Japan International Cooperation Agency (JICA)

Directorate General of Water Resources Development, Ministry of Public Works

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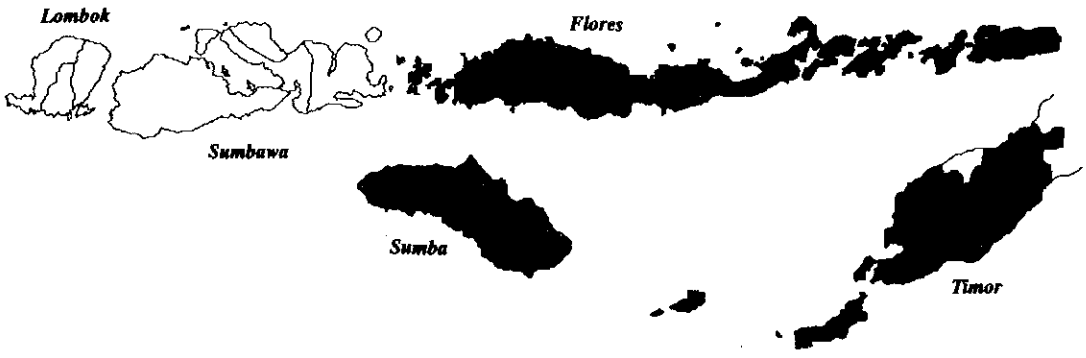
The Study on The Embung Development Project (Small Scale Impounding Pond Development Project) in East Nusa Tenggara and West Nusa Tenggara in The Republic of Indonesia

Final Report (Volume 10)

Feasibility Study Report
on
Two Embung Development Projects
in
East Nusa Tenggara



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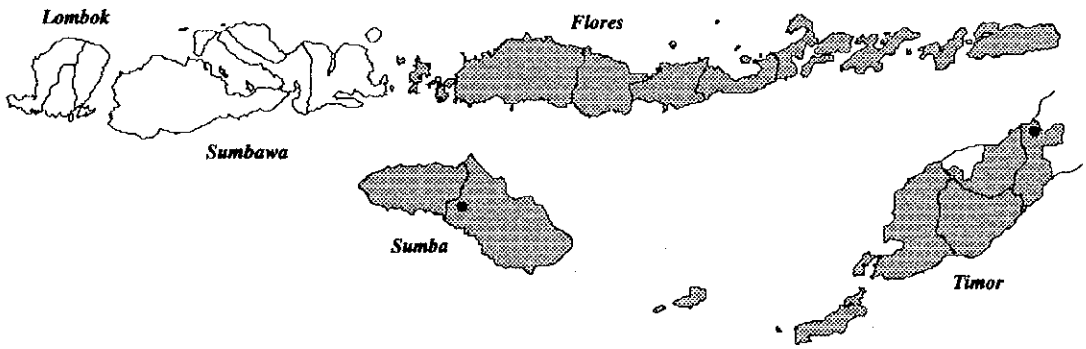

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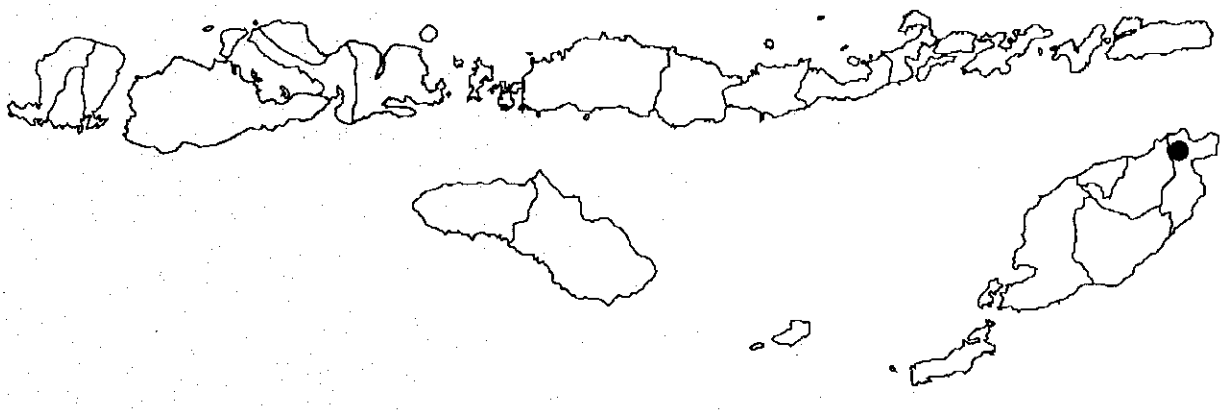
Feasibility Study
on
Fatukmetang Embung Development Project



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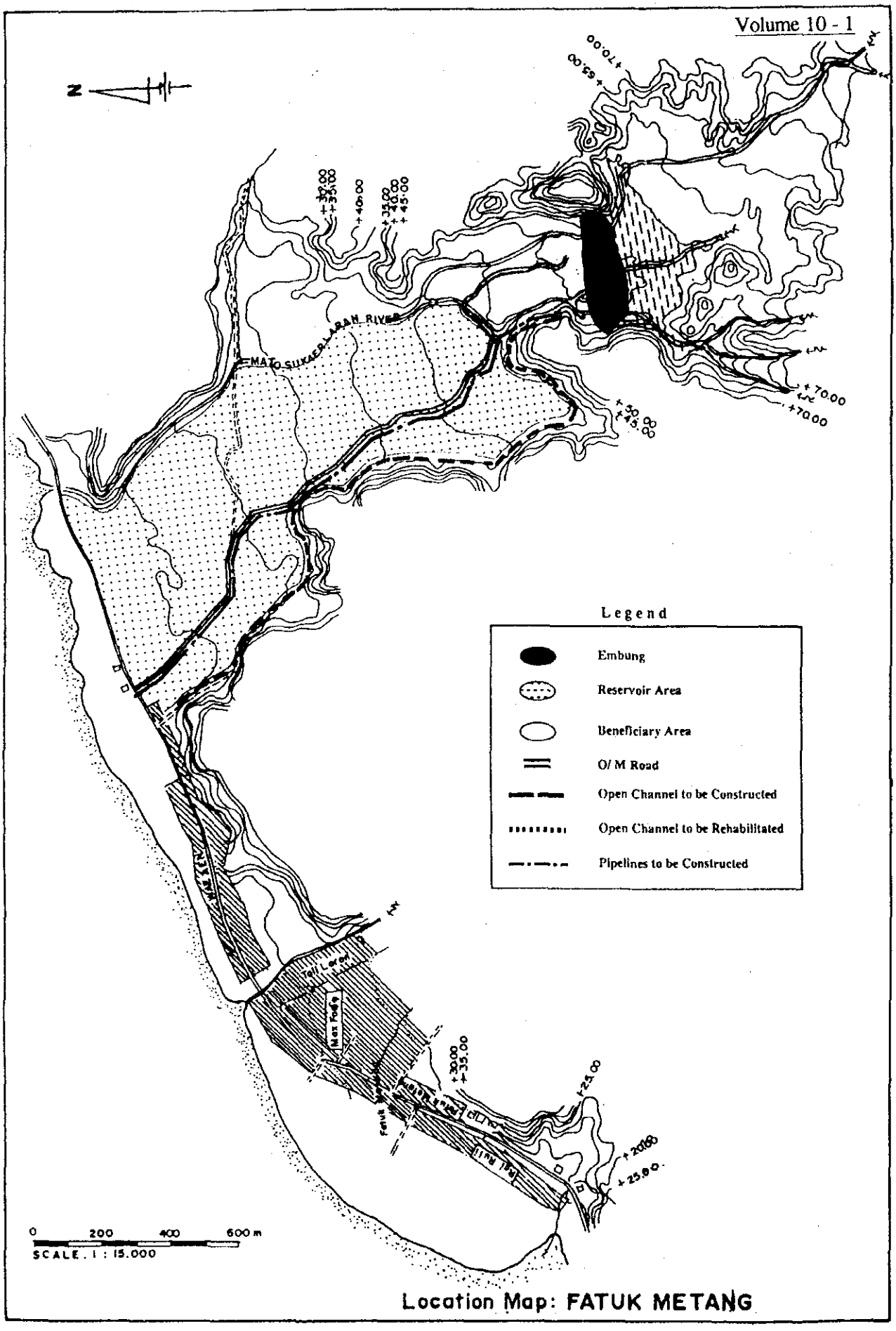

Location Map: FATUK METANG

THE STUDY
ON
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(SMALL SCALE IMPOUNDING POND DEVELOPMENT PROJECT)
IN
EAST NUSA TENGGARA AND WEST NUSA TENGGARA
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FINAL REPORT

VOLUME 10-1

FEASIBILITY STUDY
ON
FATUKMETANG 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 Jenilu Village in Kecamatan Tasifeto Barat of Kabupaten Belu on Timor Island of Nusa Tenggara Timur (NTT) Province. The proposed Embung site is located on the Jenilu river about 30 km north from Atambua.

Topographical condition of the catchment area is rather gentle, while the reservoir area is wide and flat.

Beneficiary area is situated rather flat zone along the Jenilu river until coastal area.

1.2 Climate and Hydrology

Although the Fatuoni is the nearest climate and rainfall station from the proposed Embung site, items of observation in the station are limited up to date. Therefore, the Pante - Macassar climate station, which is located in the west of the proposed Embung site and Timor Timur Province, is likely to represent the climate in the Project area. The wet season usually starts from late November and ends early April in the Project area with the average annual rainfall of 1,130 mm. Mean annual temperature is 26.5 °C with the average maximum temperature of 30.1 °C and the average minimum temperature of 22.8°C. Mean relative humidity is 74.3 %. Average sunshine hours are 5 to 7 hr/day during the wet season and increase to 8 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 3.6 km/hr. Tables 1.1 and 1.2 show monthly rainfall record at the Fatuoni station and climate data at the Pante Macassar station, respectively.

The Tarilalan river rises in Mt. Tubu Kotamanaman where the altitude is approximately 400 m and follows a northeasterly course. It then turns northwestward and discharges into the Timor Sea. The surface of the catchment area is mostly covered with rough forest. The catchment area at the proposed Embung site is 4.0 km ^{2}. There is no gauging station on this river.

1.3 Geology

The proposed Embung site is underlain by basic rock complex, which is the oldest rock in Timor Island and formed of limestone of the Triassic to Permian age and unconsolidated deposits of the Quaternary age. The geological formation is highly weathered basic rock complex composed of basalt, diabase and dioritic gabbro; weathered rock belonging to soft rock and moderately hard fresh rock; limestone composed of crystalline limestone, which is moderately hard to hard rock of Triassic to Permian age; highly weathered rock like coral limestone with many small holes; alluvium composed of sand, silt and gravel forming wide lowland; detritus composed of soil with rock fragments and distributed at foot of slope or gentle valley; river deposits composed of mainly sand with gravel, and distributed along the existing river bed.

1.4 Soils and Land Use

The Project area of Fatukmetang lies on the bottom of U-shaped valley with a length of 2,000 m and a width of 500 m. The average land slope is 2% along the valley. The valley bottom is slightly undulating.

Parent material of soils is mixed alluvial materials composed of sand and breccia. Soil drainage on farmland is generally well and soil permeability is moderate to rapid. Soil depth is deep to very deep ranging from 70 cm to more than 100 cm. Soil texture of surface soil varies from clay loam to loamy sand.

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

There is no paddy field due to lack of water. Almost all the area is categorized in bush/scrub. The land is used for grazing cattle and partly planting upland crops and sago trees, but such land use is not intensive.

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

Present Land Use on the Project Area of Fatukmetang

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	0	0		0
Upland	0	0		0
Tree crops	0	0		0
Bush/Scrub/Grassland			126	126
Residential			7	7
Cemetery			0	0
Others			0	0
Total	0	0	133	133

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 revealed by a total population of 572 and a total number of households of 156 including farm households of 62 as shown below. The average family size is 3.7 persons. Dominant ethnic is original Sumbawanese and the majority of inhabitants embrace Christian 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.)
Jenilu	Fatukmetang	149	30	5.0	10
	Railuri	215	63	3.4	25
	Makfaho	142	44	3.2	15
	Waeaen	66	19	3.5	12
Total		572	156	3.7	62

Source : JICA Water Use Survey

1.6 Domestic Water Use

The available water source facility for supplying domestic and livestock water is only small dug well. The length of prevailing water shortage period is three months between

October and December. The present water use in each sub village clarified under the Study is summarized below.

- In Fatukmetang Sub-Village, all the inhabitants carry their drinking and livestock water from eight dug wells 200 m away;
- In Railuri and Makfano Sub-Villages, all the inhabitants depend their drinking and livestock water on 12 dug wells each at the average distance of 200 m; and
- In Waelan Sub-Village, people get their drinking and livestock water from three dug wells at the maximum distance of 200 m.

1.7 Social Infrastructures

The access from Kupang, the provincial capital of NTT, to the Project area is the trans-Timor road. The proposed Embung site is linked by an earth road from the trans-Timor road. The existing rural electrification network has not reached yet to the Project area.

Inhabitants are generally using a public bathing with toilet and washing facilities for defecating purposes. There are an auxiliary hospital and an integrated health service center 10 km away from the Project area.

1.8 Agriculture and Livestock

(1) Present cropping pattern and intensity

The Project area was once opened up as wet paddy field to grow rainfed paddy but has been left as idle land for about 10 years due to unstable and less rainfall. At present, this idle paddy field is covered with bush as well as scrub and used for grazing purpose.

(2) Livestock population

Various kinds of livestock are raised in the Project area and their numbers are given below. Cows and buffaloes play important roles as draft power and cash income sources. Other livestock are raised for self-consumption and selling to local markets.

Current Population of Livestock

Unit: head

Breeding Household	Cow	Buffalo	Horse	Goat /Sheep	Pig	Chicken/ Duck
62	237	104	58	316	148	800

Source: The JICA Water Use Survey

1.9 Irrigation Facilities

In the Project area, there are no paddy field nor irrigation facilities.

1.10 Agro-economy

(1) Farmers group

Farmers are members of Village Social Activities Group (LKMD), Village Sanitation Group and Village Program of Women Education. Some farmers are also members of

Village Youth Association. Because of no crop production activities, however, Agricultural Cooperative (KUD) and Water Users' Association (P3A/HIPPA) have been yet established in the Project area.

(2) Agricultural supporting services

Agricultural extension services are provided to farmers by field extension workers (PPL) attached to a rural extension center (BPP) in Belu. 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.

Timor Water Resources Development and Conservation Project Office (Proyek PKSA Timor) under the NTT Provincial Public Works Service (DPUP) is responsible for new water resource development and watershed management. New development of irrigation system is the responsibility of Timor-Sumba Irrigation Project Office, while 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. 1.16 million and Rp. 1.13 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 572 persons as at 1993 to 618 persons in 1998, 658 persons in 2003, 700 persons in 2008, 738 persons in 2013 and 772 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 are located in places 200 m away with water shortage period of three months from October to December and no electricity is the distributed to this area. At present, there is no alternative water source facilities to meet water demand for this period.

(3) Economic development needs

All of 62 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 to 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 both the wet and dry season crops. As they carry drinking water from and bring their cattle to places where water is available during the water shortage period, 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 and livestock water throughout a year as well as irrigation water as much as possible.

(5) Development constraints

The present constraints against economic development in the Project area are featured by no irrigation system to utilize water resources of the Tarilalan river. Such lack of water supply system has acted the barrier to improve living standard and to develop agriculture and livestock. Due to small size of the river basin and concentration of runoff into the wet season, the Tarilalan river is useless without construction of water regulating facilities.

2.2 Development Concepts and Approach

(1) Development concepts

The existing gap of economic status between NTT 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 create new water resources for meeting BHN and improving rainfed agriculture.

(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 Tarilalan river. Approach to development planning of the potential Embung is as follows:

- To put the first priority to supply irrigation water followed by domestic water and livestock water taking into account inhabitants' needs and intention;
- To project the future water demand for irrigation, domestic and livestock use at the target year of 2008 being the last year of Pelita VIII;
- To examine development potential of the Fatukmetang 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

The area which is extensively used for cattle grazing and some upland or tree crop planting could be transformed into irrigated paddy field by constructing the proposed Embung. The irrigation development area is limited by water availability of the proposed Embung. Supposing the irrigation area is planned to be extended on the left bank of the Mato Sukaerlaran river, the possible irrigation area is estimated as 72 ha.

Bush/scrub land	->	Irrigated paddy field	72 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 Fatukmetang

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	0	0		0
Upland	0	0		0
Tree crops	0	0		0
Bush/Scrub/Grassland			126	126
Residential			7	7
Cemetery			0	0
Others			0	0
Total	0	0	133	133

Source : The JICA Study Team

The impounding area of the proposed Embung is covered by the grazing land for cattle and bush/scrub. The compensation of the extensive grassland is not difficult because this land will be newly developed as wet 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 some experience in rice cultivation. Therefore, they could easily master irrigated rice cultivation method to realize production target 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 A-11	Paddy	100	(Fallow)	-	-	-
With Project A-21	Paddy	100	Mungbean	50		
			Red onion	50	-	-
With Project A-52		Mango			100	

(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.

Proposed Farm Input and Labor Requirements

Item	Unit	Wet Paddy	Mungbean	Red Onion	Mango
Farm Inputs					
Seed	kg/ha	25	30	2,000	-
Fertilizer					
Urea	kg/ha	200	50	300	100
TPS	kg/ha	100	100	200	100
KCl	kg/ha	50	50	100	100
Agro-chemicals	lit/ha	2	2	10	-
Rodenticide	kg/ha	2	1	3	-
Labor	md/ha	185	80	250	50
Draft Animal	ad/ha	20	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 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 4.0 ton/ha for wet paddy, 1.0 ton/ha for mungbean, 7.5 ton/ha for red onion and 5.0 ton/ha for mango. These targets are estimated in due consideration of the present yield level in well established irrigation areas of the western part of Timor island 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 Belu during the Pelita V period.

Projected Population of Livestock

Unit: head

Cow	Buffalo	Horse	Goat /Sheep	Pig	Chicken/ Duck
370	125	73	650	352	2,276

2.5 Water Demand

(1) Domestic water demand

The future domestic water consumption level in rural areas of NTT is set to be 60 lit/day/capita up to 2003/04 for the Pelita VII period and 70 lit/day/capita from 2004/05 and onward. The public water demand and the unaccounted-for are to be included into these unit water requirements.

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 17,900 m^3.

Projected Domestic Water Demand

Item	Unit	1998	2003	2008	2013	2018
Population	person	618	658	700	738	772
Total demand	'000m^3/yr.	13.5	14.4	17.9	18.9	19.7

(2) Livestock Water Demand

The future livestock water consumption level in NTT is set to be 40 lit/day/head for cow, buffalo and horse, 5 lit/day/head for sheep and goat, 6 lit/day/head for pig and 0.6 lit/day/head for poultry according to "The Study for Formulation of Irrigation Development Program in the Republic of Indonesia".

Following the future livestock population projected, the future livestock water demand is estimated to be 10,800 m^3. The breakdown of this livestock water demand is 5,400 m^3 for 370 cows, 1,800 m^3 for 125 buffaloes, 1,100 m^3 for 73 horses, 1,200 m^3 for 650 goats and sheep, 800 m^3 for 352 pigs and 500 m^3 for 2,276 chickens.

(3) 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 Fatukmetang Embung site is selected at the narrowest point of the valley along the Jenilu river. River bed elevation shows El. 35.0 m and the width of valley is 370 m at El. 55.0m on the both abutments of dam site. Gradient of the river bed around the dam site is about 1/40 to 1/50.

3.2 Geological Condition

The proposed Embung site is underlain by basic rocks, crystalline limestone and alluvium. The foundation is mainly formed of crystalline limestone at left bank, basic rocks and crystalline limestone at the right bank and alluvium on the river bed. The drilling survey shows that the N-value of alluvium ranges from 11 to 47. The coefficient of permeability varies from 2.1×10^{-5} to 5.8×10^{-6} cm/sec for alluvium, from 1.1×10^{-4} to 8.1×10^{-5} cm/sec for crystalline limestone and from 2.4×10^{-5} to 8.3×10^{-6} cm/sec for basic rocks. No ground water is present at any bore holes.

The reservoir area is mainly underlain by basic rocks, crystalline limestone and alluvium. No major fault and landslide are recognized in the field. Geological map and profile are shown in Figures 3.1 and 3.2.

3.3 Availability of Construction Materials

In and around the proposed Fatukmetang Embung site, there are sufficient materials suitable for constructing a homogeneous earthfill dam. The borrow area for impervious soil and quarry site for sand and gravel materials are investigated from the technical and economical view points. The following shows a summary of the selected location and the availability of the materials.

Availability of Construction Materials

Material	Location	Description
1. Impervious soil	Reservoir area	Clayed silt Silty clay
2. Filter drain material	(1) Jenilu river (2) Acodato river	Sand and gravel from river deposits
3. Toe rock material	(1) Acodato river (2) Quarry mountain at left abutment of the dam	Boulders from river deposits Weathered limestone
4. Concrete aggregates	(1) Jenilu river (2) Acodato river	Sand and gravel from river deposits

3.4 Availability of Water Resources

(1) Catchment yield

As for the Tarilalan 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 Fatuoni rainfall station which is located in the west of the Fatukmetang Embung catchment

has rainfall record of nearly consecutive 15 years and is considered to represent catchment rainfall. The generated catchment rainfall is given in Table 3.1. A runoff coefficient of 0.30 is adopted considering the characteristics of the catchment area and the previous hydrological analysis in the Timor Island. Using this runoff coefficient and rainfall record at Fatuoni, river flow of the Tarilalan 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 4.0 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 1977 to 1991. 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
401	312	186	84	19	0	11	0	0	17	126	205	1,361

(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, which is widely used in NTB. In this Study, 16 years rainfall data of the Fatuoni station from 1977 to 1992 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	69
1 in 5 year	93
1 in 10 year	109
1 in 20 year	124
1 in 50 year	146
1 in 100 year	162
1 in 200 year	180

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	33
1 in 5 year	44
1 in 10 year	52
1 in 20 year	59
1 in 50 year	69
1 in 100 year	77
1 in 200 year	85

(3) Sediment load

There is no available data on sediment load on the Tarilalan 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 24, 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 Fatukmetang 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 (m^3)
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 (m3)
OD : 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 Tarilalan river, discharge is generated from rainfall of the Fatuoni 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 Fatukmetang 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. 41.5 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 Fatukmetang Embung coincides with the maximum development scale of the proposed agricultural development plan. The optimum development scale is thus in line with the maximum height of 19.0 m and effective storage capacity of 0.840 million cubic meters (MCM). The result of 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 Tarilalan river through construction of the proposed Fatukmetang Embung at the scale to utilize available land resources to the maximum extent, irrigation water can be supplied to wet paddy field of 57 ha in net for the both wet and dry seasons. The beneficiary area of the proposed Embung is converted from bush and scrub land. Taking the availability of reservoir water, the future cropping pattern under the "With-Project" condition is to be two cropping of the wet season paddy and the dry season Palawija crops under the irrigated condition as shown below and illustrated in Figure 4.3. Mungbean and red onion are grown as Palawija crops.

Under the "Without-Project" condition, no new irrigation water source can be developed so that no crop is planted in the future.

Future Cropping Pattern

Condition	Wet season			Dry Season		
	Crop	Water Supply	Area (ha)	Crop	Water Supply	Area (ha)
With Project	Paddy	Irrigated	57	Mungbean	Irrigated	28.5
				Red onion	Irrigated	28.5
Without Project	(Fallow)		-	(Fallow)		-

(2) Delineation of beneficiary area for livestock water supply

With regard to livestock water demand in the Project area, it is possible to meet the whole amount by using excess reservoir water of the proposed Embung. Thus, the livestock water for 736 equivalent heads of cow is to be distributed by installing new water 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 Fatukmetang Embung is determined. In terms of dam type, earth homogeneous type is applied in due consideration of the foundation strength and the availability of embankment materials.

The main components of Fatukmetang 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 0.840 MCM, the full supply level (F.S.L.) is set at El. 50.0 m. Taking overflow depth of spillway and freeboard into account, the dam height of Fatukmetang Embung becomes 19.0 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 77 m^3/sec from the catchment area of 4.0 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 160 mm below the dam body and valve house at the downstream of the main dam.

The principal features of Fatukmetang Embung are summarized below.

(1)	Reservoir	
	- Catchment area	4.0 km^2
	- F.S.L.	El. 50.0 m
	- Minimum operating level	El. 41.5 m
	- Effective storage capacity	840,000 m^3
	- Dead storage capacity	80,000 m^3
	- Gross storage capacity	920,000 m^3
	- Sediment deposition level	El. 40.5 m
(2)	Main dam	
	- Type	Homogeneous earthfill dam
	- Height	19.0 m
	- Crest elevation	El. 54.0 m
	- Crest length	370 m
	- Crest width	7.0
	- Upstream slope	1 : 4.0
	- Downstream slope	1 : 3.0
	- Total embankment volume	460,000 m^3
(3)	Spillway	
	- Design flood (1/100 year)	77 m^3/sec
	- Type	Overflow weir
	- Crest elevation of overflow weir	El. 50.0 m
	- Width of overflow weir	13.0 m
	- Discharge capacity	80 m^3/sec
	- Overflow depth	2.0 m
	- Length	210 m
(4)	River diversion	
	- Design flood (1/5 year)	44 m^3/sec
	- Type	Open channel
	- Diameter	8.0 m x 3 m
	- Length	120 m
(5)	Water supply system	
	- Inlet structure	1.0 x 1.0 m square with trashracks
	- Pipe diameter	ϕ 160 mm
	- Length	260 m
	- Design discharge	70 lit/sec.
	- Valve house	Left abutment of dam site
	- Type	Through valve
	- Diameter	ϕ 160 mm x 1 unit
	- Outlet elevation	El. 40.0 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 Figure 4.1.

(2) Freeboard

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

The following formula is applied for the design of the Fatukmetang Embung.

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

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

(3) Horizontal filter drain and toe rock drain

In order to reduce the seepage line within the dam body under the full reservoir water condition, horizontal filter drain (drainage mattress) and toe rock drain are provided below body and at toe portion of the main dam as shown in Figure 4.4.

(4) River diversion channel 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 a random-filled cofferdam and open channel river diversion with a trapezoidal shape of 8 m in width and 3m in height. A 4 m high cofferdam with a crest level of El. 39.0m would suffice to contain the flood inflow of 44m^3/sec having a return period of five years.

(5) Spillway

The spillway is located on the left abutment of the main dam, which is composed of overflow weir and chuteway. The over flow 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 77 m^3/sec.

Based on the comparative study on combination of overflow depth and width of the spillway, the overflow depth at 2.0 m and the width of 13.0 m are decided so as to minimize the costs of the spillway and the main dam.

A non-gated ogee crest would be set at El. 50.0 m to coincide with F.S.L. A bridge would be provided over the throughway of the spillway.

(6) Water supply system

In order to supply the water to the downstream irrigation area, the water supply system is provided to release the water of 70 lit/sec. The water supply system consists of

intake structure, pipe line and valve house. The intake structure is located at the front of diversion tunnel above the sediment deposition level of El. 40.5m. Fixed trashracks are provided on the intake structure. Pipe culvert with a diameter of 160 mm is connected from the intake structure to the downstream through the main dam foundation.

A valve house would be constructed near the downstream toe of the dam. The guard valve and control devices with a diameter of 160 mm would be installed in the valve house.

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,

(2) Irrigation plan

The outlet works of the Embung are planned to be used for dual purposes of supplying irrigation and domestic water. The water taken from the reservoir is led to the valve house through the cast iron pipe provided in the left abutment of the dam. The water is then diverted to irrigation and domestic water supply channels at the valve house with check valve and flow meter.

Irrigation water diverted at the valve house 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 by an open channel to the field to be irrigated.

General layout is shown in Figure 5.1 including the layout of irrigation canals and pipe lines for domestic water supply.

(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 unit irrigation 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 crop and its design discharge is estimated at 70 lit/sec for the net irrigation area of 57 ha. This design discharge is enough to flow design discharge for the dry season Palawija crops of net area of 57 ha at peak time.

Initial water level at the irrigation inlet box is decided taking into consideration the elevation at the box site. As a result, initial water level is E. 40.0 m at the irrigation inlet box.

(4) Irrigation facilities

The proposed canal layout and design of irrigation facilities are made based on the 1/5,000 topographic maps prepared under the Study and in accordance with the following condition:

- Canal alignment is to be straight and short as much as possible;
- The alignment is to be planned pass outside of villages and give no damages to public facilities;
- The types of canal related structures are to be minimized as much as possible; and,
- The structures are to be simplified as much as possible.

Irrigation canal to lead the water to wet field from the Embung is constructed using concrete flumes taking into consideration the rather small design discharge of the canal, steep topographic condition, construction method and available construction materials in the Project area. Canal related structures required are irrigation inlet box, cross drains and irrigation division boxes. Required irrigation facilities are summarized below.

Irrigation Facilities Requirement

Facilities	Quantities
- Valve house (included in the facilities for Embung)	1 No.
- Irrigation inlet box	1 No.
- Concrete Flume canal to be constructed	2.2 km
- Cross drain	4 Nos.
- Irrigation division box	22 Nos.

5.3 Preliminary Design of Water Distribution Facilities

The main components of water distribution facilities to inhabitants in the beneficiary area are pipe lines, division boxes with filter system for inhabitants and related structures of pipelines.

Preliminary design works for each water distribution system are carried out based on the following basic concepts.

- Distribution facilities to the beneficiary area are laid out taking into consideration the effective storage capacity of the Embung, topographic condition of the Project area and village boundary;
- Water demand for inhabitants and livestock is fully reflected in the preliminary design of pipeline and the layout of division boxes in the beneficiary areas;
- Pipeline system with pressure flow is taken up for water distribution network from the Embung to its beneficiary area. Pipes are laid along the existing roads as much as possible from the viewpoint of easy O&M works of pipeline system. Pipes are laid under the ground with a depth of 50 cm;

- Division boxes for inhabitants are arranged based on the water demand in the beneficiary area, water conveyance distance between a division box and its users' houses and topographic condition of a site for constructing a division box. The designed capacity of division box for inhabitants is 6,000 lit to cover daily water demand of 100 persons;

- Division boxes for livestock are arranged in a separate place from the division boxes for inhabitants to reduce risks such as contamination of water quality in and damages to division boxes for inhabitants, and so on. The designed capacity of division box for livestock is 900 lit to meet daily water demand of 22 heads of cattle;

- Related structures of pipelines such as check valves, air valves and blowoffs are set taking into account the topographic condition along and the layout of pipeline system; and,

- High Density PVC pipes are used for the water supply in due consideration of the safety against unexpected high pressure to the pipes, the steep and undulating topographic condition and the easiness to get the materials in Indonesia.

The design discharge of pipeline is decided on the basis of the unit water demand of inhabitants and livestock as well as projected population of inhabitants and livestock for the beneficiary area.

Main features of the pipeline system are summarized below.

Main Features of the Pipeline System

Facilities	Quantities
Pipeline (Dia. 75 mm)	3.9 km
Check valve	2 Nos.
Air valve	1 Nos.
Blowoff	2 Nos.
Division box for domestic water	22 Nos.
Division box for livestock	22 Nos.

5.4 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	2.2
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 the construction equipment and key staffs to the site from beginning of November in the first year. Following the above, 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 started by using equipment available at the Project site. The excavation works for the river diversion channel and the main dam would be commenced at the beginning of March in the second year.

3) Embankment works and excavation of spillway and water supply conduit

After the river water diverts into the diversion channel around June in the second year, embankment works for the main and saddle dams shall be commenced and completed before the wet season in the third year. Excavation works for the spillway and water supply conduit shall also be commenced and completed before October in the second year.

4) Concrete works of spillway and water supply conduit

Concrete work of the spillway will be commenced in March and completed before October in the third year. Concrete work of the water supply conduit will be completed before re-starting the embankment of the main dam in the dry season, of the third year.

5) Commencement of reservoir water impounding

Commencement of the reservoir water impounding will be done at the beginning of October in the third year after completion of the main and saddle dam embankment and spillway construction works. Considering the rainfall in November and December in the third year, the Fatukmetang reservoir would be quite full, the water could be supplied from the reservoir to the water users from January in the fourth year.

6) Water distribution system

Construction works for the water distribution system will be executed in parallel with the Embung construction works by using mainly manpower because those work quantities are not so much. The construction works shall be completed by the end of December in the third year 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 channel during the second and third year, which is provided along the right bank of the Jenilu river.

In the dry season of the third year, the river diversion channel below the main dam will be filled by the embankment materials of the main dam. In this period, the river water shall be released to the downstream through the water supply pipe culvert to be constructed below the dam foundation.

(3) Main dam works

Following the foundation excavation, and completion of the river diversion channel, the embankment works will be commenced at the beginning of July in the second year.

Considering a total embankment volume of 460,000m^3 and the dry season in the second and third year, the daily embankment volume is to be 1,300m^3 which is quarried from the borrow area around the Embung site.

(4) Spillway construction

Excavation of the spillway will be scheduled to be performed for about five months from March to September in the second year. Most of the excavated materials may be used for the main and saddle dam embankments so that the excavated materials will be stocked on the designated area.

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

(5) Water supply system

The inlet structure of water supply system is constructed above the sediment load disposition level of El. 40.5m in the reservoir area. Connecting with the inlet structure, pipe culvert with a diameter of 160 mm is constructed up to the downstream end of the main dam. Construction of the water supply conduit should be completed before re-starting the main dam embankment at the beginning of March in the third year as seen in Figure 6.1.

The valve house of the water supply system will be constructed before the reservoir water reaches to F.S.L. of El. 50.0m, around the end of December in the third year.

6.3 Construction Plan of Irrigation Facilities, Water Distribution Facilities and O&M Road

Since the construction of irrigation facilities, water distribution facilities and O&M road is rather small in working quantities and the sites are scattering in the beneficiary area in comparison with the Embung construction works, almost all the works except earth works for irrigation canal and road will be basically executed by manpower. Earth works for the irrigation canal and road including clearing, stripping, excavation and embankment works will be executed by using heavy construction equipment such as bulldozer, excavator, compactor and so on. All of these works will be 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 NTT, after getting approval from DGWRD, will direct the PKSA Timor Project Office to commence undertaking of detailed investigation and design works of the Fatukmetang Embung. These works will be done by the Survey Section as well as the Technical Program and Design Section of the said Project Office. Based on the cost estimate, DPUP of NTT 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 Construction Implementation Section of the Project Office. Supervision of construction works, being entrusted to a contractor through tendering, will be the responsibility of the Construction Implementation Section of the Project Office as well as the Timor Sub Project Office under 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 Timor 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 Fatukmetang 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 Project works for Fatukmetang Embung, DPUP of NTT 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 NTT Province will order DPUP of NTT to take a necessary action for O&M of the said Project facilities. Following this, DPUP of NTT will direct its Provincial O&M Project Office to arrange O&M works and disburse the Provincial Government's budget to DPUP Kabupaten Belu Office.

(4) Water User's Association (P3A)

In the Project area, no P3A has been established. It is therefore necessitated to organize the beneficiary farmers for establishing 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 Fatukmetang 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 Fatukmetang Embung is estimated at Rp. 18,999 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 with work quantities of the main work items and unit prices.

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

Summary of Project Cost for Fatukmetang Embung

Unit : Rp. Million

Item		Project cost
I.	Direct construction cost	10,430
1.1	Preparatory works	497
1.2	Embung construction	9,328
1.3	Irrigation facilities	187
1.4	Domestic water supply	284
1.5	Operation & maintenance road	134
II.	Administration cost	521
III.	Engineering services	1,564
IV.	Physical contingencies	1,877
V.	Contract tax	1,387
VI.	Land acquisition	52
VII.	Price contingency	3,166
	Grand Total	18,999

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. 95.0 million, which is equivalent to 0.5 % of the Project cost.

8. PROJECT JUSTIFICATION

8.1 Satisfaction of BHN

(1) Satisfaction of domestic water demand

The benefit of domestic water supply to 700 beneficiary inhabitants in Jenilu Village could be indicated as the value of water and the investment amount to each beneficiary inhabitant. If the total amount of direct construction cost is defined as the total amount of investment for the construction of Fatukmetang Embung, this investment amount could be allocated to the investment in domestic water supply according to the proportion of annual domestic water demand against the total annual water demand. Then, the value of water can be estimated by dividing the sum of allocated amount of direct construction cost of Embung and the whole amount of domestic water supply system by the annual domestic water demand, while the investment amount to each beneficiary inhabitant can be given by dividing the said sum by the total number of domestic water users.

The direct construction cost is broken down into the cost for Embung, dam O&M road and preparatory works of Rp. 9,959 million, irrigation facilities of Rp. 187 million and domestic and livestock water supply system of Rp. 284 million. The total number of beneficiary inhabitants is 700 persons. The annual water demand is 0.018 MCM for domestic use, 0.011 MCM for livestock use and 0.77 MCM for irrigation use, totaling 0.799 MCM. The direct construction cost is allocated as shown below.

Allocation of Direct Construction Cost

Item	Unit	Total demand	Domestic water	Livestock water	Irrigation water
Annual water demand	'000 m^3	799	18	11	770
Direct construction cost	Million Rp.	10,430	400	245	9,785

Thus, the benefit of domestic water supply is indicted by the value of water of Rp. 12,708/m^3 and also the investment amount to the respective beneficiary inhabitants of Rp. 14 million a person.

(2) Satisfaction of livestock water demand

The benefit of livestock water supply to 736 equivalent heads of cow fed by beneficiary breeding households in Jenilu Village could be indicated as the net value of additionally increasing cattle weight, either cow or buffalo, attributable to stabilized livestock water supply condition. In order to estimate this net value, it is assumed that a cow or buffalo aged 1.5 to 2 years old and with the initial weight of 200 kg will get an additional increase of 0.6 kg/day in weight during four months of the dry season as a result of stable supply of livestock water. Further assumptions made for other unit values are Rp. 2,500/kg for the both initial and increasing weights, Rp. 490,000/head for the overall feeding cost and Rp. 24,000/head for by-products.

The value of livestock water is estimated to be Rp. 22,273/m^3. As the unit net value of additionally increasing cattle weight is estimated to be Rp. 180,000/head, the total net value can be expected to be Rp. 132.5 million by supplying stable livestock water being worth Rp. 245 million in total to 736 equivalent heads of cow fed by beneficiary breeding households.

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 consumables 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. 148.6 million. This increment benefit will accure from the first year when irrigation water can be released from the Fatukmetang 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 Fatukmetang 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 in developing the proposed Fatukmetang Embung because the economic benefit attributed to the Embung development is too small compared with the required capital cost as the availability of irrigable land resources is limited according to topographic condition resulting in the maximum extent of irrigation area up to 57 ha. Although the cattle feeding in Desa Jenilu can be stabilized by constant supply of livestock water to 736 equivalent heads of cow throughout the year, the investment efficiency is negative being 0.54 when the value of additionally increasing cattle weight is compared with the total value of livestock water. Also, the huge amount of investment in satisfaction of the pressing BHN in Desa Jenilu is required, being estimated to be Rp. 14 million for each of 700 beneficiary inhabitants.

(4) Farm budget analysis

With the implementation of Fatukmetang 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. 6,094,700/year under the "With Project" condition with the cropping intensity of 200% from no net income under the "Without Project" condition as shown in Table 8.5 and below. Such improvement of farm budget would give much incentive for farmers to make further investment in improvement of their living standard and also could increase their payment capacity enabling beneficiary farmers to pay irrigation water charge 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/Irrigated	-	-	100.0	1,097,875
Mungbean	Dry/Irrigated	-	-	50.0	491,585
Red onion	Dry/Irrigated	-	-	50.0	4,505,250
Fallow		100.0	0	-	-
Total		100.0	0	200.0	6,094,710

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 Fatukmetang Project area are summarized as below.

Environmental Features in the Fatukmetang Project Area

Item	Description
1. Human Environment	
Social intention	Lack of water sources and facilities for irrigation water and insufficient water sources for domestic and livestock use
Human use	Use of well water (shortage in the dry season) or spring
Economic activities	Shifting cultivation, livestock farming and fishery
Health and sanitation	Prevalence of waterborne intestinal diseases
2. Physical environment	
Geology/land	Basic rock complex of oldest age
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 Embung development in this Project area. At present, illegal shifting cultivation is practiced in the level land of the proposed reservoir area. Since these shifters live in the beneficiary area of this Project, they will be settled in the beneficiary area after completion of the Project.

(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 the Volume 4.

8.4 Contribution to Women in Development

With provision of permanent water source facilities, women and children of 156 families can be quite free from their daily hard job to carry their domestic water at the average distance of 200 m. As a result, women will be able to utilize the saved time for improving their activities in relation to not only agriculture and livestock but also small business. Since housewives in the Project area manage their family budgets, increasing farmer's income would encourage women in investing surplus in improvement and diversification of their economic activities.

9. CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

On the basis of categorization of 157 candidate schemes for the Study, the Fatukmetang Embung scheme is selected representing a typical sample scheme of which potential beneficiary area has no irrigation facility, shifting cultivation system and inhabitants' demand for irrigation, domestic and livestock water. The proposed Fatukmetang Embung site has physically irrigable land resources of 57 ha in net and the annual discharge of 1.4 MCM from its catchment area of 4.0 km^2. A total of 700 inhabitants projected for the year of 2008 needs additional water source facilities to solve their water shortage problem during the dry season. Breeding households with a total of 736 equivalent heads of cow projected for the year of 2008 need to solve livestock water shortage problem during the dry season.

The availability of irrigable land resources in the Project area is the determining factor in the optimization of development scale. To supply irrigation water to the available land to the maximum extent, the dam height of Fatukmetang Embung is set to be 19.0 m with the total and effective storage capacities of 0.92 and 0.84 MCM, respectively. Under such condition, it can be expected to practice irrigated cropping of the wet season paddy followed by irrigated cropping of high-valued Palawija crops for the dry season. It can be expected to meet increasing domestic water demand of 700 inhabitants and livestock water demand of 423 equivalent heads of cow in the beneficiary area.

The structural components are main dam, spillway and dam O&M road as well as irrigation and domestic water distribution systems. The homogeneous embankment dam is constructed with the crest length of 370 m, embankment volume of 460,000 m^3 and side-channel typed spillway having design flood discharge of 77 m^3/sec and overflow weir width of 13 m. The required investment cost amounts to Rp. 19.0 billion of which direct construction cost is estimated to be 10.4 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 availability of irrigable area. As the proposed Fatukmetang Embung requires a large embankment volume, the investment efficiency for domestic and livestock water source development is tremendously low. Therefore, such type of Embung is worthless implementing from the economic viewpoints.

9.2 Recommendations

If the development of this water source facility is required from the social viewpoint, it is recommended to assess the possibility of selling clean water to domestic trading ships arriving at Atapupu port located near the Project area for increasing the Project benefit.

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

Feasibility Study on Fatukmetang Embung Development Project

Tables

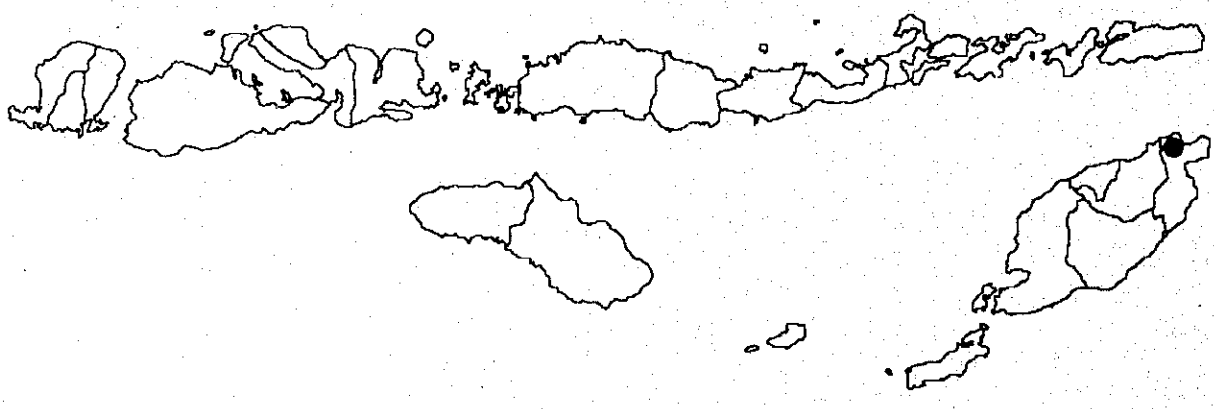


Table 1.1 Rainfall Record in Fatuoni

Station: Fatuoni
Elavation: 20
Island: Timor
Kabupaten: TTU
Latitude: 9.1167
Longitude: 124.78

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total	Max.
1977	545	263	294	129	58	0	0	0	0	0	50	163	1,502	55
1978	247	393	109	57	68	0	78	0	0	23	122	154	1,251	51
1979	162	171	256	0	112	21	0	0	0	0	88	247	1,057	72
1980	205	337	71	78	0	0	0	0	0	0	75	422	1,188	51
1981	474	414	208	205	0	0	0	0	0	0	199	200	1,700	52
1982	232	282	163	56	9	0	0	0	0	0	24	5	771	55
1983	93	108	73	204	0	0	0	0	0	114	156	70	818	60
1984	205	134	111	60	13	0	0	0	0	0	97	113	733	46
1985	251	450	150	7	10	0	0	0	0	34	38	88	1,028	111
1986	572	138	141	23	9	0	0	0	0	12	79	107	1,081	115
1987	452	275	116	0	0	0	0	0	0	0	114	295	1,252	50
1988	374	213	174	2	0	0	0	2	11	7	384	249	1,416	113
1989	183	146	210	79	14	10	6	7	11	93	38	123	920	89
1990	631	154	95	25	13	16	62	0	0	15	32	192	1,235	87
1991	385	421	146	172	-	-	2	0	0	0	203	136	******	-
1992	243	407	75	106	9	0	0	0	0	4	63	179	1,086	95
Mean	328	269	150	75	21	3	9	1	1	19	110	171	1,136	

Source : DPU NTT

Table 1.2 Climate in Pante Makassar

Station: Cusse-Pante Makassar
Island : Timor Timur
Kabupaten :

Latitude : 09 12 S
Longitude : 124 23 E
Elevation : 2 m

Description	Unit	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Average	Year
Average daily maximum temperature	C	30.1	29.7	29.8	29.9	31.1	30.3	30.1	29.5	29.7	30.1	30.7	30.6	30.1	1964 - 1973
Average daily minimum temperature	C	23.8	23.7	23.4	22.7	22.9	21.8	21.5	21.7	21.5	22.5	23.8	24.4	22.8	1964 - 1973
Mean daily temperature	C	27.0	26.7	26.6	26.3	27.0	26.1	25.8	25.6	25.6	26.3	27.3	27.5	26.5	1964 - 1973
Mean daily relative humidity	%	80.0	83.0	82.0	75.0	72.0	68.0	66.0	69.0	71.0	73.0	75.0	78.0	74.3	1964 - 1973
Mean daily wind run over 24 hours	km/day	86.0	82.0	65.0	70.0	101.0	115.0	146.0	101.0	86.0	62.0	70.0	60.0	87.0	1964 - 1973
Wind speed at time of observation	m/s	1.0	1.0	0.8	0.8	1.2	1.3	1.7	1.2	1.0	0.7	0.8	0.7	1.0	1964 - 1973
Mean daily observed bright sunshine	hr/month	171.0	150.0	183.0	264.0	260.0	252.0	276.0	288.0	240.0	285.0	252.0	226.0	2,847.0	1964 - 1973
Mean daily observed bright sunshine	hr/day	5.5	5.0	5.9	8.8	8.4	8.4	8.9	9.3	8.0	9.2	8.4	7.3	7.8	1964 - 1973
Mean daily maximum possible sunshine	hr/day	12.6	12.5	12.2	11.9	11.7	11.6	11.6	11.8	12.1	12.3	12.6	12.7	12.1	1964 - 1973
Mean Solar Radiation	mm/day	16.2	16.2	15.8	14.5	13.2	12.5	12.8	13.8	15.0	16.0	16.1	16.3	14.9	1964 - 1973

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

Table 1.3 Typical Soil Profile in the Fatukmetang Project Area

Profile No.:	3
Soil Classification:	Fluventic Ustropepts
Physiography:	Alluvial fan
Topography:	Slightly undulating (2 - 4 %)
Land Use/Vegetation:	Shrubs
Parent material:	Mixed alluvium (sand and breccia)
Drainage:	Well
Groundwater Table:	> 4 m
Permeability:	Rapid (15.6 cm/hr)
Land Morphology:	

Horizon	Depth (cm)	Description
Ap	0 - 12	Yellowish brown (2.5Y 5/3, dry); sandy loam; subangular blocky, weak, fine structure; non sticky, non plastic consistency; many messo and macro pores, few micropores, many root; few (< 2 %) stoniness; gradual, smooth horizon boundary
Bw	12 - 37	Dark brown (10YR 3/4, dry); sandy loam; single grain, weak, fine structure; friable, non sticky, non plastic consistency; few, medium stoniness; few micropores, common messo and macropores; gradual, smooth horizon boundary
2A	37 - 70	Olive brown (Y 4/3, dry); loam; single grain, weak structure; loose, non sticky, non plastic consistency; gradual, wavy horizon boundary
C	> 70	Fine sand; structureless

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 the Fatukmetang Project Area

Soil Pit	Layer	Texture			Permeability	pH	pH	Organic	Total N	Ava. P	CEC	Ex. Na	Ex. Ca	Ex. K	Ex. Mg	Base	EC
		Sand (%)	Silt (%)	Clay (%)	(cm/hr)	(H2O)	(KCl)	matter	(%)	(ppm)	(me/100g)	(me/100g)	(me/100g)	(me/100g)	(me/100g)	Saturation (%)	(mS/cm)
3	Ap	67.7	17.3	15.0	15.6	6.9	6.6	3.26	0.11	28.76	22.82	0.07	10.29	1.24	2.05	60	0.16
	Bw	70.9	13.0	16.1	18.3	7.0	6.7	1.61	0.07	24.64	20.48	0.10	8.86	0.65	1.97	57	0.06
	2A	76.4	30.5	22.1		6.9	6.6	0.64	0.04	17.13	14.45	0.07	7.71	0.53	1.72	69	0.04
5	Ap	35.9	51.1	13.0	4.8	7.1	6.6	3.28	0.12	2.64	26.39	0.59	11.82	1.28	2.89	63	0.32
	2A	12.0	77.7	10.3	3.2	7.4	6.3	0.41	0.12	3.69	13.24	0.13	7.59	0.71	1.25	73	0.12
	3A	33.9	53.1	13.0		7.5	6.9	1.09	0.06	3.15	22.41	0.22	12.57	0.29	2.72	71	0.12
7	Ap	81.8	7.2	11.0	35.0	6.9	6.6	2.75	0.11	3.78	17.37	0.16	8.55	0.40	0.62	56	0.16
	2A	83.2	5.8	11.0	40.0	7.1	5.6	1.58	0.07	2.64	13.59	0.26	7.71	0.14	0.40	63	0.08
	2C	85.5	4.1	10.4		7.6	5.4	0.41	0.04	1.95	13.07	0.29	4.99	0.20	0.15	43	0.10

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

Table 1.5 Soil Classification in the Fatukmetang Project Area

Land Unit	Description	Physiography	Topography	Potential Suitability			Area	
				Paddy	Soybean	Maize	(ha)	(%)
I	Typic Ustifluvents deep; coarse loamy; neutral; high CEC; moderate-rapid permeability; well drainage	Alluvial fan	Flat (0-2%)	S2	S2	S2	48	36%
II	Typic Ustarents deep; coarse loamy; neutral; high CEC; slightly rapid permeability; well-excessive drainage	Alluvial fan	Slightly undulating (2-4%)	S3	S2	S2	12	9%
III	Fluventic Ustropepts deep; coarse loamy; neutral; moderate CEC; rapid permeability; well drainage	Alluvial fan	Slightly undulating (2-4%)	S1	S2	S2	11	8%
IV	Typic Ustropepts deep; fine loamy; neutral; moderate CEC; moderate permeability; moderate-well drainage	Alluvial fan	Flat (0-2%)	S2	S2	S2	15	11%
V	Typic Haplustalfs deep; coarse loamy; neutral; moderate CEC; moderate permeability; low-moderate drainage	Alluvial fan	Flat (0-3%)	S1	S2	S2	5	4%
VI	Typic Ustipsamments deep; coarse loamy; neutral; moderate CEC; very rapid permeability; well drainage	Alluvial fan	Flat (0-3%)	S2	S3	S3	13	10%
#	Unclassified						29	22%
	Total						133	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 Fatukmetang 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 45	Male 28	Male 27	Male 34	Male 50	Male 55	Male 29	Male 24	Male 48	Male 52	Male 72	Male 72	Male 42	Male 29	Male 36	Male 43
2	No. of Family Member		M-2/F-3	M-1/F-3	M-2/F-3	M-1/F-4	M-0/F-2	M-3/F-1	M-2/F-2	M-0/F-3	M-1/F-3	M-1/F-1	M-0/F-2	M-1/F-1	M-1/F-1	M-1/F-2	M-1/F-2	M-1/F-2
3	Type of Side Job		Worker	Worker	None	Worker	Worker	Worker	Worker	Worker	Worker	None	None	None	Fisherman	Worker	Worker	
4	Own Farmland	ha	0.53	0.77	1.03	0.60	1.40	1.50	2.00	2.40	1.90	1.60	4.50	1.50	0.50	2.10	1.10	1.56
	Rented Farmland	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
	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	0.00	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
5	Cropped Area	ha	0.50	0.75	1.00	0.50	1.20	1.00	1.50	3.00	1.00	1.50	4.00	1.00	0.30	0.50	0.50	1.22
	(Paddy)	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
	(Palawija)	ha	0.50	0.75	1.00	0.50	1.20	1.00	1.50	3.00	1.00	1.50	4.00	1.00	0.30	0.50	0.50	1.22
	(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	0	2	0	2	2	2	3	2	0	4	4	5	0	0	0	2
	Horse	head	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Goat/Sheep	head	2	0	6	0	0	0	0	5	0	0	0	0	0	0	0	1
	Pig	head	4	9	0	0	0	0	0	1	6	6	4	4	4	3	3	3
	Chicken/Duck	head	9	1	5	6	2	4	2	0	0	0	0	0	0	0	4	2
7	Gross Income	Rp.'000/yr	545.0	397.5	477.5	700.0	685.0	950.0	1,410.0	1,300.0	850.0	1,655.0	1,280.0	3,575.0	775.0	725.0	650.0	1,065.0
	(Crop)	Rp.'000/yr	125.0	187.5	437.5	100.0	375.0	150.0	810.0	700.0	175.0	625.0	1,250.0	125.0	25.0	125.0	50.0	350.7
	(Livestock)	Rp.'000/yr	0.0	0.0	40.0	0.0	100.0	200.0	0.0	0.0	75.0	30.0	30.0	450.0	0.0	0.0	0.0	61.7
	(Side job)	Rp.'000/yr	420.0	210.0	0.0	600.0	210.0	600.0	600.0	600.0	600.0	1,000.0	0.0	3,000.0	750.0	600.0	600.0	652.7
	(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	0.00
8	Expenditure	Rp.'000/yr	561.3	497.5	349.5	633.2	425.2	577.3	1,128.1	1,279.9	807.8	1,341.5	966.2	2,338.5	851.4	712.3	737.7	880.5
	(Food/drink)	Rp.'000/yr	486.0	396.0	246.0	468.0	342.0	342.0	702.0	656.4	542.4	565.8	528.0	630.0	582.0	486.0	378.0	490.0
	(Living)	Rp.'000/yr	64.1	67.5	71.5	150.0	76.0	223.8	268.8	414.2	245.4	616.7	192.7	1,076.0	254.0	146.3	280.2	276.5
	(Education)	Rp.'000/yr	7.2	24.0	12.0	7.2	7.2	0.0	72.0	72.0	0.0	120.0	72.0	600.0	7.2	72.0	72.0	76.3
	(Production)	Rp.'000/yr	4.0	10.0	20.0	8.0	0.0	11.5	85.3	137.3	20.0	39.0	173.5	32.5	8.2	8.0	7.5	37.7
9	Surplus/Deficit	Rp.'000/yr	-16.3	-100.0	128.0	66.8	259.8	372.7	281.9	20.1	42.2	313.5	313.8	1,236.5	-76.4	12.7	-87.7	184.5
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-economy Survey

Table 2.1 Estimated Evapotranspiration in Fatukmetang Project

Site : Fatukmetang
Mteorological Station : Pante Mankasar

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean	C	27.00	26.70	26.60	26.30	27.00	26.10	25.80	25.60	25.60	26.30	27.30	27.50
RH mean	%	80.00	83.00	82.00	75.00	72.00	68.00	66.00	69.00	71.00	73.00	75.00	78.00
U km/day	km/day	86.00	82.00	65.00	70.00	101.00	115.00	146.00	101.00	86.00	62.00	70.00	60.00
ea	mbar	35.49	34.86	34.65	34.02	35.49	33.60	33.03	32.65	32.65	34.02	36.12	36.54
RH/100		0.80	0.83	0.82	0.75	0.72	0.68	0.66	0.69	0.71	0.73	0.75	0.78
ed	mbar	28.39	28.93	28.41	25.52	25.55	22.85	21.80	22.53	23.18	24.83	27.09	28.50
(ea-ed)	mbar	7.10	5.93	6.24	8.51	9.94	10.75	11.23	10.12	9.47	9.19	9.03	8.04
f(u)		0.50	0.49	0.45	0.46	0.54	0.58	0.66	0.54	0.50	0.44	0.46	0.43
(1-W)		0.24	0.24	0.25	0.25	0.24	0.25	0.25	0.26	0.26	0.25	0.24	0.24
(1-W)f(u)(ea-ed)	mm/day	0.86	0.71	0.68	0.97	1.30	1.56	1.89	1.40	1.21	1.00	0.99	0.82
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	5.50	5.00	5.90	8.80	8.40	8.40	8.90	9.30	8.00	9.20	8.40	7.30
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)		0.47	0.45	0.49	0.62	0.61	0.62	0.63	0.64	0.58	0.62	0.58	0.54
Rs	mm/day	7.68	7.36	7.65	8.84	7.83	7.38	7.86	8.69	8.63	9.92	9.45	8.71
Rns	mm/day	6.14	5.89	6.12	7.08	6.27	5.91	6.29	6.96	6.91	7.94	7.56	6.96
f(T)		16.10	16.02	16.02	15.94	16.10	15.90	15.85	15.80	15.80	15.94	16.14	16.18
f(ed)		0.10	0.10	0.10	0.11	0.11	0.13	0.13	0.13	0.12	0.12	0.11	0.10
f(n/N)		0.49	0.46	0.54	0.77	0.75	0.76	0.79	0.81	0.70	0.77	0.70	0.62
Rnl=f(T)f(ed)f(n/N)	mm/day	0.80	0.73	0.87	1.40	1.37	1.52	1.64	1.63	1.37	1.44	1.21	1.01
Rn =Rns-Rnl		5.34	5.15	5.25	5.68	4.89	4.39	4.65	5.33	5.53	6.50	6.35	5.96
W		0.76	0.76	0.76	0.75	0.76	0.75	0.75	0.75	0.75	0.75	0.76	0.76
W Rn		4.05	3.90	3.96	4.27	3.71	3.29	3.47	3.97	4.12	4.89	4.84	4.55
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	5.40	5.07	5.11	5.76	5.52	5.34	5.89	5.91	5.87	6.47	6.41	5.91

Suorce : JICA Study Team estimation by Modified Penman Method based on the meteorological data at the Pante Makasar station.

Table 2.2 Effective Rainfall in Fatukmetang Project

Site : Fatukumetang
Meteorological Station : Fatuoni

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	167	322	28.3%	259	182	138
February	142	264	23.2%	213	149	129
March	158	147	12.9%	118	83	86
April	173	74	6.5%	60	42	48
May	171	21	1.8%	17	12	13
June	160	3	0.3%	2	2	0
July	183	9	0.8%	7	5	0
August	183	1	0.1%	1	1	0
September	176	0	0.0%	0	0	0
October	201	19	1.7%	15	11	14
November	192	108	9.5%	87	61	70
December	183	168	14.8%	135	95	103
Total	2,089	1,136	100.0%	915	641	601

Note ;

[1] : Estimated by Modified Penman Method based on Pante Makassar station
[2] : Rainfall data in station compiled by DPU (1977-1992)
[3] : Percentage of monthly rainfall to annual rainfall, calculated from column [2]
[4] : 915 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 estimation based on the rainfall data at the Futuoni station

Table 2.3 Irrigation Water Requirement in Fatukmetang Project (1/3)

Site : Fatukmetang
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 (Etc)		mm/day	5.40	5.40	5.07	5.07	5.11	5.11	5.76	5.76	5.52	5.52	5.34	5.34	5.89	5.89	5.91	5.91	5.87	5.87	6.47	6.47	6.41	6.41	5.91	5.91	
		mm	81	86	71	71	77	82	86	86	83	88	80	80	88	94	89	95	88	88	97	104	96	96	89	95	2,090
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	89	95	75	75	73	0																			406
- WP-2		mm		95	78	75	80	78	0																		406
- WP-3		mm			78	78	80	86	82	0																	405
(3) Land preparation (IR)																											
- WP-1		mm																							200	213	413
- WP-2		mm	194																							213	407
- WP-3		mm	194	206																							400
(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	88	94	75	74	40	43	21	21	6	6	1	1	2	3	0	1	0	0	5	6	30	31	46	49	643
(7) Field water requirement																											
- WP-1		mm	31	83	28	79	63	0																	154	164	601
- WP-2		mm	106	33	81	29	120	67	0																	164	600
- WP-3		mm	106	112	31	82	70	125	91	0																	618
(8) Diversion requirement		mm	125	117	72	97	130	98	47	0															79	168	933
		m3/ha	1,250	1,170	720	970	1,300	980	470	0															790	1,680	9,330

Source : JICA Study Team estimate based on the meteorological data at the Cusse-Pante Makassar and the Futuoni station

Table 2.3 Irrigation Water Requirement in Fatukmetang Project (2/3)

Site : Fatukmetang
Crops : Palawija (1/2) : Mumbean and Red onion

Item		Month	Jan.		Feb.		Mar.		Apr.		May		Jun.		Jul		Aug.		Sep.		Oct.		Nov.		Dec.		Annual
		(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	5.40	5.40	5.07	5.07	5.11	5.11	5.76	5.76	5.52	5.52	5.34	5.34	5.89	5.89	5.91	5.91	5.87	5.87	6.47	6.47	6.41	6.41	5.91	5.91	
		mm	81	86	71	71	77	82	86	86	83	88	80	80	88	94	89	95	88	88	97	104	96	96	89	95	2,090
II. Palawija(1) : Mungbeans																											
(1) Proposed cropping pattern / Crop coefficient(Kc)									**Mungbeans**																		
- Pwj(1)-1									0.45		0.75	1.05	0.30														
- Pwj(1)-2											0.45	0.75	1.05	0.30													
- Pwj(1)-3												0.45	0.75	1.05	0.30												
(2) Crop consumptive use(Etc)																											
- Pwj(1)-1		mm								39	62	93	24														
- Pwj(1)-2		mm									37	66	84	24													
- Pwj(1)-3		mm										40	60	84	27												
(3) Effective rainfall (ER)		mm	67	71	65	64	42	44	24	24	6	7	0	0	0	0	0	0	0	0	7	7	35	35	50	53	601
(4) Field water requirement																											
- Pwj(1)-1		mm								15	56	86	24														181
- Pwj(1)-2		mm									31	59	84	24													199
- Pwj(1)-3		mm										33	60	84	27												203
(5) Diversion requirement		mm								10	58	118	112	72	18												389
		m3/ha								100	580	1,180	1,120	720	180												3,880
III. Palawija (2) : Red onion																											
(1) Proposed cropping pattern / Crop coefficient(Kc)									**Red onion**																		
- Pwj(2)-1									0.50	0.60	0.95	0.75															
- Pwj(2)-2										0.50	0.60	0.95	0.75														
- Pwj(2)-3											0.50	0.60	0.95	0.75													
(2) Crop consumptive use(Etc)																											
- Pwj(2)-1		mm								43	50	84	60														
- Pwj(2)-2		mm									41	53	76	60													
- Pwj(2)-3		mm										44	48	76	66												
(3) Effective rainfall (ER)		mm	67	71	65	64	42	44	24	24	6	7	0	0	0	0	0	0	0	0	7	7	35	35	50	53	601
(4) Field water requirement																											
- Pwj(2)-1		mm								19	44	77	60														200
- Pwj(2)-2		mm									35	46	76	60													218
- Pwj(2)-3		mm										37	48	76	66												228
(5) Diversion requirement		mm								13	53	107	123	91	44												430
		m3/ha								130	530	1,070	1,230	910	440												4,310

Source : JICA Study Team estimate based on the meteorological data at the Cusse-Pante Makassar and the Fatuoni station

Table 2.3 Irrigation Water Requirement in Fatukmetang Project (3/3)

Site : Fatukmetang
Crops : Palawija (2/2) : Mango

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	5.40	5.40	5.07	5.07	5.11	5.11	5.76	5.76	5.52	5.52	5.34	5.34	5.89	5.89	5.91	5.91	5.87	5.87	6.47	6.47	6.41	6.41	5.91	5.91	
	mm	81	86	71	71	77	82	86	86	83	88	80	80	88	94	89	95	88	88	97	104	96	96	89	95	2,090
II. Mango																										
(1) Proposed cropping pattern / Crop coefficient(Kc)																										
- Ma-1		0.9	0.90	0.90	0.90	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	
(2) Crop consumptive use(Etc)																										
- Ma-1	mm	73	78	64	64	65	69	73	73	70	75	68	68	75	80	75	80	75	75	82	88	82	82	75	80	
(3) Effective rainfall (ER)	mm	67	71	65	64	42	44	24	24	6	7	0	0	0	0	0	0	0	0	7	7	35	35	50	53	601
(4) Field water requirement																										0
- Ma-1	mm	6	7	0	0	23	25	49	49	64	68	68	68	75	80	75	80	75	75	75	81	47	47	25	27	1,192
																										0
(5) Diversion requirement	mm	10	11	0	0	39	42	82	82	107	113	113	113	125	134	126	134	125	125	126	135	78	78	42	46	1,987
	m3/ha	100	110	0	0	390	420	820	820	1,070	1,130	1,130	1,130	1,250	1,340	1,260	1,340	1,250	1,250	1,260	1,350	780	780	420	460	19,860

Source : JICA Study Team estimate based on the meteorological data at the Cusse-Pante Makassar and the Fatuoni station

Table 3.1 Estimated Catchment Rainfall in Fatukmetang Embung Site

Unit : mm

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	
1977	273	273	132	132	147	147	65	65	29	29	0	0	0	0	0	0	0	0	0	0	25	25	82	82	1,506
1978	124	124	197	197	55	55	29	29	34	34	0	0	39	39	0	0	0	0	12	12	61	61	77	77	1,256
1979	81	81	86	86	128	128	0	0	56	56	11	11	0	0	0	0	0	0	0	0	44	44	124	124	1,060
1980	103	103	169	169	36	36	39	39	0	0	0	0	0	0	0	0	0	0	0	0	38	38	211	211	1,192
1981	237	237	207	207	104	104	103	103	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100	1,702
1982	116	116	141	141	82	82	28	28	5	5	0	0	0	0	0	0	0	0	0	0	12	12	3	3	774
1983	47	47	54	54	37	37	102	102	0	0	0	0	0	0	0	0	0	0	57	57	78	78	35	35	820
1984	103	103	67	67	56	56	30	30	7	7	0	0	0	0	0	0	0	0	0	0	49	49	57	57	738
1985	126	126	225	225	75	75	4	4	5	5	0	0	0	0	0	0	0	0	17	17	19	19	44	44	1,030
1986	286	286	69	69	71	71	12	12	5	5	0	0	0	0	0	0	0	0	6	6	40	40	54	54	1,086
1987	226	226	138	138	58	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	57	148	148	1,254
1988	187	187	107	107	87	87	1	1	0	0	0	0	0	0	1	1	6	6	4	4	192	192	125	125	1,420
1989	92	92	73	73	105	105	40	40	7	7	5	5	3	3	4	4	6	6	47	47	19	19	62	62	926
1990	316	316	77	77	48	48	13	13	7	7	8	8	31	31	0	0	0	0	8	8	16	16	96	96	1,240
1991	193	193	211	211	73	73	86	86	0	0	0	0	1	1	0	0	0	0	0	0	102	102	68	68	1,468
Mean	167	167	130	130	77	77	37	37	10	10	2	2	5	5	0	0	1	1	10	10	57	57	86	86	1,165

Table 3.2 Estimated Discharge at Fatukmetang Embung Site

Unit : 1000 m3

	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	
1977	328	328	158	158	176	176	78	78	35	35	0	0	0	0	0	0	0	0	0	0	30	30	98	98	1,806
1978	149	149	236	236	66	66	35	35	41	41	0	0	47	47	0	0	0	0	0	0	73	73	92	92	1,478
1979	97	97	103	103	154	154	0	0	67	67	0	0	0	0	0	0	0	0	0	0	53	53	149	149	1,246
1980	124	124	203	203	43	43	47	47	0	0	0	0	0	0	0	0	0	0	0	0	46	46	253	253	1,432
1981	284	284	248	248	125	125	124	124	0	0	0	0	0	0	0	0	0	0	0	0	120	120	120	120	2,042
1982	139	139	169	169	98	98	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	880
1983	56	56	65	65	44	44	122	122	0	0	0	0	0	0	0	0	0	0	68	68	94	94	42	42	982
1984	124	124	80	80	67	67	36	36	0	0	0	0	0	0	0	0	0	0	0	0	59	59	68	68	868
1985	151	151	270	270	90	90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53	53	1,128
1986	343	343	83	83	85	85	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	65	65	1,248
1987	271	271	166	166	70	70	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68	68	178	178	1,506
1988	224	224	128	128	104	104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230	230	150	150	1,672
1989	110	110	88	88	126	126	48	48	0	0	0	0	0	0	0	0	0	0	56	56	0	0	74	74	1,004
1990	379	379	92	92	58	58	0	0	0	0	0	0	37	37	0	0	0	0	0	0	0	0	115	115	1,362
1991	232	232	253	253	88	88	103	103	0	0	0	0	0	0	0	0	0	0	0	0	122	122	82	82	1,760
Mean	201	201	156	156	93	93	42	42	10	10	0	0	6	6	0	0	0	0	8	8	63	63	103	103	1,361
	401		312		186		84		19		0		11		0		0		17		126		205		

Table 3.3 Probable Flood Discharge at Fatukmetang Embung Site

Characteristics of the catchment area								
Catchment Area	(km2)	4.00						
Eelevation at Dam Site (1)	(m)	30						
Maximum elevation in the catchment area (2)	(m)	400						
Height (3)=(2)-(1)	(h)	370						
Length of Catchment Area (L	(m)	3,000						
Flow velocity	W2 (km/hr)	20.51						
Time of concentration	T2 (hrs)	0.15						
Probable Flood Discherge								
Return Period	(years)	2	5	10	20	50	100	200
Rainfall	(mm/day)	69	93	109	124	146	162	180
Rainfall intensity within the time of concentration	(mm)	37	50	58	66	78	86	96
Probable Flood Discharge	(m3/s)	33	44	52	59	69	77	85
Specific Discharge	(m3/s/km2)	8	11	13	15	17	19	21

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 Fatukmetang Project

DESCRIPTION	UNIT	1 downstream of proposed embung	2 downstream of proposed embung	3	4	Max. Limit of B Class by GR. NO. 20/1990
I. PHYSICS						
1 Temperature	C	28.50	27.50			Normal water temperature
2 Dissolved solid matter	mg/liter	930.00	1024.00			1000
3 Electric Conductivety	umhos/cm	1264.00	1392.00			-
II. CHEMISTRY						
a. Unorganic chemistry						
1 Mercury	mg/liter	0.00	0.00			0.001
2 Ammonia	mg/liter	0.00	0.00			0.5
3 Aroenic	mg/liter	-	-			0.05
4 Barium	mg/liter	-	-			5
5 Ferro	mg/liter	0.00	0.00			1
6 Fluoride	mg/liter	1.08	1.19			1.5
7 Cadmium	mg/liter	0.00	0.00			0.005
8 Chloride	mg/liter	64.00	177.00			600
9 Chronium, valense-6	mg/liter	0.00	0.00			0.05
10 Manganese	mg/liter	0.00	0.00			0.5
11 Nitrate, N	mg/liter	0.00	0.00			10
12 Nitric, N	mg/liter	0.01	0.00			1
13 Dissolved Oxygen	mg/liter	4.00	3.40			*
14 pH	-	7.10	7.40			5-9
15 Selenium	mg/liter	-	-			0.01
16 Zinc	mg/liter	0.00	0.00			5
17 Cyanide	mg/liter	0.00	0.00			0.1
18 Sulphate	mg/liter	224.00	5.10			400
19 Sulfide, H2S	mg/liter	0.00	0.00			0.1
20 Copper	mg/liter	0.00	0.00			1
21 Lead	mg/liter	0.00	0.00			0.1
b. Organic Chemistry						
1 Aldrin and Dieldrin	mg/liter	0.00	0.00			0.017
2 Chlordane	mg/liter	0.00	0.00			0.003
3 DDT	mg/liter	0.00	0.00			0.042
4 Endrine	mg/liter	0.00	0.00			0.001
5 Fenol	mg/liter	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			0.056
9 Methoxychlor	mg/liter	-	-			0.035
10 Oil and Fat	mg/liter	0.00	0.00			Nil
11 Organofosphate and Carbomate	mg/liter	0.00	0.00			0.1
12 PCB	mg/liter	-	-			Nil
13 Senyawa atife biru (Sulfaktan)	mg/liter	0.00	0.00			0.5
14 Toxaphene	mg/liter	0.00	0.00			0.005
III MICRO BIOLOGY						
1 Coliform tinja	per 100 ml	88	150			2,000
2 Total Coliform	per 100 ml	88	150			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 Fatukmetang Project

Item	Amount (Rp. million)
I. Direct Construction Cost	
1.1 Preparatory Works	497
1.2 Embung Construction	
1) Main dam	5,529
2) Spillway	2,951
3) Diversion Tunnel	0
4) Seepage protection works	0
5) Miscellaneous	848
Sub-total of 1.2	9,328
1.3 Irrigation Facilities	187
1.4 Domestic Water Supply	284
1.5 Embung Operation and Maintenance Road	134
Sub-total of I.	10,430
II. Administration Cost	521
III. Engineering Services	1,564
Sub-total of I, II & III	12,516
IV. Physical Contingency	1,877
Sub-total of I, II, II, & IV	14,393
V. Contract Tax	1,387
VI. Land Acquisition Cost	52
Sub-total I, II, III, IV, V & VI	15,832
VII. Price Contingency	3,166
GRAND TOTAL	18,999

Table 7.2 Direct Construction Cost in Fatukmetang 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	40,600	16,240
2) Excavation, common	m3	3,500	40,600	142,100
, weathered rock	m3	7,500	121,900	914,250
, rock	m3	11,500	0	0
3) Embankment, impervious soil	m3	8,000	429,600	3,436,800
, filter	m3	12,000	30,800	369,600
, transition	m3	12,000	0	0
, random material	m3	6,000	0	0
4) Stone masonry	m3	80,000	0	0
5) Rip-rap protection	m3	15,000	25,800	387,000
1.2 Grouting	m	71,000	0	0
1.3 Other miscellaneous works				263,300
Sub-total of 1.				5,529,290
2. Spillway				
2.1 Earth works				
1) Clearing	m2	400	12,300	4,920
2) Excavation, common soil	m3	3,500	12,800	44,800
, weathered rock	m3	7,500	76,900	576,750
, rock	m3	11,500	38,400	441,600
3) Backfill	m3	5,200	8,400	43,680
2.2 Concrete works				
1) Concrete - A	m3	250,000	340	85,000
2) Concrete - B	m3	170,000	6,380	1,084,600
3) Reinforcement bar	ton	1,500,000	17	25,500
4) Form	m2	15,000	33,600	504,000
2.3 Other miscellaneous works	L.S			140,543
Sub-total of 2.				2,951,393
3. Miscellaneous & Others				848,068
Total - I.				9,328,750
II. Irrigation Facilities				
1. Canal works (including the rehabilitation works)				
1.1 Earth works				
1) Clearing	m2	400	10,200	4,080
2) Excavation	m3	5,000	1,800	9,000
3) Embankment	m3	6,300	2,300	14,490
1.2 Stone masonry	m3	80,000	1,300	104,000
Sub-total of 1.				131,570
2. Related structures				
2.1 Turnout	nos.	2,540,000		0
2.2 Syphon	nos.	5,500,000		0
2.3 Aqueduct		5,975,000		0
2.3 Cross drain	nos.	4,700,000	4	18,800
2.4 Irrigation division box	nos.	900,000	22	19,800
2.5 Division box for livestock		1,170,000		
Sub-total of 2.				38,600

Table 7.2 Direct Construction Cost in Fatukmetang Project (2/2)

Item	Unit	Unit Price Rp.	Quantity	Total 1000 Rp.
3. Miscellaneous & Others	L.S			17,017
Total - II				187,187
III. Domestic Water Supply				
1. Pipe line				
1.1 Earth works				
1) Clearing	m2	400	3,500	1,400
2) Excavation	m3	5,000	2,200	11,000
3) Backfill	m3	5,200	2,180	11,336
1.2 Pipe line setting works				
1) Dia 75 mm	m	13,300	3,930	52,269
2) Dia 150 mm	m	33,200		0
1.3 Pipe line related structures				
1) Check valve		624,000	2	1,248
2) Air valve		506,000	1	506
3) Drainage valve		1,036,000	2	2,072
Sub-total of 1.				79,831
2. Division Boxes				
1) Division box for inhabitants	nos.	6,990,000	22	153,780
2) Division box for livestock	nos.	1,130,000	22	24,860
Sub-total of 2.				178,640
3. Miscellaneous & Others	L.S			25,847
Total - III.				284,318
IV. Dam Operation and Maintenance Road				
1. Road Works				
1.1 Earth works				
1) Clearing	m2	400	19,600	7,840
2) Excavation	m3	5,000	2,800	14,000
3) Embankment	m3	6,300	8,400	52,920
4) Pavement (lime stone)	m3	15,000	2,800	42,000
2. Related structures				
2.1 Cross drain	nos.	4,700,000	1	4,700
3. Miscellaneous and others	L.S			12,146
Total - IV				133,606
GRAND TOTAL				9,933,861

Table 8.1 Economic Construction Costs and Annual Disburement Schedule

Fatukmetang Project (Unit : Rp. million)

Item	SCF	Total cost	1st year	2nd year	3rd year
1 Direct Construction Cost		6,804	177	2,983	3,644
1) Preparatory Works	0.71	353	177	176	0
2) Dam Construction					
- Main dam	0.71	3,926	0	1,963	1,963
- Spillway	0.71	2,095	0	629	1,466
- Diversion tunnel	0.71	0	0	0	0
- Seepage protection works	0.71	0	0	0	0
Sub-total		6,021	0	2,592	3,429
3) Irrigation Facilities	0.71	133	0	66	67
4) Domestic Water Supply System	0.71	202	0	101	101
5) Dam O & M Road	0.71	95	0	48	47
2 Administration Cost	0.90	469	12	206	251
3 Engincering Services	0.90	647	259	194	194
4 Physical Contingency		1,021	27	447	547
Total		8,941	475	3,830	4,636

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 NTT

Item		Unit	Flores & Sumba		West Timor	
			Financial Price *1	Economic Price *2	Financial Price *1	Economic Price *2
1 Farm Products						
Paddy *3		kg	325	392	325	389
Maize *3		kg	200	210	200	205
Mungbeans *3		kg	1,000	896	1,000	890
Soybeans *3		kg	900	637	900	632
Red onion *4		kg	1,500	694	1,500	689
Tobacco *5		kg	900	520	900	519
2 Seeds						
Paddy	Certified	kg	537	605	537	605
	Own	kg	-	325	-	325
Maize	Certified	kg	533	922	533	922
	Own	kg	-	297	-	297
Mungbeans	Certified	kg	1,170	1,383	1,170	1,383
	Own	kg	-	893	-	893
Soybeans	Certified	kg	810	617	810	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	424	350	429
TSP		kg	400	496	400	501
KCl		kg	400	426	400	431
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	2,000	1,500	2,000	1,500
Family labour		man-day	-	1,500	-	1,500
6 Draft Animal						
Hired		head-day	5,000	5,000	5,000	5,000
Own		head-day	-	5,000	-	5,000
7 Farm Machinery						
Tractor		ha	200,000	200,000	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

Fatukmetang Project

Item		Q'ty of Unit	Value (Rp.)	Without Project: Fallow Q'ty	Without Project: Fallow Am't (Rp.)	With Project: Paddy (Irrigated) Q'ty	With Project: Paddy (Irrigated) Am't (Rp.)	With Project: Mungbean (Irrigated) Q'ty	With Project: Mungbean (Irrigated) Am't (Rp.)	With Project: Red Onion (Irrigated) Q'ty	With Project: Red Onion (Irrigated) Am't (Rp.)
1 Gross Production Value											
Paddy		kg	389	0	0	4,000	1,556,000	0	0	0	0
Soybean		kg	632	0	0	0	0	0	0	0	0
Mungbean		kg	890	0	0	0	0	1,100	979,000	0	0
Red onion		kg	689	0	0	0	0	0	0	7,500	5,167,500
2 Production Cost											
Seed											
Paddy	Certified	kg	605	0	0	25	15,125	0	0	0	0
	Own	kg	325	0	0	0	0	0	0	0	0
Soybean	Certified	kg	617	0	0	0	0	0	0	0	0
	Own	kg	606	0	0	0	0	0	0	0	0
Mungbean	Certified	kg	1,383	0	0	0	0	10	13,830	0	0
	Own	kg	893	0	0	0	0	20	17,860	0	0
Red onion	Certified	kg	850	0	0	0	0	0	0	2,000	1,700,000
Fertiliser											
Urea		kg	429	0	0	200	85,800	50	21,450	300	128,700
TSP		kg	501	0	0	100	50,100	100	50,100	200	100,200
KCl		kg	431	0	0	50	21,550	50	21,550	100	43,100
Agro-chemicals											
Insecticide	Lquid	lit	10,000	0.0	0	2.0	20,000	2.0	20,000	10.0	100,000
	Powder	kg	3,000	0.0	0	0.0	0	0.0	0	0.0	0
Rodenticide		kg	5,500	0.0	0	2.0	11,000	1.0	5,500	3.0	16,500
Labor											
Family		md	1,500	0	0	172	258,000	80	120,000	151	226,500
Hired		md	1,500	0	0	13	19,500	0	0	99	148,500
Draft Animal											
Family		ad	5,000	0	0	20	100,000	10	50,000	20	100,000
Hired		ad	5,000	0	0	0	0	0	0	0	0
Tractor		ha	200,000	0	0	0	0	0	0	0	0
Total production cost					0		581,075		320,290		2,563,500
3 Net Production Value					0		974,925		658,710		2,604,000

Table 8.4 Economic Costs and Benefits Flow

Fatukmetang Project Unit : Million Rp.

Year	Cost				Benefit			Increment
	Capital	Replace	O&M	Total	Irrigation	Negative	Total	
1.	475	0	0	475	0	0	0	-475
2.	3,830	0	0	3,830	0	0	0	-3,830
3.	4,636	0	0	4,636	0	0	0	-4,636
4.	0	0	36	36	89	0	89	53
5.	0	0	36	36	104	0	104	68
6.	0	0	36	36	119	0	119	83
7.	0	0	36	36	134	0	134	98
8.	0	0	36	36	149	0	149	113
9.	0	0	36	36	149	0	149	113
10.	0	0	36	36	149	0	149	113
11.	0	0	36	36	149	0	149	113
12.	0	0	36	36	149	0	149	113
13.	0	0	36	36	149	0	149	113
14.	0	0	36	36	149	0	149	113
15.	0	0	36	36	149	0	149	113
16.	0	0	36	36	149	0	149	113
17.	0	0	36	36	149	0	149	113
18.	0	0	36	36	149	0	149	113
19.	0	0	36	36	149	0	149	113
20.	0	0	36	36	149	0	149	113
21.	0	0	36	36	149	0	149	113
22.	0	0	36	36	149	0	149	113
23.	0	0	36	36	149	0	149	113
24.	0	0	36	36	149	0	149	113
25.	0	0	36	36	149	0	149	113
26.	0	0	36	36	149	0	149	113
27.	0	0	36	36	149	0	149	113
28.	0	0	36	36	149	0	149	113

EIRR = #DIV/0! %

Table 8.5 Financial Crop Budget per Ha

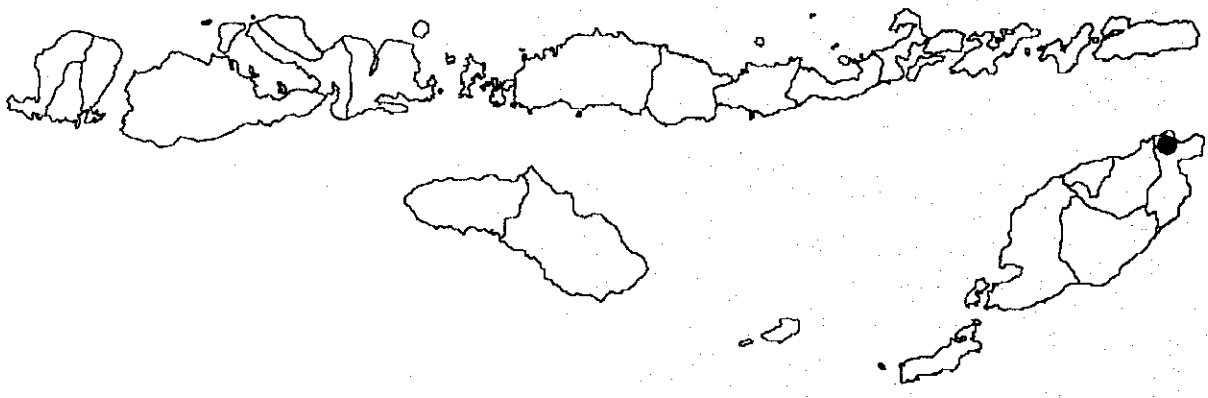
Fatukmetang Project

Item		Q'ty of Unit	Value (Rp.)	Without Project: Fallow Q'ty	Without Project: Fallow Am't (Rp.)	With Project: Paddy (Irrigated) Q'ty	With Project: Paddy (Irrigated) Am't (Rp.)	With Project: Mungbean (Irrigated) Q'ty	With Project: Mungbean (Irrigated) Am't (Rp.)	With Project: Red Onion (Irrigated) Q'ty	With Project: Red Onion (Irrigated) Am't (Rp.)
1 Gross Production Value											
Paddy		kg	325	0	0	4,000	1,300,000	0	0	0	0
Soybean		kg	900	0	0	0	0	0	0	0	0
Mungbean		kg	1,000	0	0	0	0	1,100	1,100,000	0	0
Red onion		kg	1,500	0	0	0	0	0	0	7,500	11,250,000
2 Production Cost											
Seed											
Paddy	Certified	kg	605	0	0	25	15,125	0	0	0	0
	Own	kg	0	0	0	0	0	0	0	0	0
Soybean	Certified	kg	617	0	0	0	0	0	0	0	0
	Own	kg	0	0	0	0	0	0	0	0	0
Mungbean	Certified	kg	1,383	0	0	0	0	10	13,830	0	0
	Own	kg	0	0	0	0	0	20	0	0	0
Red onion	Certified	kg	850	0	0	0	0	0	0	2,000	1,700,000
Fertiliser											
Urea		kg	350	0	0	200	70,000	50	17,500	300	105,000
TSP		kg	400	0	0	100	40,000	100	40,000	200	80,000
KCl		kg	400	0	0	50	20,000	50	20,000	100	40,000
Agro-chemicals											
Insecticide	Lquid	lit	10,000	0.0	0	2.0	20,000	2.0	20,000	10.0	100,000
	Powder	kg	3,000	0.0	0	0.0	0	0.0	0	0.0	0
Rodenticide		kg	5,500	0.0	0	2.0	11,000	1.0	5,500	3.0	16,500
Labor											
Family		md	0	0	0	172	0	80	0	151	0
Hired		md	2,000	0	0	13	26,000	0	0	99	198,000
Draft Animal											
Family		ad	0	0	0	20	0	10	0	20	0
Hired		ad	5,000	0	0	0	0	0	0	0	0
Tractor		ha	200,000	0	0	0	0	0	0	0	0
Total production cost					0		202,125		116,830		2,239,500
3 Net Production Value					0		1,097,875		983,170		9,010,500

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

Feasibility Study on Fatukmetang Embung Development Project

Figures



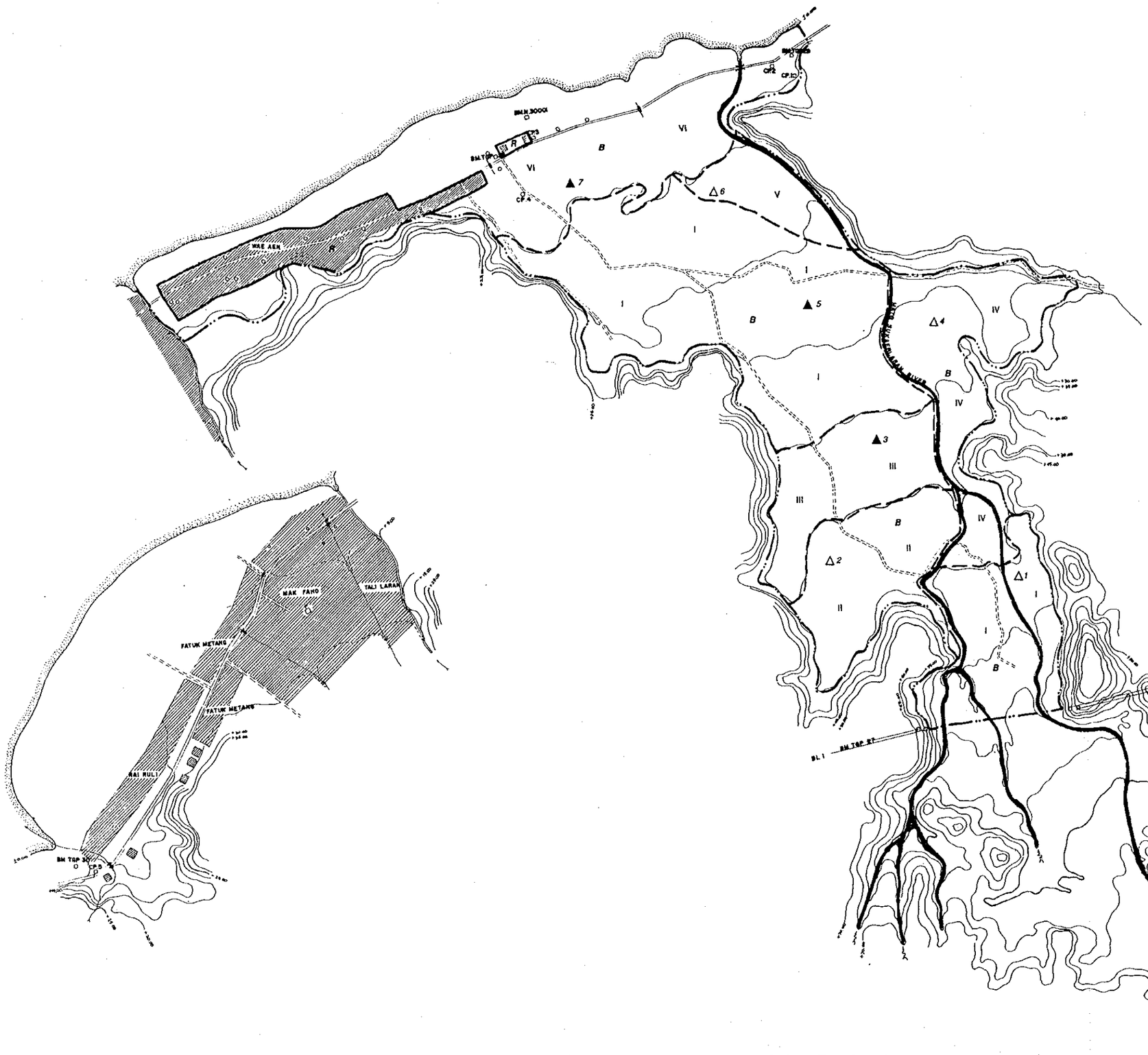


Figure 1.1 Present Land Use and Soils (Fatukmetang)

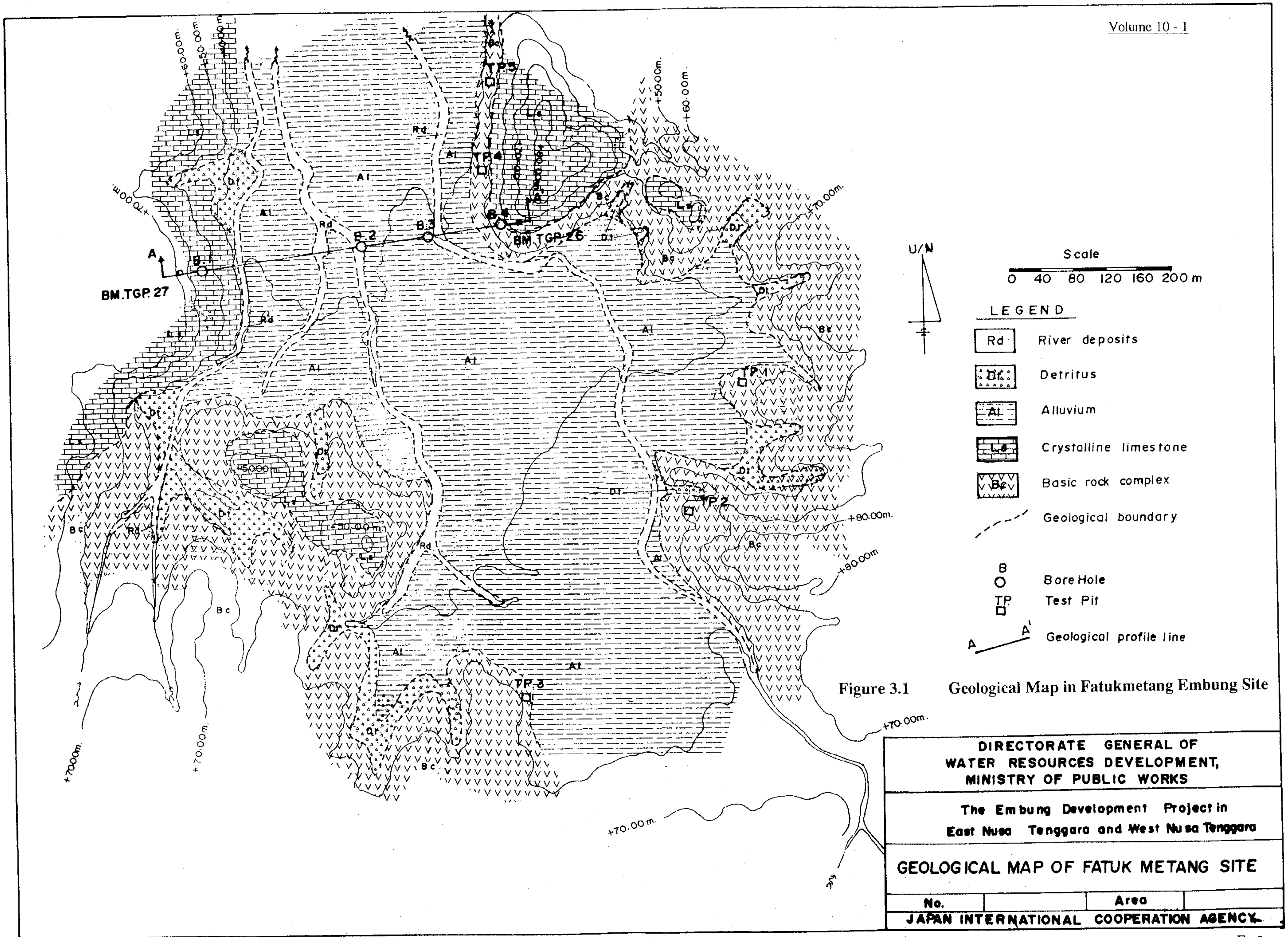


Figure 3.1 Geological Map in Fatukmetang Embung Site

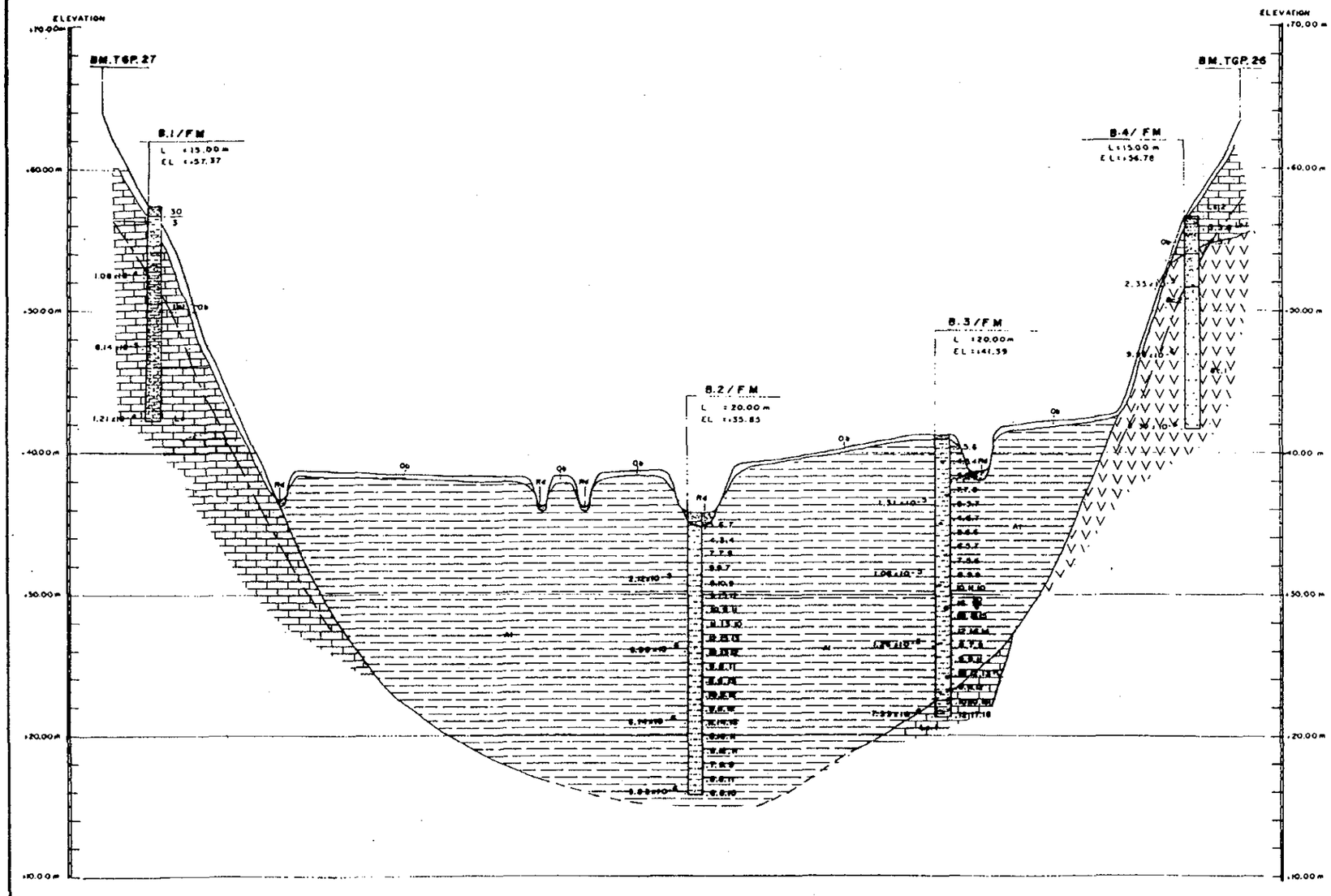
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT, MINISTRY OF PUBLIC WORKS

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

GEOLOGICAL MAP OF FATUK METANG SITE

No. | Area

JAPAN INTERNATIONAL COOPERATION AGENCY



DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT, MINISTRY OF PUBLIC WORKS

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

GEOLOGICAL PROFILE OF FATUK METANG

No. | Area

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.2 Geological Profile in Fatukmetang Embung Site

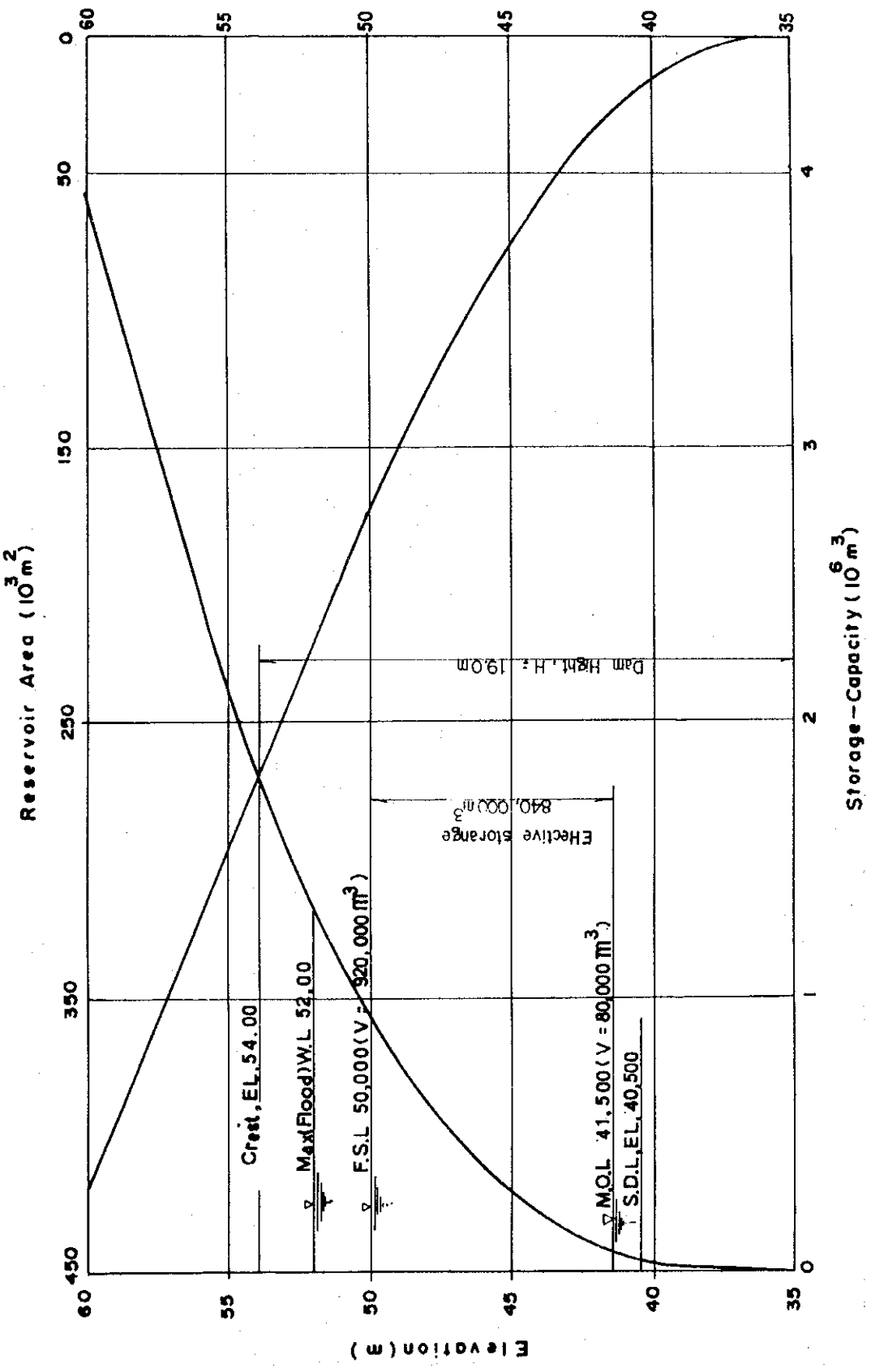


Figure 4.1 Reservoir Storage Curve in Fatukmetang Embung

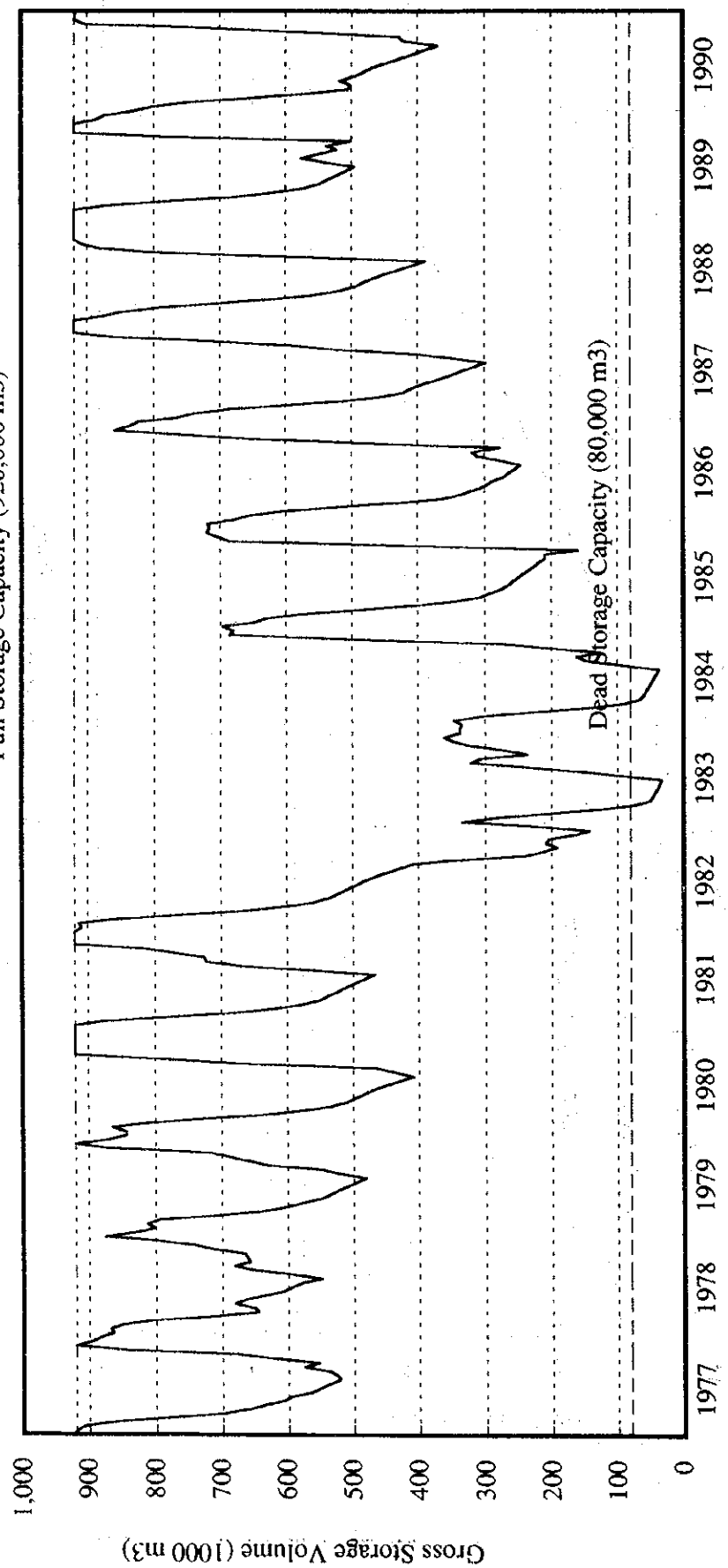
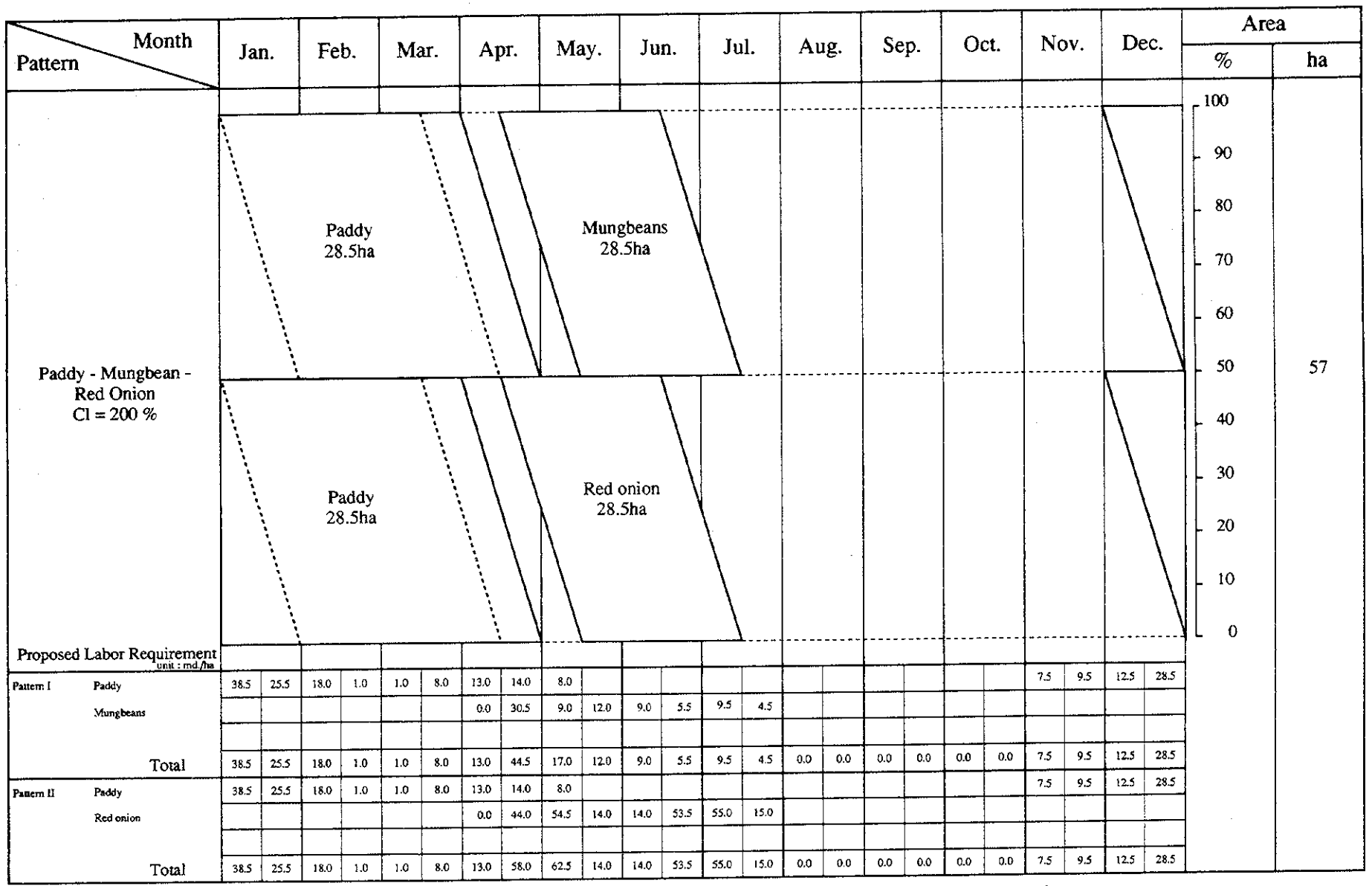


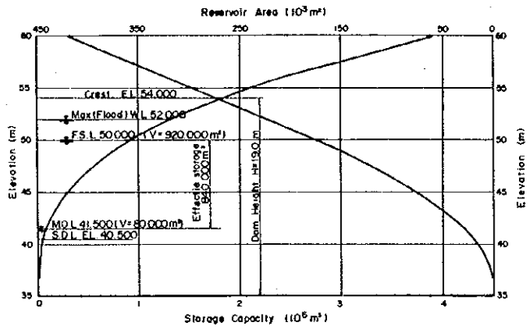
Figure 4.2 Result of Reservoir Operation in Fatukmetang Embung



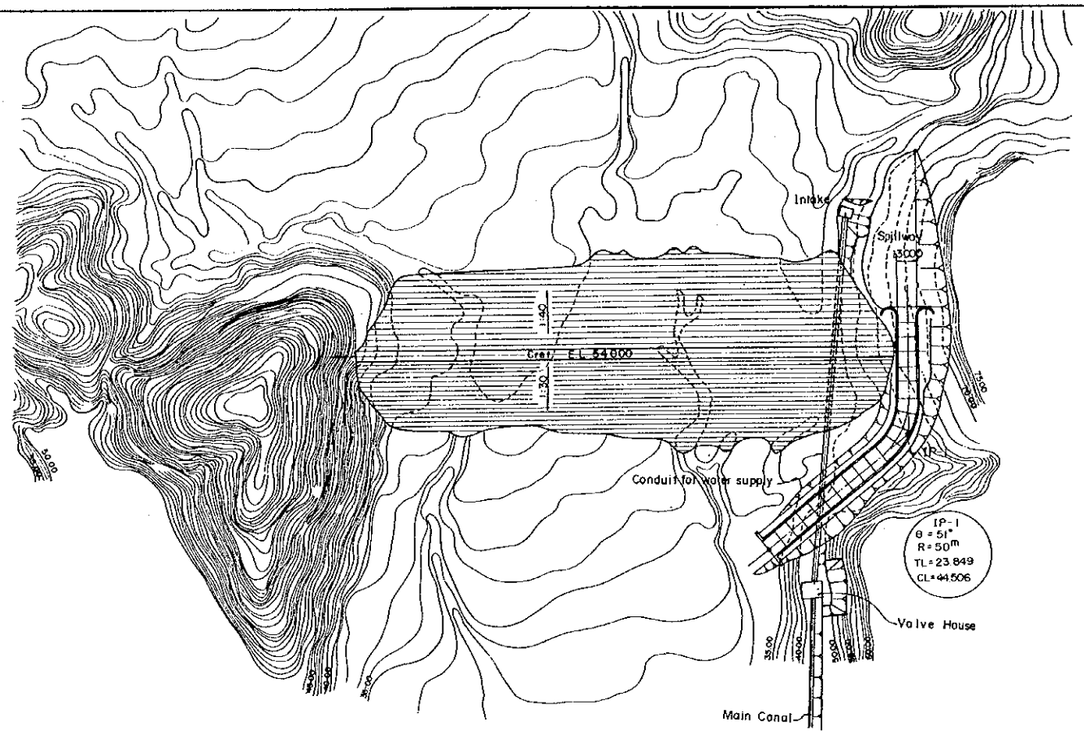
Proposed Labor Requirement
unit : md./ha

Pattern I	Paddy	38.5	25.5	18.0	1.0	1.0	8.0	13.0	14.0	8.0												7.5	9.5	12.5	28.5
	Mungbeans							0.0	30.5	9.0	12.0	9.0	5.5	9.5	4.5										
	Total	38.5	25.5	18.0	1.0	1.0	8.0	13.0	44.5	17.0	12.0	9.0	5.5	9.5	4.5	0.0	0.0	0.0	0.0	0.0	0.0	7.5	9.5	12.5	28.5
Pattern II	Paddy	38.5	25.5	18.0	1.0	1.0	8.0	13.0	14.0	8.0												7.5	9.5	12.5	28.5
	Red onion							0.0	44.0	54.5	14.0	14.0	53.5	55.0	15.0										
	Total	38.5	25.5	18.0	1.0	1.0	8.0	13.0	58.0	62.5	14.0	14.0	53.5	55.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	9.5	12.5	28.5

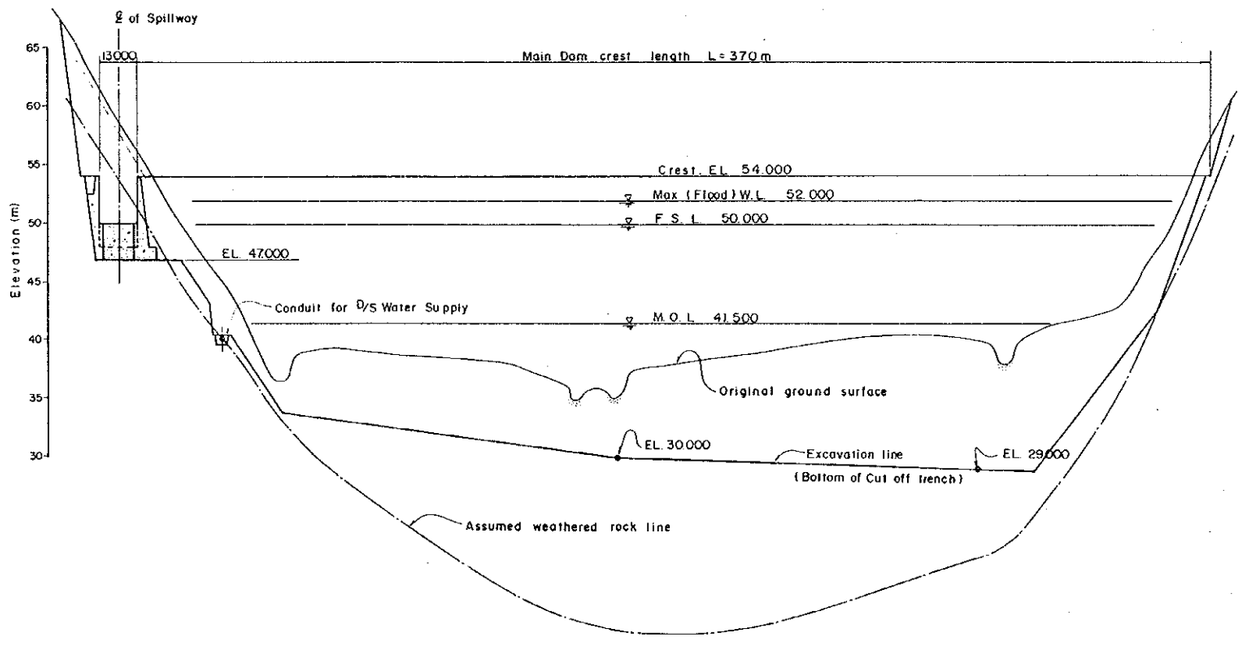
Figure 4.3 Proposed Cropping Pattern for Fatukmetang Project



RESERVOIR STORAGE CAPACITY CURVE FATUKMETANG

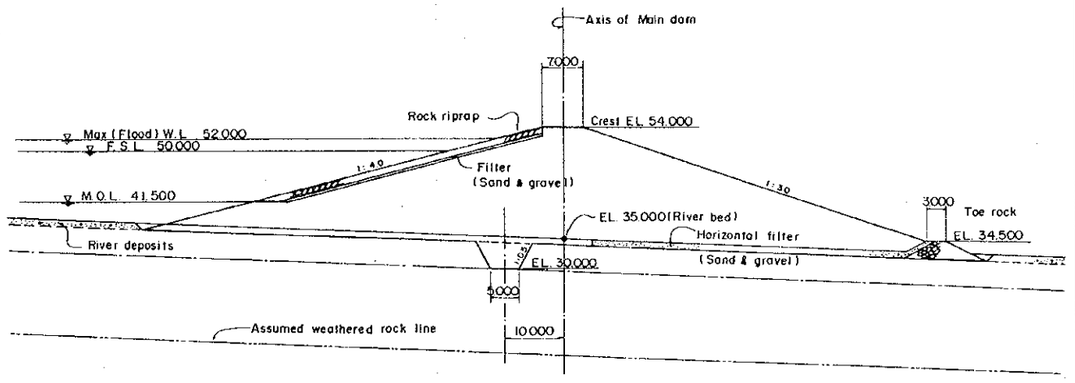


PLAN Scale A



PROFILE OF MAIN DAM

Scale H = 1 : 1000
V = 1 : 250



MAXIMUM CROSS SECTION OF MAIN DAM

Scale B

Scale A 0 50 100 150 200m

Scale B 0 10 20 30 40 50m

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 FATUKMETANG EMBUNG	
No.	Area
JAPAN INTERNATIONAL COOPERATION AGENCY	

Figure 4.4 General Plan of Fatukmetang Embung

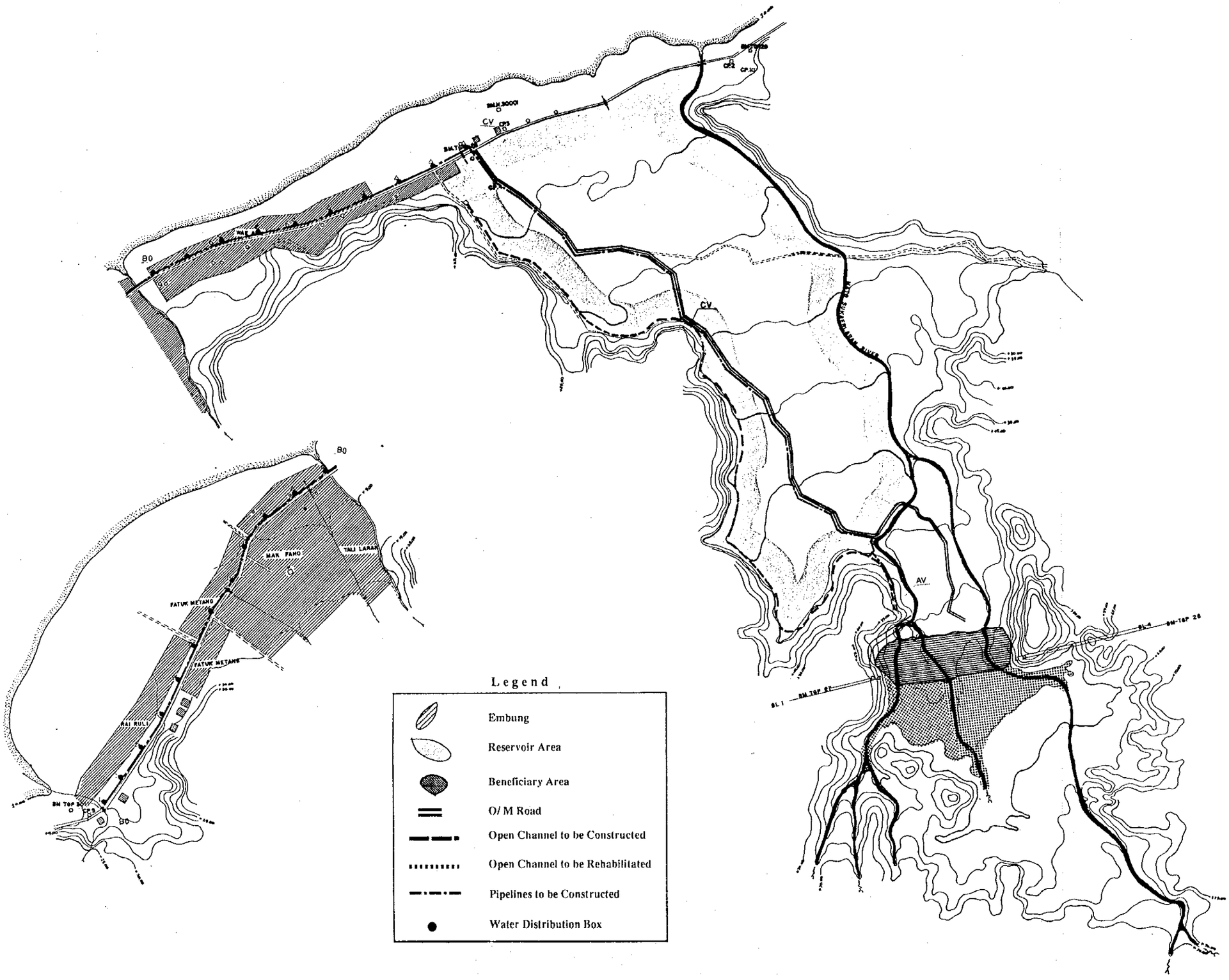


Figure 5.1 Genelal Layout of Fatukmetang Project

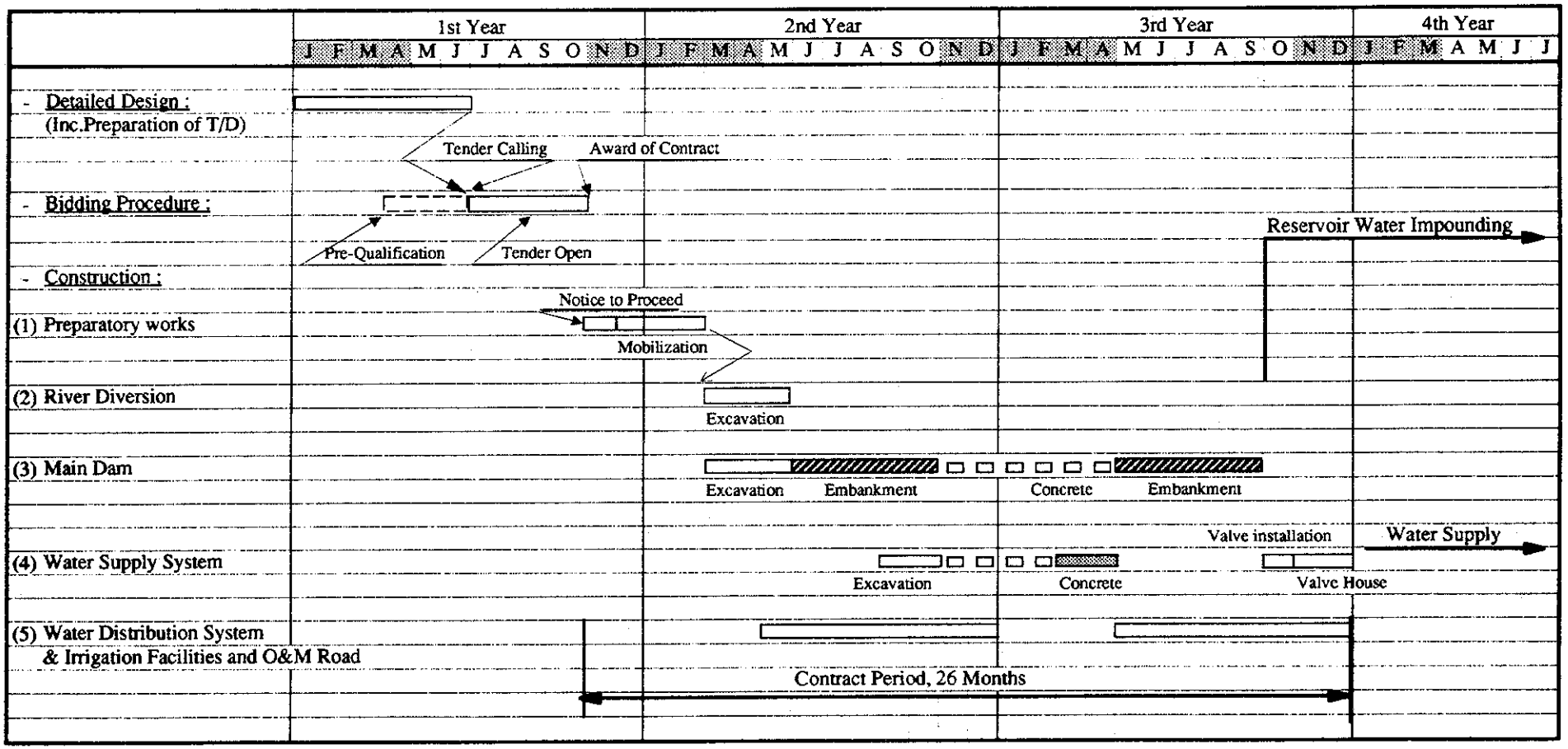


Figure 6.1 Construction Time Schedule for Fatukmetang Project

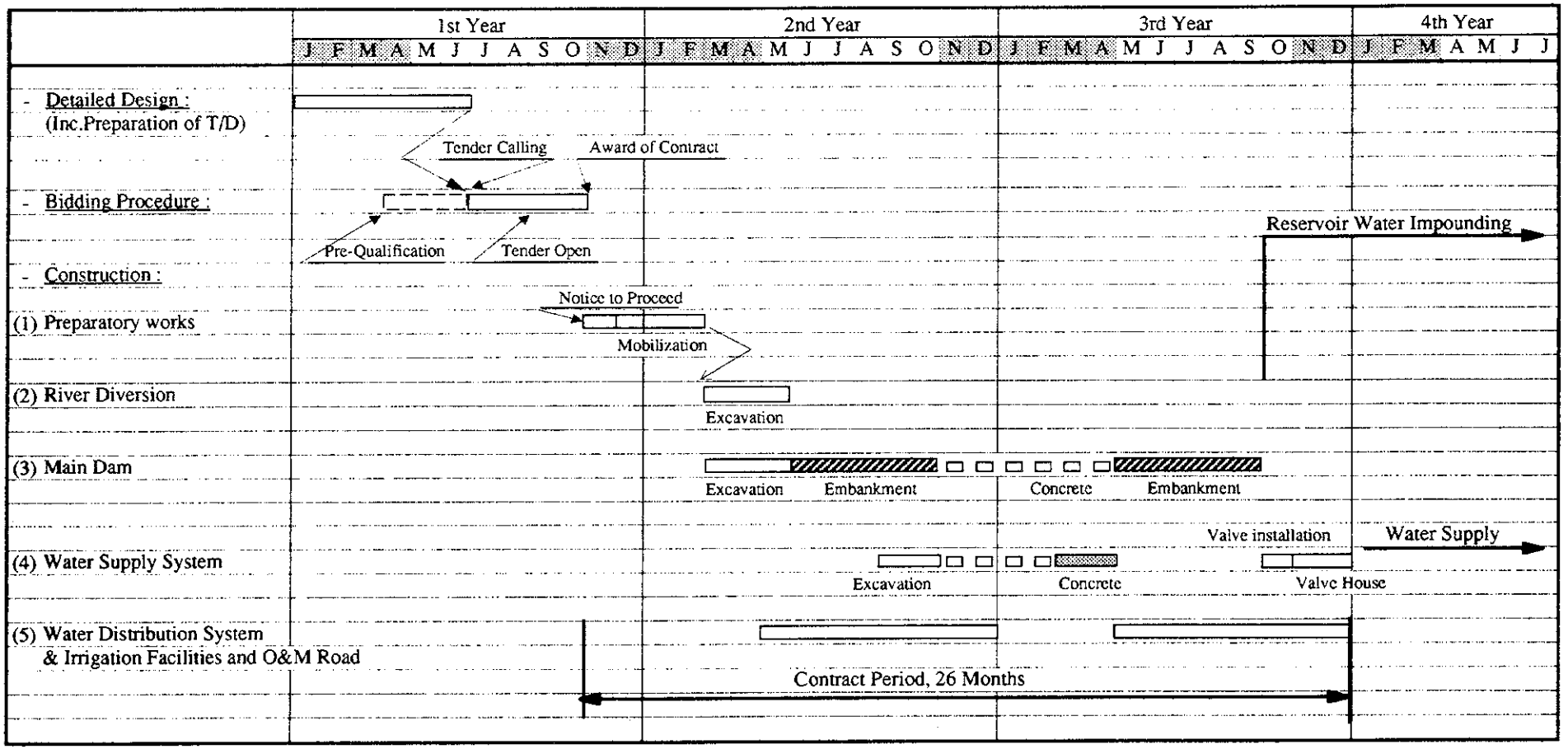


Figure 6.1 Construction Time Schedule for Fatukmetang Project

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

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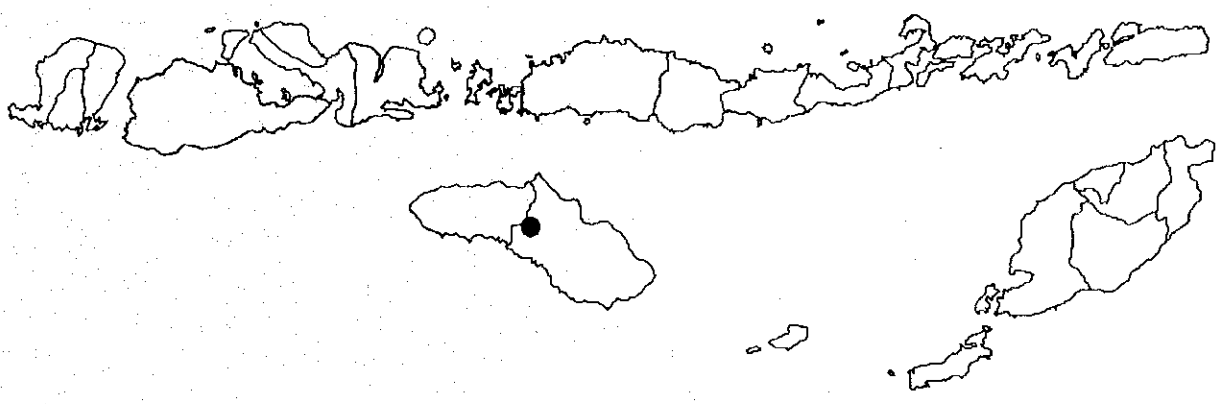
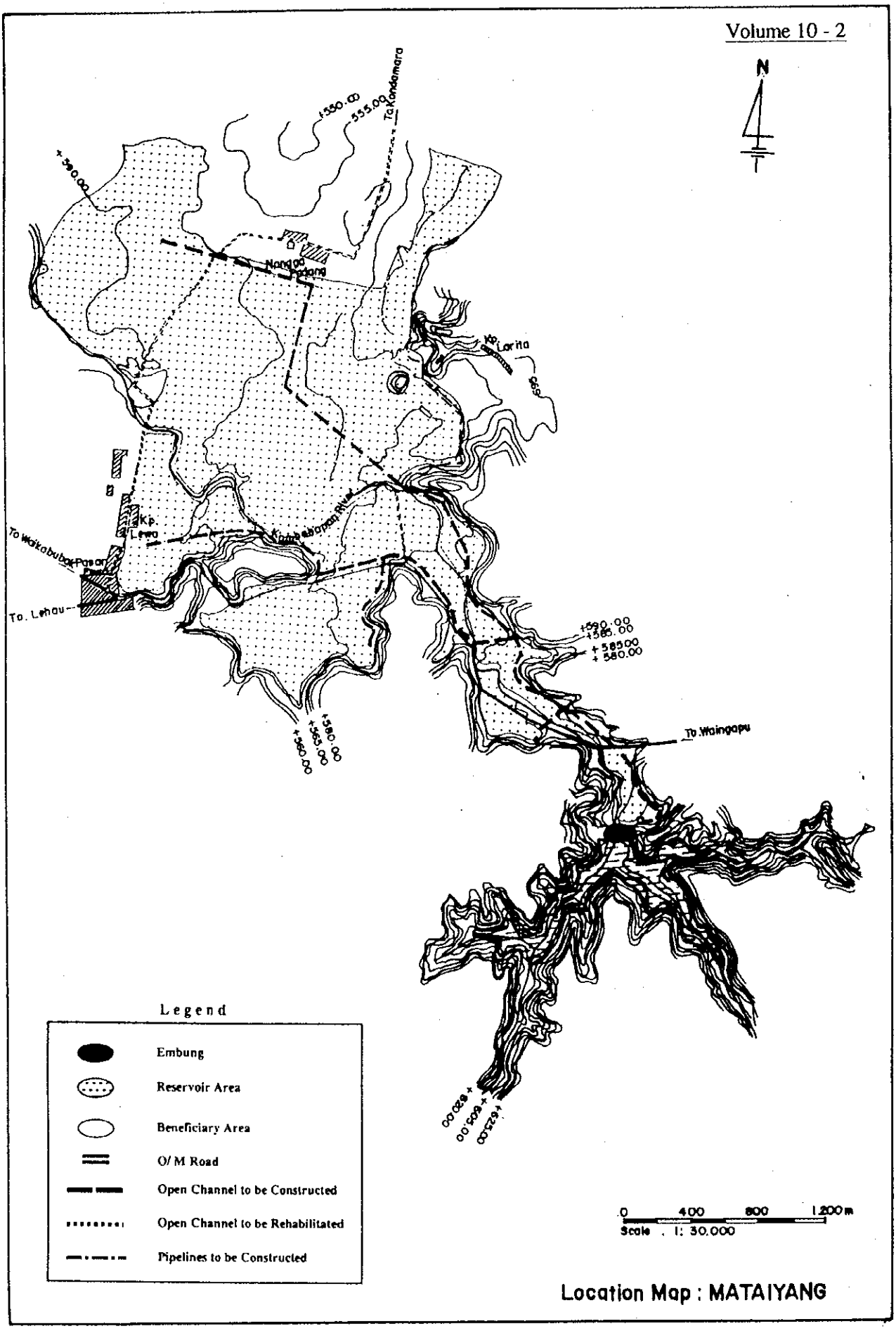
Feasibility Study
on
Mataiyang Embung Development Project



May 1995

Nippon Koei Co., Ltd.



Location Map : MATAIYANG

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 10-2

FEASIBILITY STUDY
ON
MATAIYANG 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 Lewa/Paku Village of Kabupaten Sumba Timur on Sumba Island of Nusa Tenggara Timur (NTT) about 60 km west from Waingapu.

Topographical condition of the catchment area is rather steep slope in the mountainous zone, while the reservoir area and the downstream area are flat. The paddy field is therefore developed in beneficiary area situated in the downstream from the proposed Embung site.

1.2 Climate and Hydrology

There is only one climate station in Sumba Island, at Waingapu on the north coast of the eastern Sumba. As for the rainfall station the Mataiyang rainfall station is the nearest station but observation period is not less than ten years. There are some rainfall stations of Waikabubak, Waibakul, Waitabula, and Waingapu. The wet season usually starts from October and ends May in the Project area with the average annual rainfall of 2,420 mm in the Waikabubak station. Mean annual temperature is 26.4 °C with the average maximum temperature of 31.7 °C and the average minimum temperature of 20.9 °C. Mean relative humidity is 75.3 %. Average sunshine hours are 4 to 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 5.0 km/hr. Table 1.1 and Table 1.2 show monthly rainfall record at the Waikabubak station and climate data at the Waingapu station.

The L. Laimoh rises in the hilly area where the altitude is approximately 500 m and follows a northwesterly course and it turns northward and discharges into the Sumba Sea. The surface of the catchment area is mostly covered with forest. The catchment area at the Embung site is 19.1 km^2. There is no gauging station on this river.

1.3 Geology

The proposed Embung site is mainly underlain by limestone of the Tertiary age, named as Waikabubak Formation. A spring from cave of limestone exists near the proposed Embung site. Some caves in limestone are distributed in the reservoir area. The geological formation is: limestone with lenses of limy silt stone belonged to the Waikabubak Formation; marl exposed at limited area in the reservoir with yellowish white color; terrace deposits composed of sandy silt with gravel and distributed in limited area; 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 and gravel and distributed along the limited existing river bed.

1.4 Soils and Land Use

The Project area of Mataiyang extends on the wide and flat hilly plain surrounded by rolling hills. The average land slope of the plain is less than 1%. This area is one of the biggest paddy field zone on Sumba island.

Parent material of soils in the Project area is calcareous rocks. Soil drainage on farmland is poor to moderate and permeability of water is very slow to moderate. Soil depth is very deep recording more than 80 cm. Soil texture of surface soil is clay to clay loam.

The results of the soil survey are shown in Table 1.3 on a typical soil profile out of 13 soil test pits, Table 1.4 on soil laboratory tests for soil samples taken from three representative pits out of 13 pits and Table 1.5 on the soil classification.

Most of the plain land is covered by the wet paddy field amounting to 530 ha. Some parts of the wet paddy field are used as grassland, although the field is surrounded by bund as a common paddy field. The relatively higher and flat land in the north is used as unirrigated upland field covering 100 ha.

There is an intake weir to irrigate 63 ha of the wet paddy field. The water source is a spring located at the proposed Embung site, and the intake weir is constructed at 1.5-km downstream from the spring by local people. The water from the spring runs throughout a year. The remaining 467 ha of the paddy field are still under the rainfed condition.

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

Present Land Use on the Project Area of Mataiyang

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	63	467		530
Upland	0	100		100
Tree crops	0	0		0
Bush/Scrub/Grassland			103	103
Residential			24	24
Cemetery			0	0
Others			0	0
Total	63	567	127	757

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 revealed by a total population of 876 and a total number of households of 206 as shown below. All of them are engaged in agriculture. The average family size is 4.3 persons. Dominant ethnic is original Somberness and the majority of inhabitants embrace Christian 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.)
Lewa / Paku	Mattel	538	132	4.1	132
	Ampere	338	74	3.5	74
Total		876	206	4.3	206

Source : JICA Water Use Survey

1.6 Domestic Water Use

The available water source are perennial springs for supplying domestic water and rivers flowing from these springs for providing livestock water in the Project area. The present water use in each sub village clarified under the Study is summarized below.

- In Mattel Sub-Village, all the inhabitants carry their drinking water from Kamba Hapang spring at the average distance of 1,500 m and further get drinking water from a public water basin 100 m away and livestock water from the Kamba Hapang river 1,500 m away; and

- In Ampere Sub-Village, people get their drinking water from Waikadambung spring and livestock water from the Waikadambung river both 1,500 m away from the village.

In addition to these inhabitants in the Project area, nearly 3,200 people living in the town of Lewa are provided with their domestic water through the existing pipeline system from these springs.

1.7 Social Infrastructures

The access from Waingapu, the capital of Kabupaten Sumba Timur in NTT, to the Project area is the trans-Sumba road paved but narrow. The proposed Embung site is linked by a foot path from the trans-Timor road. The existing rural electrification network has not reached yet to the Project area.

Inhabitants are generally using a public bathing with toilet and washing facilities for defecating purposes. There are an auxiliary hospital and an integrated health service center 4 km away from 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 - Fallow	437.0	437.0	82.9	100
(3) Upland crop - Fallow	90.0	90.0	17.1	100
Total / Average	527.0	527.0	100.0	100

Source : The JICA Land Use Survey and Inventory Survey

(2) Farming practice and farm inputs

Single cropping of the wet season paddy is common both on irrigated and rainfed paddy field. Maize is grown on the upland field for the wet season.

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 IR64 and Pelita are grown. Local rice varieties are also planted to a limited extent. 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 method of upland crop is simple. 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	Maize
Farm Inputs			
Seed	kg/ha	50	25
Fertilizer			
Urea	kg/ha	300	50
TPS	kg/ha	100	0
KCl	kg/ha	50	0
Agro-chemicals	lit/ha	-	-
Labor Requirements			
Nursery	md/ha	4	-
Land preparation	md/ha	2	3
	ad/ha	5	-
Planting	md/ha	3	3
Transplanting	md/ha	15	-
Weeding	md/ha	10	3
Pest & disease control	md/ha	2	1
Farm management	md/ha	2	2
Harvesting	md/ha	15	12
Transportation	md/ha	5	6
Others	md/ha	4	2
Total	md/ha	62	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	57	2.20	125
Rainfed			
Wet season paddy	380	1.50	570
Upland Field			
Maize	90	0.80	72

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, buffaloes and horses play important roles in land preparation and transportation as draft power. 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
775	200	76	52	218	125	700

Source: The JICA Water Use Survey

1.9 Irrigation Facilities

In the Project area, there exist paddy field of 500 ha in gross on the both banks of the Kambahapang river. Water source of this river is a spring situated nearby the proposed Embung site. The existing paddy field is almost rainfed except some field on the left bank of the river is irrigated by the existing weir situated at around 1.2-km downstream of the proposed Embung site. This weir is functioning well. Irrigation water taken by this weir is led by the existing canal to the paddy field in the Project area during only the wet season. This canal is earth-lined.

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 (PKK). No farmers benefited by the existing irrigation scheme have yet established Water Users' Association (P3A/HIPPA) 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 (PPS) assigned to a district center for agricultural extension (WKBPP). 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/BRI) both handling "Credit for Farmer (KUT)".

Flores-Sumba Water Resources Development and Conservation Project Office (PPKSA Flores-Sumba) under the NTT Provincial Public Service (DPUP) is responsible for new water resource development and watershed management. New development of irrigation system is the responsibility of Timor-Sumba Irrigation Project Office (PITS), while operation and maintenance 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. 1.54

million and Rp. 1.22 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 projected 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 876 persons as at 1993 to 966 persons in 1998, 1,056 persons in 2003, 1,142 persons in 2008, 1,220 persons in 2013 and 1,292 persons in 2018. Those who live in Lewa town and depend their domestic water source on the same spring of the Project area will increase from 3,189 persons as at 1993 to 3,517 persons in 1998, 3,845 persons in 2003, 4,158 persons in 2008, 4,442 persons in 2013 and 4,704 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 and livestock water sources are located in very far places from their houses 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 shorten the distance of water carriage averaging 1,500 m.

(3) Economic development needs

All of 206 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 to 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 living in the town area of Lewa intend to use more domestic water.

(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 weirs established on the L.Laimoh river are of very simple structures and some are left under deteriorated condition. Such limited use of surface runoff has acted as the barrier to promote intensification of agriculture. Thus, no more utilization of the L.Laimoh river can be expected unless countermeasures to regulate the wet season runoff are practiced. A pressured pipeline has been installed from the proposed Embung site in order to convey spring water to Lewa town.

2.2 Development Concepts and Approach

(1) Development concepts

The existing gap of economic status between NTT 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 improve the existing primitive irrigation system and to maintain domestic water supply system to the Lewa town area.

(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 L. Laimoh 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 Mataiyang 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

The transformation of the agricultural land use is not expected to be drastic by constructing the proposed Embung. Some mixed paddy fields with grassland would be changed to the complete paddy field with irrigation water supply. Most of the existing paddy field could be irrigated by the proposed Embung from the viewpoint of the topographical condition, covering as much as 437 ha.

Rainfed paddy field	->	Irrigated paddy field	437 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 Mataiyang

Unit: ha

Land Use	Irrigated	Rainfed	Others	Total
Paddy field	63	467		530
Upland	0	100		100
Tree crops	0	0		0
Bush/Scrub/Grassland			103	103
Residential			24	24
Cemetery			0	0
Others			0	0
Total	63	567	127	757

Source : The JICA Study Team

There are 4 ha of the rainfed paddy field and 5 ha of managed grassland in the impounding area of the proposed Embung. In the Project area, there is no newly developed paddy field as an alternative land resource for these impounding areas. However, the hundreds hectares of the new irrigation field would cover the impounding farmland if translocation to other places is required.

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 A-21	Paddy	100	Soybean	50	-	-
			Mungbean	50	-	-
With Project A-22	Paddy	100	Soybean	50	Mungbean	100
			Mungbean	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 present level under the "Without Project" condition.

Proposed Farm Input and Labor Requirements

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

(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 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 4.0 ton/ha for wet paddy, 1.2 ton/ha for soybean and 1.0 ton/ha for mungbean. These targets are estimated in due consideration of the present yield level in well established irrigation areas of Kabupaten Sumba Timur 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
313	91	63	424	242	2,000

2.5 Water Demand

(1) Domestic water demand

The future domestic water consumption level in rural areas of NTT is set to be 60 lit/day/capita up to 2003/04 for the Pelita VII period and 70 lit/day/capita from 2004/05 and onward. The public water demand and the unaccounted-for are considered to be included into these unit water requirements.

Following the projected population projected, the future domestic water demand of inhabitants in the Project and Lewa town areas 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	4,483	4,901	5,300	5,662	5,996
Total demand	'000m^3/yr.	98.2	107.3	135.4	144.7	153.2

(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 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 proposed site is selected at the narrowest gorge on the Laimoh river, where spring water is come out from a cave on the right bank of the Laimoh river immediately upstream from the selected dam axis. Constant water from the spring has been obtained for domestic water and the irrigation throughout a year. River bed elevation shows El. 578.0 m and the width of gorge is 250 m at El. 600.0 m on the both abutments of dam site.

3.2 Geological Condition

The proposed Embung site is mainly underlain by limestone. The foundation is mainly formed of limestone on the both banks, and alluvium at river bed . The drilling survey shows that average N-value of highly weathered limestone will be expected more than 20. The coefficient of permeability of limestone varies from 3.8×10^{-4} to 2.7×10^{-5} cm/sec. No ground water is present at hilly area except river bed.

The reservoir is mainly underlain by limestone and alluvium. No major fault and landslide are recognized in the reservoir area. Some huge caves existing in area causes the main problem of water leakage through limestone. Saddles behind both abutments are also supposed to be paths of water leakage. Geological detailed survey will be necessary before undertaking detailed design works. Some large-scale measures for water leakage should be required. Geological map and profile for this site are shown in Figures 3.1 and 3.2, respectively.

3.3 Availability of Construction Materials

In and around the proposed Mataiyang Embung site, these are sufficient materials for constructing a zone type fill dam. Random and transition materials will be obtained from the limestone mountain in the reservoir area. The following shows a summary of the selected location and the availability of the materials.

Availability of Construction Materials

Material	Location	Description
1. Impervious soil	Reservoir area	Clayed sandy silt clayed silt
2. Filter & Transition material	(1) Quarry mountain in the reservoir area	Crushed limestone
	(2) Sea shore on the Laut Sabu	Sand & gravel from sea shore
3. Random materials	(1) Spillway/ dam foundation	Excavated limestone Alluvial deposits (Sand and gravel)
	(2) Reservoir area	
4. Concrete aggregates	(1) Downstream of Moharong river	River deposits
	(2) Laimoh river	Sand fro sea shore
	(3) Sea shore on the Laut Sabu	

3.4 Availability of Water Resources

(1) Catchment yield

As for the L. Laimoh 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 Mataiyang rainfall station is established by the Department of Agriculture, but its observation period is not sufficient to carry out reservoir operation study for the Embung. Taking the observation period, location, and altitude into account, accordingly, the Waikabubak rainfall station which is located in the west of the Mataiyang Embung catchment has rainfall record of nearly consecutive 16 years and is considered to represent catchment rainfall. 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 Sumba Island. Using this runoff coefficient and rainfall record at Waikabubak, river flow of the L. Laimoh at proposed site is estimated.

Following conditions are considered for estimation of the half monthly discharge:

- Catchment area of the proposed Embung site is 19.1 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 1962 to 1977. 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
2,425	2,229	2,626	1,219	1,045	216	145	74	474	865	1,408	2,368	15,093

(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, which is widely used in NTB. In this Study, 19 years rainfall data of the Waikabubak station from 1954 to 1976 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	111
1 in 5 year	134
1 in 10 year	149
1 in 20 year	162
1 in 50 year	178
1 in 100 year	189
1 in 200 year	201

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	136
1 in 5 year	164
1 in 10 year	182
1 in 20 year	198
1 in 50 year	217
1 in 100 year	231
1 in 200 year	246

(3) Sediment load

There is no available data on sediment load on the L. Laimoh 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 November 4, 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 described below, the water balance study of the Mataiyang 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 (m^3)
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)
OD : outflow needed for domestic water during the half monthly period (m3)
OL : outflow needed for livestock water during the half monthly period (m3)
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 L. Laimoh river, discharge is generated from rainfall of the Waikabubak 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 Mataiyang 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. 585.5 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. 610.0 m.

(2) Optimum development scale

The optimum development scale of proposed Mataiyang Embung coincides with the maximum development scale considering the proposed agricultural development plan. The optimum development scale is thus in line with the height of 20.0 m and effective storage capacity of 1.832 million cubic meters (MCM). The result of 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 L. Laimoh river through construction of the proposed Mataiyang Embung at the maximum scale, irrigation water can be supplied to wet paddy field of 450 ha in net for the both seasons. The beneficiary area of the proposed Embung comprises the presently irrigated paddy field of 57 ha and newly converted fields from the existing rainfed paddy field of 380 ha and dry upland of 13 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 and sustain soil fertility. In this regard, the proposed cropping pattern is to be the wet season irrigated paddy coupled with double cropping of irrigated Palawija crops to the full extent as shown below and illustrated in Figure 4.3. Soybean and mungbean are grown as Palawija crops.

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	450	Soybean	Irrigated	450
				Mungbean	Irrigated	450
Without Project	Paddy	Irrigated	57	(Fallow)		-
	Paddy	Rainfed	380	(Fallow)		-
	Maize	Rainfed	13	(Fallow)		-

(2) Delineation of beneficiary area for domestic water supply

With regard to domestic water demand in and around 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 5,300 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 Mataiyang 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 with 1,200 m length considering the geological condition of the Embung site.

The main components of Mataiyang 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 1.832 MCM, the full supply level (F.S.L.) is set at El. 594.0 m. Taking overflow depth of spillway and freeboard into account, the dam height of Mataiyang 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 a concrete pipe of 3.0 m in diameter is provided below the dam body. The spillway is designed on the left bank of the main dam to release the flood discharge of 164 m^3/sec from the catchment area of 19.1 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 450 mm below the dam body and valve house at the downstream of the main dam.

The principal features of Mataiyang Embung are summarized below.

(1)	Reservoir	
	- Catchment area	19.1 km^2
	- F.S.L.	El. 594.0 m
	- Minimum operating level	El. 585.8 m
	- Effective storage capacity	1,832,000 m^3
	- Dead storage capacity	328,000 m^3
	- Gross storage capacity	2,160,000 m^3
	- Sediment deposition level	El. 584.8 m
(2)	Main dam	
	- Type	Zone fill dam
	- Height	20.0m above river bed
	- Crest elevation	El. 598.0 m
	- Crest length	240 m
	- Crest width	7.0
	- Upstream slope	1 : 2.5
	- Downstream slope	1 : 2.0
	- Total embankment volume	189,000 m^3
	- Foundation Treatment	Curtain grout, 1,200 m
(3)	Spillway	
	- Design flood (1/100 year)	231 m^3/sec
	- Type	Overflow weir
	- Crest elevation of overflow weir	El. 594.0 m
	- Width of overflow weir	38.0 m
	- Discharge capacity	231 m^3/sec
	- Overflow depth	2.0 m
	- Length	300 m
(4)	River diversion	
	- Design flood (1/5 year)	164 m^3/sec
	- Type	Tunnel
	- Diameter	D 3.0 m
	- Length	Tunnel =140 m Open channel = 215 m
(5)	Water supply system	
	- Inlet structure	1.5 x 1.5 m square with trash racks
	- Pipe diameter	ϕ 450 mm steel pipe in the river diversion tunnel
	- Length	90 m

- Design discharge	400 lit/sec
- Valve house	Right abutment of dam site
- Type	Through valve
- Diameter	ϕ 300 mm x 2 unit
- Outlet elevation	El. 583.0 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 reservoir water surface due to extraordinary flood discharge and wave uprush on the slope.

The following formula is applied for the design the Mataiyang Embung.

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

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

(3) River diversion tunnel 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 division tunnel with a diameter of 3.0 m as shown in Figure 4.4. A 5-m high cofferdam with a crest level of El. 583.0 m would suffice to contain the flood inflow of 164 m^3/sec having a return period of five years.

(4) Spillway

The spillway is located on the left abutment of the main dam, which is composed of overflow weir and chuteway. The over flow 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 231 m^3/sec.

Based on the result of comparative study on combination of overflow depth and width of the spillway, the overflow depth at 2.0 m and the width of 38.0 m are decided so as to minimize the costs of the spillway and the main dam.

A non-gated ogee crest would be set at El. 584.0 m to coincide with F.S.L. A bridge would be provided over the throughway of the spillway.

(5) Water supply system

In order to supply the water to the downstream irrigation area, the water supply system is provided to release the water of 400 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 584.8 m. Fixed trashracks are provided on the intake structure. Steel pipe with a diameter of 450 mm is installed from the plug portion of the river diversion tunnel to the valve house located immediately downstream of the main dam as shown in Figure 4.4.

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 is carried out by using the remaining impounded water after satisfying of full requirements of domestic water supply in the beneficiary area;
- 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

The outlet works of the Embung are planned to be used for dual purposes of supplying irrigation and domestic water. The 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 then diverted to irrigation and domestic water supply channels at the valve house with check valve and flow meter.

Irrigation water diverted at the valve house 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 area by open channel.

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 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 October for Palawija crops and its design discharge is estimated at 400 lit/sec for the net irrigation area of 450 ha. This design discharge is enough to flow design discharge for the wet season paddy crop of net area of 450 ha at peak time.

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. 583.0 m at the irrigation inlet box.

(4) Irrigation facilities

The proposed canal layout and design of irrigation facilities are made based on the 1/5,000 topographic map prepared under the Study and in accordance with the following conditions:

- Canal alignment is to be straight and short as much as possible;
- The alignment is to be planned to pass outside of villages and give no damages to public facilities;
- The types of canal related structures are to be minimized as much as possible; and,
- The structures are to be simplified as much as possible.

Irrigation canal to lead the water to the existing wet paddy field from the Embung is constructed using stone masonry flumes with trapezoid section taking into account the design discharge of the canal, construction method and available construction materials in the Project area. Canal related structures required are irrigation inlet box turnouts, siphons, cross drains and irrigation division boxes. Required irrigation facilities are summarized below.

Irrigation Facilities Requirement

Facilities	Quantities
- Valve house (including in the facilities for Embung)	1 No.
- Irrigation inlet box	1 No.
- Masonry canal to be constructed	11.0 km
- Turnout	2 Nos.
- Siphon	3 Nos.
- Cross drain	2 Nos.
- Irrigation division box	110 Nos.

5.3 Preliminary Design of Water Distribution Facilities

The main components of water distribution facilities to inhabitants in the beneficiary area are pipe lines, division boxes with filter system for inhabitants and related structures of pipelines.

Preliminary design works for each water distribution system are carried out based on the following basic concepts.

- Distribution facilities to the beneficiary areas are laid out taking into consideration the effective storage capacity of Embung, topographic condition of the Project area and village boundary;
- Water demand for inhabitants is fully reflected in the preliminary design of pipeline and the layout of division boxes in the beneficiary areas;
- Pipeline system with pressure flow is taken up for water distribution network from the Embung to its beneficiary area. Pipes are laid along the existing roads as much as possible from the viewpoint of easy O&M works of pipeline system. Pipes are laid under the ground with a depth of 50 cm;