of two tributaries. One rises near Mt. Ketapang where the altitude is approximately 300 m and follows a southwesterly course for about 8 km. The another rises near Mt. Belatung where the altitude is approximately 300 m and follows a northwesterly course for about 8 km. These two tributaries join just upstream of the proposed Embung site, where the catchment area is 46 km^2. Subsequently, the river flows westward about 4 km and discharges into Lombok Strait at Pelangan Barat Village. The surface of the catchment area is mostly covered with forest. There is no gauging station on this river.

1.3 Geology

The proposed Embung site is mainly underlain by volcanic rocks and sedimentary rocks of the Tertiary age, named as the Pengulung Formation. It consists of andesitic tuff composed of andesitic tuff, soft to moderately hard rock of the Pengulung Formation distributing near the axis of proposed Embung; limestone composed of moderately hard rock of the Pengulung Formation probably forming lens between andesitic tuff and andesite.; andesite composed of massive and moderately hard rock of the Pengulung Formation, distributing upperstream of the proposed Embung site; lithlogy composed of mostly andesite and partly rhyolitic; terrace deposits composed of mainly sand and gravel forming terrace with flat to gentle slope with three stairs or more; alluvium composed of sand, silt and gravel forming lowland; alluvial cone deposits composed of soil with gravel forming small cone at the mouth of valley; detritus composed of soil with rock fragments distributing at foot of slope or gentle valley; and river deposits composed of sand, silt, gravel and boulder, distributing along the existing river bed.

1.4 Soils and Land Use

The Project area of Pelangan lies on the bottom of the U-shaped valley of the Pelangan river. The valley bottom is a long and narrow shape with a length of 8 km and a width of 500 to 1,000 m. The land is nearly flat with a slope of 0.3%.

Soils of the Project area are developed from the alluvial materials or basalt. Soil drainage on farmland is moderate to well and soil permeability is slow to rapid. Soil depth is deep to very deep ranging from 55 cm to more than 150 cm. Soil texture of surface soils is sandy loam to silty clay.

The results of the soil survey are shown in Table 1.3 on a typical soil profile out of 20 soil test pits, Table 1.4 on soil laboratory tests for soil samples taken from three representative pits and Table 1.5 on the soil classification.

The wet paddy field covers 257 ha or 43% of the valley. The upstream paddy field of 96 ha are irrigated by the existing intake weir at the proposed Embung site. Irrigation area lies on the both sides of the river. However, the irrigation area on the left bank has been reduced significantly because the irrigation canal is cut by road construction. The remaining 161 ha of paddy field are under the rainfed condition.

Upland covers only 16 ha, but tree crops area is 52 ha or 9 % of the Project area. Tree crops, mainly coconut and banana, are planted in the center of the valley and coastal area. The both upland and tree crops area are not irrigated.

The present land use is classified on the 1/5,000 topographic map and summarized below.

Present Land Use on the Project Area of Pelangan

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	96	161		257
Upland	0	16		16
Tree crops	0	52		52
Bush/Scrub/Grassland			195	195
Residential			70	70
Cemetery			0	0
Others			7	7
Total	96	229	272	597

Source : The JICA Study Team

The present land use and soil classification of the Project area is illustrated in Figure 1.1.

1.5 Demography

The demographic condition in the Project area as of 1993 is indicated by a total population of 3,649 and a total number of households of 982 including farm households of 943 as shown below. The average family size is 3.6 persons. Predominant ethnics are Balinese with Hindust religion and Sasaknese with Islam religion. Their education attainment is commonly primary school grade.

Present Demographic Condition

Village	Sub-Village	Total Population (person)	Total Household (No.)	Family Size (person)	Farm Household (No.)
Sekotong Barat	Pelangan Timur	1,033	357	2.9	344
	Pelangan Tengah	1,132	284	4.0	275
	Pelangan Barat	1,484	341	4.4	324
Total		3,649	982	3.7	943

Source : JICA ,Water Use Survey

1.6 Domestic Water Use

The existing water source facilities for supplying domestic and livestock water are dug well and river in the Project area. The present water use in each sub village clarified under the Study is summarized below:

- In Pelangan Timur and Pelangan Barat Sub Villages, all the inhabitants are using dug wells at the average distance of 150 m as drinking and livestock water sources. They are suffering from water shortage problems during the period from August to January; and

- In Pelangan Tengah Sub-Village, all the inhabitants normally get their drinking and livestock water at a dug well similar to other sub-villages and supplement their water source by using flow of the Mesanggah river. The average distance is 150 m to the dug well and 500 m to the river. All of these source facilities can provide users with less water for half a year between August and January.

1.7 Social Infrastructures

The main access from Mataram to the Project area is the Mataram-Lembar road. This is a two-lane paved road up to Lembar, ferry port to Bali, and therefrom a low cost paved road to Pelangan. The proposed Embung site is linked by an earth road with this main access. Extension works of the existing rural electrification network to Sekotong Barat Village are under way at present.

Inhabitants are generally using private toilets outside their houses or the river bed for defecating purposes. There are an auxiliary hospital about 4 km from the village and an integrated health service center within the Project area.

1.8 Agriculture and Livestock

(1) Present cropping pattern and intensity

The average annual planted areas of major crops are summarized below.

Present Cropping Pattern and Intensity

Cropping Pattern	Net Area (ha)	Planted Area (ha)	Proportion of Planted Area (%)	Cropping Intensity (%)
(1) Paddy - Palawija	66.0	86.0	35.1	130
(2) Paddy - Fallow	145.0	145.0	59.2	100
(3) Upland crop - Fallow	14.0	14.0	5.7	100
Total / Average	225.0	245.0	100.0	166

Source : The JICA Land Use Survey and Inventory Survey

(2) Farming Practice and Farm Inputs

Wet paddy is generally grown in the irrigated area during the wet season, while mungbean is partly planted as Palawija crop for the dry season. On the rainfed paddy field, wet paddy is cultivated during the wet season. Maize is grown on the upland field.

In terms of paddy, most farmers carry out land preparation with an animal-drawn plough and harrow their paddy field once or twice every season, while this work done by other marginal farmers depend on their own man power. High yielding rice varieties such as IR36, IR64, Krueng Aceh, Pelita and C4 are grown. Rice seed is sown on a nursery bed which is in the ratio of one twentieth against the main paddy field. Manual weeding is usually done one to three times throughout the rice growing period. Harvesting is carried out by using a sickle and hand threshing is made by beating rice plants against a frame.

Predominant cultivation methods of Palawija and upland crops are very primitive and local varieties are commonly used. Land preparation, planting, weeding and harvesting are done by hand.

Farm inputs and labor requirements currently used for growing these crops are given below.

Present Farm Inputs and Labor Requirements

Description	Unit	Wet Paddy	Mungbean	Maize
Farm Inputs				
Seed	kg/ha	50	35	25
Fertilizer				
Urea	kg/ha	300	25	50
TPS	kg/ha	100	50	50
KCl	kg/ha	50	25	0
Agro-chemicals	lit/ha	-	-	-
Labor Requirements				
Nursery	md/ha	3	-	-
Land preparation	md/ha	2	2	3
	ad/ha	5	-	-
Planting	md/ha	3	2	3
Transplanting	md/ha	15	-	-
Weeding	md/ha	10	4	3
Pest & disease control	md/ha	2	2	1
Farm management	md/ha	2	1	2
Harvesting	md/ha	15	8	12
Transportation	md/ha	5	4	6
Others	md/ha	4	2	2
Total	md/ha	61	25	32
	ad/ha	5	-	-

Source : The JICA Farm Economy Survey

(3) Crop yield and production

The present crop yield and production in the Project area are estimated as shown below. Unit yield of major crops remains extremely low due to the shortage of irrigation water, insufficient farm input supply and traditional farming practices.

Present Crop Yield and Production

Crops	Planted Area (ha)	Unit Yield (ton/ha)	Production (ton)
Wet Paddy Field			
Irrigated			
Wet season paddy	86	4.00	344
Rainfed			
Wet season paddy	145	2.00	290
Dry season Palawija			
Mungbean	26	0.50	13
Upland Field			
Maize	14	2.00	28

Source: The JICA Inventory Survey

(4) Livestock population

Various kinds of livestock are raised in the Project area and their numbers are given below. Cows and buffaloes play important roles in land preparation and transportation as draft power as well as fulfillment of local demand for beef meat. Other livestock are raised for self-consumption or selling to local markets.

Current Population of Livestock

Unit: head

Breeding Household	Cow	Buffalo	Horse	Goat /Sheep	Pig	Chicken/ Duck
1,664	3,913	101	94	2,177	1,282	27,831

Source: The JICA Water Use Survey

1.9 Irrigation Facilities

In the Project area, there exists paddy field of 240 ha in gross on the both banks of the Pelangan river. Among these, the paddy field of 96 ha have been irrigated and the remaining 144 ha have been used and the rainfed condition. The existing weir situated at the proposed Embung site. This weir is functioning almost well. Irrigation water taken by the weir is led by the wet canal to the existing paddy field with a distance of about 5.5 km. This canal is also functioning almost well. Due to the shortage of surface water of the river, only 40% of the existing paddy field has been irrigated in the wet season.

1.10 Agro-economy

(1) Farmers group

Farmers are members of Agricultural Cooperative (KUD). From its branch shop, they commonly purchase fertilizers and use credit services. Some farmers are also members of Village Youth Association or Village Program of Women Education. About 50 % of farmers benefited by the existing irrigation scheme established Water Users' Association (P3A/HIPPA) in 1993 and since then have operated it for the purpose of maintaining on-farm irrigation service facilities and managing irrigation water distribution.

(2) Agricultural supporting services

Agricultural extension services are provided to farmers by field extension workers (PPL) attached to a rural extension center (BPP) in Sekotong. Usually, farmers receive PPL's visiting service very few because of limited budget for field operation in BPP. Some PPLs are livestock specialists to provide various services under the instructions of a specialized agricultural extension agent assigned to a district center for agricultural extension. Veterinary care services are given to breeding households through an animal health center of the Veterinary Service of the Department of Livestock. The present level of livestock extension services is similar to that of the agricultural extension services.

Credit services are available in KUD as well as in the service network of the Indonesian People's Bank (Bank Rakyat Indonesia) both handling "Credit for Farmer (KUT)" and "Income Generating Project for Marginal and Landless Farmers (P4K)". Financial sources of these credits are the Government for KUT and IFAD for P4K aiming at group financing.

Lombok Water Resources Development and Conservation Project Office (Proyek PKSA Lombok) under the NTB Provincial Public Works Service (DPUP) is responsible for new water resource development and watershed management. New development of irrigation system is the responsibility of Lombok Irrigation Project Office, while upgrading and rehabilitation works are the main task of Provincial Project Office for Rehabilitation and Upgrading of Irrigation. Operation and maintenance (O&M) works of all facilities are conducted by Provincial Project Office for Operation and Maintenance (PPO&M APBD). These project offices are under the direction of DPUP.

(3) Farmers' household economy

The results of agro-economy survey carried out in the Project area under the Study reveal that the average income and expenditure of 15 sample farmers amount to Rp. 1.58 million and Rp. 1.48 million, respectively. Some sample farmers make up for deficit in their household economy by selling their livestock. Table 1.6 shows the summary of replies of 15 respondents.

2. DEVELOPMENT NEEDS AND CONCEPTS

2.1 Development Needs and Constraints

(1) Population Increase

The future population in the Project area is anticipated by referring to "Projection of Population for Kabupaten/Kotamadya in Indonesia 1990-2000" prepared by National Statistic Bureau and the Second Long Term Development Plan (PJPT II). The total number of inhabitants living in the Project area will increase from 3,649 persons as at 1993 to 4,037 persons in 1998, 4,427 persons in 2003, 4,800 persons in 2008, 5,138 persons in 2013 and 5,451 persons in 2018.

(2) Basic human needs (BHN)

The inhabitants in the Project area are unsatisfied with the present condition of rural infrastructures because the existing domestic water supply sources can meet drinking and livestock water requirements during half the year and no electricity is distributed to this area. As extension of the rural electrification scheme to the Project area is under way, the pressing need is to solve water shortage problems which have forced nearly 3,700 inhabitants to carry their drinking water from the dry season water source at the minimum distance of 500 m for the period of six months from August to January.

(3) Economic development needs

All of 943 farm households have principally consumed their farm products for their own use and then sold the remaining amount to local markets. Even though a new tourist resort development scheme is on-going near the Project area, there is not much possibilities of offering job opportunities to all farmers. It is therefore indispensable for promoting public investment in economic infrastructures, especially for irrigation water source facilities, which encourage farmers to improve their farming system and enable them to increase their agricultural production. Increasing farm outputs could clue farmers themselves to upgrade their living standard and to catch up with faster economic growth of other sectors and places.

(4) Inhabitants' intention to development pattern

Inhabitants in the Project area intend to use their farm land more intensive because no expansion of land holding size can be expected. To do so, they need all year-round water source facilities from which they will be able to get sufficient irrigation water for growing the dry season crops. Those who are suffering from water shortage problems from August to January also intend to save the time presently spent for carriage of drinking water and removal of cattle aiming to utilize such time for productive purposes. In this connection, they need permanent water source facilities which enable them to secure stable drinking water throughout a year.

(5) Development constraints

The present constraints against social upgrade and economic development in the Project area are featured by the condition that available surface runoff of the river has not been fully utilized. The reason is that the existing intake weir established on the Pelangan river can divert only the wet season discharge, because the water level at the intake site becomes very lower during the dry season and also the intake itself has no function of storing water. Due to such situation of limited use of surface runoff, no more utilization of the Pelangan river can be expected unless countermeasures to regulate the wet season runoff are practiced.

In order to supplement insufficient water sources during the dry season, inhabitants take river flow available at the deteriorated downstream weir located near the river mouth. Such limited water resources have acted as the barrier to meet BHN and to promote development of intensive agriculture.

2.2 Development Concepts and Approach

(1) Development concepts

The existing gap of economic status between NTB and other Provinces is caused by insufficient fulfillment of BHN, slow pace of poverty alleviation and less concerns about a balanced investment to regional development. In harmony with the national policy to correct this economic imbalance, the development concept is formed aiming at improvement of social and economic infrastructures with the highest priority so as to meet BHN and increase agricultural outputs. Among others in the Project area, it is prerequisite to pay special attention to how to solve irrigation and domestic water shortage problems originated from insufficient use of potential water resources in the Pelangan river basin.

(2) Development strategies and approach

To overcome development constraints prevailing in the Project area, water resources seasonally available are to be regulated by means of constructing Embung as water reservoir on the Pelangan river. Approach to development planning of the potential Embung is as follows:

- To put the first priority to supply irrigation water and the second to domestic water taking into account inhabitants' needs and intention;
- To project the future water demand for irrigation and domestic use at the target year of 2008 being the last year of Pelita VIII;
- To examine development potential of the Pelangan Embung from the technical viewpoints;
- To determine the optimum development scale of the Embung;
- To make preliminary design and cost estimate; and
- To conduct investment justification from the viewpoints of economic soundness, social satisfaction and environmental impact.

2.3 Land Potential

In future, rainfed paddy field, upland and tree crops land in the downstream part could be transformed into irrigated paddy field by constructing the proposed Embung and also rehabilitating the left bank canal. Although the extension of irrigation area depends on the water availability, cropping plan, land suitability and economic viability, the possible extension area on the left bank is estimated at 184 ha as shown below.

Rainfed paddy field	->	Irrigated paddy field	144 ha
Rainfed upland	->	Irrigated paddy field	4 ha
Rainfed tree crops	->	Irrigated paddy field	36 ha

In conclusion, the future land use plan of the Project area is offered as shown below.

Future Land Use Plan on the Project Area of Pelangan

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	280	17		297
Upland	0	12		12
Tree crops	0	16		16
Bush/Scrub/Grassland			195	195
Residential			70	70
Cemetery			0	0
Others			7	7
Total	280	45	272	597

Source : The JICA Study Team

In the impounding area of the proposed Embung, there exist maximum 2 ha of the rainfed paddy field and 8 ha of the dry upland field. The alternative land resources for the existing farmland to be impounded are available within 144 ha of the newly irrigated paddy field or 40 ha of the newly developed paddy field with irrigation.

2.4 Agricultural and Livestock Development Plan

(1) Alternative cropping patterns

In formulating the future cropping patterns in the Project area, the following basic principles have been adopted:

- Higher benefit for farmers;
- Optimum use of irrigation water;
- Practical farming system for family labor; and,
- Crops and cropping patterns acceptable to farmers.

Wet paddy is the most predominant crop in the Project area and acceptable to farmers as they have long experience in rice cultivation. Therefore, they could easily master irrigated rice cultivation method to realize higher production and thereby large irrigation benefit under the condition of "With Project". Aiming to determine the optimum development scale of the proposed Embung, the following alternative cropping patterns are established.

Alternative Cropping Patterns

Pattern Code	Wet season		Dry season			
			First cropping		Second Cropping	
	Crop	Coverage (%)	Crop	Coverage (%)	Crop	Coverage (%)
With Project C-12	Paddy	100	Paddy	100	-	-
With Project C-21	Paddy	100	Soybean*	100	-	-
With Project C-22	Paddy	100	Soybean*	50	Red onion	50
			Mungbean	50	Tomato	50
With Project C-23	Paddy	100	Paddy	100	Mungbean	100

Remarks : * ; Mixed with groundnut

(2) Farm input and labor requirements

Under the "With Project" condition, farmers who are depending on unreliable rainfall, river flow or irrigation water can be expected to get stable irrigation water supply. They will be able to increase farm inputs to the optimal level with less risk. Proposed farm inputs are

estimated in consideration of the present input level in advanced irrigation areas as well as data collected from BPP. Labor requirements are also expected to increase substantially in cultivation under the technical irrigation system. On the other hand, farm input and labor requirements are expected to remain at present level under the "Without Project" condition.

Proposed Farm Input and Labor Requirements

Item	Unit	Wet Paddy	Soybean	Mungbean	Red Onion	Tomato
Farm Inputs						
Seed	kg/ha	25	40	30	2,000	0.5
Fertilizer						
Urea	kg/ha	300	50	75	300	50
TPS	kg/ha	100	100	100	200	100
KCl	kg/ha	50	50	50	100	35
Agro-chemicals	lit/ha	2	2	2	10	10
Rodenticide	kg/ha	2	1	1	3	3
Labor	md/ha	185	70	80	250	35
Draft Animal	ad/ha	20	10	10	20	20

(3) Proposed farming practices

Proposed farming practices for wet paddy are as follows:

- High yielding rice varieties to be used under the With Project condition are IR64, Krueng Aceh, Pelita, C4 and IR36 with maturing periods of 110 to 135 days. These varieties are moderately resistant or resistant to several major rice pests and diseases. Land preparation on wet paddy field has to be done by animal ploughing and harrowing;

- Fertilizers need to be applied three times; the first application at the final stage of land preparation, and the second and third applications as top-dressing at the 20th and 37th day after transplanting, respectively. The top-dressing will be applied while water depth on wet paddy field is shallow. The phosphorous (TPS) and potassium (KCl) fertilizers have to be applied at the final stage of land preparation. The required amount of fertilizers is 60 kg/ha of N, 30 kg/ha of P and 30 kg/ha of K;

- Seed rates are 20 to 40 kg/ha for nursery. The best period for transplanting is 3 to 4 weeks after sowing, when the seedlings have 5 to 6 leaves. Ratio of the nursery bed to the main wet paddy field is about one twentieth. Planting density is about 2 to 3 plants per hill and spacing of hill is 20 cm x 20 cm;

- Weeding is required to be performed two to three times during the rice growing period according to weed growth. Irrigation water supply needs to be guaranteed during the most critical stages of the plant growth such as tillering, booting, flowering and germination stages. Timely control of insects, pest and diseases is necessitated on the basis of advice by PPLs and their assistants; and

- It is desirable to carry out harvesting when the ears are nearly ripened and are still in slight green. Harvesting is made by labors using a sickle. Harvested paddy plants need to be dried on the field for 3 to 4 days.

For growing Palawija crops under the irrigated condition, advanced farming practices similar to irrigated wet paddy cultivation and high yielding varieties are to be adopted. Land preparation will require animal-draft in order to enhance efficiency and accuracy of the work. Proper fertilization matching with soil conditions and timely insect/disease control are also

indispensable. These farming practices need to be applied for, following technical instructions of PPLs.

(4) Anticipated crop yield

It is anticipated that the future yield of proposed crops under the "With Project" condition increases to 4.5 ton/ha for wet paddy, 1.4 ton/ha for soybean, 1.1 ton/ha for mungbean, 7.5 ton/ha for red onion and 8.0 ton/ha for tomato. These targets are estimated in due consideration of the present yield level in well established irrigation areas of Kabupaten Lombok Barat as well as introduction of high yielding varieties and advanced farming practices, stable irrigation water supply and optimum use of farm inputs. As for build-up period to attain the anticipated yield, it is also prospected that crop yield level is 60% of the target in the first year, 70% in the second year, 80% in the third year, 90% in the fourth year and 100% from the fifth year and onward.

(5) Projected livestock population

The future livestock population in the Project area for the target year 2008/2009 is projected as shown below taking into account the actual growth rate of each livestock in Kabupaten Lombok Barat during the Pelita V period.

Projected Population of Livestock

Unit: head

Cow	Buffalo	Horse	Goat /Sheep	Pig	Chicken/ Duck
5,274	169	107	2,414	1,838	17,816

2.5 Water Demand

(1) Domestic water demand

The future domestic water consumption level in rural areas of NTB is set to be 60 lit/day/capita up to 1998/99 for the Pelita VI period, 70 lit/day/capita up to 2003/04 for the Pelita VII period and 80 lit/day/capita from 2004/05 and onward. The public water demand is to be 30 lit/day for 10% of the projected population, while the unaccounted-for is to be equivalent to 20% of the total water demand.

Following the projected population, the future domestic water demand is estimated as shown below. The annual domestic water demand for 2008 is projected to be 174,600 m^3.

Projected Domestic Water Demand

Item	Unit	1998	2003	2008	2013	2018
Population	person	4,037	4,427	4,800	5,138	5,451
Domestic water	'000m^3/yr.	88.4	113.1	140.2	150.0	159.2
Public water	'000m^3/yr.	4.4	4.8	5.3	5.6	6.0
Un-accounted for	'000m^3/yr.	18.6	23.6	29.1	31.1	33.0
Total demand	'000m^3/yr.	111.4	140.5	174.6	186.7	198.2

(2) Irrigation water demand

In order to optimize the development scale and delineate the beneficiary area of the Project, irrigation water demand for each proposed crop is estimated for unit irrigation area of one hectare on the seem-monthly base taking into account crop consumptive use, evapotranspiration, crop coefficient, effective rainfall and irrigation efficiency both for wet

paddy and Palawija crops as well as land preparation water, layer replacement and percolation loss only for wet paddy. As described in Attachment 1, irrigation water demand in the Project area is calculated by referring to the standard quoted in "Irrigation Design Standard, KP-01" by DGWRD.

Tables 2.1 and 2.2 show the calculation results of evapotranspiration and effective rainfall, respectively, and Table 2.3 presents the unit irrigation water demands for each crop.

3. EXAMINATION OF EMBUNG DEVELOPMENT POTENTIAL

3.1 Topographic Condition

The Pelangan Embung site was identified by PRIS of NTB through its identification study and geological investigation with topographical survey in 1991.

Under the Study, the possibility of developing this Embung is firstly confirmed through the inventory survey. Then topographical survey with mapping and geological investigations for the above-mentioned site are carried out. Although proposed Embung site, two main tributaries join and then Kali Pelangan river water flows through U-shaped valley on rather steep slope of the mountain. The width of valley at the proposed Embung site is about 350 m at El. 50 m and the river bed shows El. 16 m. The intake weir made by wet masonry exists at the proposed Embung site with an overflow length of 35 m and earth dike is provided on the right portion of the weir with a length of about 100 m.

3.2 Geological Condition

The dam site is underlain by tuff, terrace deposits and alluvium. The foundation is mainly formed of tuff at the left bank, tuff and terrace deposits at the right bank, and alluvium at river bed. The drilling survey shows that the expected average N-value of alluvium is 20 at least. The coefficient of permeability varies from 3.6×10^{-5} to 8.5×10^{-6} cm/sec for tuff and from 1.2×10^{-3} to 2.9×10^{-4} cm/sec for alluvium. The coefficient of permeability for terrace deposits is supposed to be 10^{-3} cm/sec order. Problem at the proposed Embung is water leakage through terrace deposits and alluvium. Some countermeasures for water leakage will be required. Groundwater is present at middle layer of alluvium.

The reservoir is mainly underlain by tuff, andesite, limestone and terrace deposits. No major fault and landslide are recognized in the reservoir area. No major problem for water leakage is assumed to occur in the reservoir area. Geological map and profile are shown in Figures 3.1 and 3.2.

3.3 Availability of Embankment Materials

In and around the Project area, there are sufficient embankment materials to be used for impervious core, filter (sand and gravel) and rock. The concrete aggregates are also available near the proposed Embung site. These materials are suitable for constructing a zone type fill dam.

The borrow area, quarry sites and sand and gravel deposits are investigated from the technical and economical viewpoints. The following shows the summary of the materials available and its locations.

Availability of Construction Materials

Material	Location	Description
1. Impervious soil	Reservoir area	Sandy clayed silt weathered tuff Pengulung Formation
2. Filter material	Pelangan river	River deposits consists of sand and gravel. Available quantity is estimated to be more than 20,000m^3
3. Transition material	Pelangan river	River deposits (sand and gravel). Available quantity is more than 50,000m^3
4. Random materials	(1)Reservoir area (2)Spillway, dam foundation	Soft rock with weathered tuff Boulders in the river deposit
6. Concrete aggregates	Pelangan river	gravel) with estimated quantity of more than 30,000m^3

3.4 Availability of Water Resources

(1) Catchment yield

As for the Pelangan river, there is no record of discharge. Accordingly, runoff at the proposed Embung site is estimated by use of the rainfall record near the proposed site. The Sekotong rainfall station which is located in the east of the Pelangan Embung catchment has rainfall record of nearly consecutive 36 years and is considered to represent catchment rainfall. The generated catchment rainfall is given in Table 3.1. A runoff coefficient of 0.40 is adopted considering the characteristics of the catchment area and the previous hydrological analysis in the Lombok Island. Using this runoff coefficient and rainfall record at Sekotong, river flow of the Pelangan at proposed Embung site is estimated.

The following conditions are considered for estimation of the half monthly discharge:

- Catchment area of the proposed Embung site is 46.0 km^2, and,
- Less than 20 mm of half monthly rainfall is ignored for estimation.

This estimation is made based on the rainfall record from 1960 to 1985. The estimated half monthly discharge is given in Table 3.2 and monthly discharge is summarized below.

Mean Monthly Discharge

Unit: 1,000 m^3

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
4,727	4,174	3,252	1,636	1,357	324	330	242	517	1,040	2,295	3,469	23,565

(2) Floods

The flood analysis is made to determine the design discharge of the structures, such as spillway, diversion tunnel, and so on. Taking availability of the flood record and size of the catchment area into account, the rational formula is adopted to estimate the flood discharge in the Study. The formula is;

$$Q = 0.2778\ f\ r\ A$$

where, Q : Peak discharge (m^3/s)
f : Runoff coefficient
r : Average rainfall intensity within time of concentration (mm/hr)
A : Catchment area (km)

1) Design rainfall

Design rainfall is estimated by the Log Pearson Type III method is adopted, which is widely used in NTB. In this Study, 9 years rainfall data of the Sekotong station from 1984 to 1993 are analyzed by the method. The result of probability analysis is summarized below.

Design Rainfall

Unit : mm

Return Period	Design Rainfall
1 in 2 year	88
1 in 5 year	117
1 in 10 year	138
1 in 20 year	160
1 in 50 year	191
1 in 100 year	217
1 in 200 year	244

2) Design flood

The following is the Ruziha's formula to estimate the flood travel time:

$$T = L/V$$
$$V = 72(H/L)^{0.6}$$

where, T : Flood travel time (hr)
L : Horizontally projected length of river course (km)
H : Difference of elevation (m)
V : Velocity of flood (km/hr)

The rainfall intensity within concentration time of the flood is estimated by an empirical formula prepared by Dr. Mononobe as follows:

$$r = (R_{24}/24) \times (24/T)^{2/3}$$

where; r : Maximum average rainfall intensity within concentration time (mm/hr)
R_{24} : Daily rainfall (mm)
T : Time of concentration (hr)

The runoff coefficient is estimated at 0.8 considering the condition of the catchment area.

Based on the above condition, the peak floods in various return period are estimated. The result is shown in Table 3.3 and summarizes below.

Probable Flood

Unit : m^3/s

Return Period	Probable Flood
1 in 2 year	212
1 in 5 year	281
1 in 10 year	332
1 in 20 year	385
1 in 50 year	459
1 in 100 year	522
1 in 200 year	587

(3) Sediment load

There is no available data on sediment load on the Pelangan river. The Technical Report I (Embung Study Program) in the Sumbawa Water Resources Development Planning Study Extension Phase in 1982 indicates that the sedimentation rate is 0.5 mm/year/km ^{2}. Taking data availability and characteristics of the catchment area into account, 0.4 mm/year/km^2 is adopted in this Study.

(4) Water quality

On October 23, 1994, water samplings were carried out at the proposed Embung site and upstream and downstream of the site for the clarification of the water quality. The result of the test is shown in Table 3.4.

4. EMBUNG DEVELOPMENT PLAN

4.1 Optimization of Development Scale

The water balance study aims to clarify the relationship among the proposed Embung scale, irrigable area and cropping pattern. According to the water demand and procedure to be described below, the water balance study of the Pelangan Embung Project is conducted.

(1) Methodology

The simulation equation is as follows:

$$W_2 = W_1 + I - L - S_P - O_D - O_L - O_I$$

where, I : inflow to reservoir at the half monthly period (m3)
L : water losses from the reservoir caused by evaporation during the half monthly period (m^3)
S_P : flow of water over the spillway during the half monthly period (m^3)
O_D : outflow needed for domestic water during the half monthly period (m^3)
O_L : outflow needed for livestock water during the half monthly period (m^3)
O_I : outflow needed for irrigation water during the half monthly period (m^3)
W_1 : volume of water in the reservoir at the beginning of the half monthly period (m^3)
W_2 : volume of water in the reservoir at the end of the half monthly period (m^3)

1) Inflow

Since there is no gauging station on the Kali Pelangan river, discharge is generated from rainfall of the Sekotong station.

2) Reservoir storage curve

Reservoir storage curve with surface area is shown in Figure 4.1 in relation to the elevation at the proposed Embung site.

3) Losses

Evaporation from inundation area can be estimated as "1.1 x ETo", indicating, "open water evaporation", which is employed in the Design Criteria KP-1.

4) Spill out discharge from reservoir

Spill out discharge is considered if there is any excess storage which exceeds the maximum storage capacity of dam.

5) Water Demand

The 100% dependability of the domestic water demand shall be secured by the proposed Pelangan Embung.

To meet 80% dependability of irrigation water, reservoir capacity will be determined.

6) Water level of reservoir

Minimum water level is estimated at El. 26.8 m considering sedimentation volume for 25 years and 1.0 m allowance. Maximum water level for the simulation is equal to the crest elevation of spillway.

(2) Optimum development scale

The optimum development scale of proposed Pelangan Embung coincides with the maximum development scale considering the proposed agricultural development plan. The optimum development scale is thus in line with the maximum height of 29.5 m and effective storage capacity of 5.040 million cubic meters (MCM). The result of the reservoir operation is shown in Figure 4.2.

4.2 Delineation of Beneficiary Area

(1) Delineation of beneficiary irrigation area

By developing available water resources of the Pelangan river through construction of the proposed Pelangan Embung at the maximum scale, irrigation water can be supplied to wet paddy field of 248 ha in net for the both wet dry seasons. The beneficiary area of the proposed Embung comprises the presently irrigated paddy field of 86 ha and newly converted paddy field from the existing rainfed paddy field of 130 ha, dry upland of 3 ha and dry tree crop field of 29 ha. Taking such sufficient water supply condition into account, it becomes possible that the future cropping pattern under the "With-Project" condition aims to maximize rice production, sustain soil fertility and enhance cash income sources. In this regard, the proposed cropping pattern is to be double cropping of irrigated paddy with irrigated mungbean and red onion as the second dry season Palawija crops to the full extent as shown below and illustrated in Figure 4.3.

Under the "Without-Project" condition, no new irrigation water source can be developed so that the future cropping pattern is to remain in the same condition of the present pattern.

Future Cropping Pattern

Condition	Wet season			Dry Season		
	Crop	Water Supply	Area (ha)	Crop	Water Supply	Area (ha)
With Project	Paddy	Irrigated	248	Paddy	Irrigated	248
				Mungbean	Irrigated	124
				Red onion	Irrigated	124
Without Project	Paddy	Irrigated	86	Mungbean	Rainfed	26
	Paddy	Rainfed	130	(Fallow)		-
	Maize	Rainfed	3	(Fallow)		-
	Coconut	Rainfed	29			

(2) Delineation of beneficiary area for domestic water supply

With regard to domestic water demand in the Project area, it is possible to create clean water source by using reservoir water of the proposed Embung. Thus, the future water demand for domestic use by 4,800 inhabitants is to be met by installing new water distribution pipeline networks.

4.3 Embung Development Plan

Following the results of the geological and material surveys as well as the optimization study, the proposed development plan of Pelangan Embung is determined. In terms of dam type, earth zone type is applied in due consideration of the foundation strength and the availability of embankment materials. As for the foundation treatment, it is proposed to adopt the curtain grout, the consolidation grout, the blanket grout with a total length of 7,900 m considering the geological condition of the proposed Embung site.

The main components of Pelangan Embung are the main dam, spillway, river diversion conduit and water supply facility as shown in Figure 4.4. In order to provide the reservoir with the optimum storage capacity of 5.040 MCM, the full supply level (F.S.L.) is set at El. 41.0 m. Taking overflow depth of spillway and freeboard into account, the dam height of Pelangan Embung becomes 29.5 m above the river bed. In order to release the flood discharge during the construction period, an open river diversion is provided. The spillway is designed on the left bank of the main dam to release the flood discharge of 522 m^3/sec from the catchment area of 46.0 km^2. For the purpose of supplying domestic water to the beneficiary area, such related facilities are provided as an intake structure in the reservoir, water supply pipe with a diameter of 500 mm below the dam body and valve house at the downstream of the main dam.

The principal features of Pelangan Embung are summarized below.

(1)	Reservoir	
	- Catchment area	46.0 km^2
	- F.S.L.	El. 46.0 m
	- minimum operating level	El. 26.8 m
	- Effective storage capacity	5,040,000 m^3
	- Dead storage capacity	660,000 m^3
	- Gross storage capacity	5,700,000 m^3
	- Sediment deposition level	El. 25.8 m
(2)	Main dam	
	- Type	Zone type fill-dam
	- Height	29.5 m above river bed
	- Crest elevation	El. 45.5 m
	- Crest length	360 m
	- Crest width	9.0 m
	- Upstream slope	1 : 2.5
	- Downstream slope	1 : 2.0
	- Total embankment volume	622,000 m^3
	- Foundation Treatment	Curtain Grout Consolidation Grout Blanket Grout (Total length = 7,900 m)
(3)	Spillway	
	- Design flood (1/100 year)	522 m^3/sec
	- Type	Side-Channel
	- Crest elevation of overflow weir	El. 41.0 m
	- Width of overflow weir	73.0 m
	- Discharge capacity	550 m^3/sec
	- Overflow depth	2.2 m
	- Length	223 m
(4)	River diversion	
	- Design flood (1/5 year)	280 m^3/sec

-	Type	Open Tunnel
-	Dimension	20 x 5 m
-	Length	300 m

(5) Water supply system

-	Inlet structure	1.5 x 1.5 m with trashracks
-	Pipe diameter	500 mm pipe culvert
-	Valve house	Right abutment, D/S
-	Design discharge	500 lit/sec
-	Type	Jet flow valve
-	Diameter	350 mm x 2 unit
-	Outlet elevation	El. 21.0 m

5. PRELIMINARY DESIGN OF FACILITIES

5.1 Preliminary Design of Embung

(1) Dam height

Resulting from the optimization study based on irrigation benefit and the construction cost, the dam height is decided on the basis of "Reservoir Storage Curve" as shown in Figure 4.1.

(2) Freeboard

The freeboard of main dam is designed taking into consideration the rise of the reservoir water surface due to extraordinary flood discharge and wave uprush on the slope. The following formula is applied for the design of the Pelangan Embung.

$$Hf = 0.05h + 1.0 \text{ (m)}$$

where, Hf : freeboard
h : height from river bed to the designed flood level.

(3) River diversion during construction

During the dam embankment period, river flow including floods has to be diverted to avoid inundation of the Embung construction site. This can be effectively and economically made by providing with an open channel river diversion for one year from the beginning of July in the second year to the end of April in the third year. In the second dry season, the river water will be switched into the conduit for the downstream water supply. Accordingly, embankment work for the remaining section of the dam can be completed within this period as seen in Figure 6.1.

(4) Spillway

The spillway is located on the left abutment of main dam, which is composed of side channel type overflow weir, throughway, chuteway and downstream channel. The overflow weir is designed to cope with the inflow design flood with a flood surcharge space provided above F.S.L. The inflow design flood is determined at 100 year probable flood having a peak discharge of 522 m^3/sec.

Based on the result of comparative study on combination of overflow depth and width of the spillway, overflow depth of 2.2 m and the width of 73.0 m are decided so as to minimize the costs of spillway and the main dam.

A non-gated ogee crest would be set at El. 41.0 m to coincide with F.S.L. Spillway bridge is provided across the crest portion of the spillway because of provision of an access road from the right to left abutments of the main dam.

(5) Water supply system

In order to supply water to the downstream water users, the water supply system is provided to release the water of 500 lit/sec for irrigation use and domestic water supply. The water supply system consists of intake structure, pipe line inbedded in concrete conduit and valve house. The intake structure is located in the reservoir area just above the sediment deposition level of El. 25.8 m. Fixed trashracks are provided on the intake structure. Steel pipe with a diameter of 500 mm is connected from the intake structure to the downstream through the main dam. A value house would be constructed near the downstream toe of the dam. The guard valve and control devices would be installed in the valve house.