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. Some construction equipment will be purchased through international competitive bidding, if necessary.

The construction plan is based on the mode of construction and the target schedule of construction works as well as taking into consideration the construction conditions such as availability of construction labor, material and equipment as well as weather and the topographic conditions of the construction site. Generally, the mechanized construction method is assumed to be adopted although other construction methods may be practiced.

It is assumed that 200 working days per year are available for conducting the earthfill embankment works, 270 days per year for the filter drain and toe 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, one 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 in the receipt of the "Notice to Proceed", the contractor would commence the mobilization of the construction equipment and key staffs to the Project site from the 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 culvert, and leakage protection walls would be commenced at the beginning of March in the second year.

3) Concrete works embankment works

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

4) Commencement of reservoir water impounding

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

5) Water distribution system

Construction works for the water distribution system will be executed in parallel with the construction works of the Embung by using mainly manpower since those work quantities are not so much. The construction works shall be completed by the end of December in the second year before supplying the impounded 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 of 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 during four months from November in the first year to February in the second year.

1) Temporary buildings and yards

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

The temporary buildings will require a total floor area of 1,200 m^2 for an anticipated staff strength of 15 persons and labor force of 80 persons. The land required for the temporary buildings and construction facilities is estimated at 2,500 m^2. The temporary buildings and yards may be located near the construction site.

2) Water and power supply

The water required for the construction works and the daily use of 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 constructor's diesel generators with installed capacity of 200 kW to meet the requirements as shown below.

Power Requirement

Place / works	Power Requirement (kW)
Office and quarters	30
Construction plant	50
Repair shop	60
Dam site	20
Water supply	20
Others	20
Total	200

(2) River diversion works

The river flow will be released through the river diversion conduit during the dry season in the second year. The river diversion culvert would be provided along the right bank of the Lis river. In order to avoid the leakage or seepage water from the reservoir along the river diversion conduit across the dam body, the river diversion conduit is planned to be

installed in the excavated rock foundation so as to contact the concrete surface smoothly to the homogeneous earth materials as seen in Dwg. - 404.

Considering very short construction period as four months from the beginning of March to the end of June in the second year, two lanes of concrete pipe culvert with diameter of 1.2 m are used, and therefore the concrete placing will be made without inside-forms nor reinforcement bars in the conduit.

After completion of the main dam embankment around the end of September in the second year, the river diversion conduit shall be plugged by the concrete using concrete pump with a capacity of 20 m^3/hr for the whole length from the reservoir-side to the downstream outlet.

(3) Main dam works

Following the foundation excavation and completion of the river diversion conduit, the dam embankment will be commenced at the beginning of July in the second year. Considering a embankment volume of 221,000 m^3 and remaining dry season period of three months until the end of September in the second year, the daily embankment volume is to be 2,950 m^3 which is quarried from the reservoir area.

Excavation of the embankment materials at the borrow area will be done with D-7 class (21 ton) bulldozers and the excavated materials will be loaded with 1.2-m^3 wheel loader and be hauled to the dam site by 11-ton dump trucks. The embankment materials will be spread at the dam site will be spread with 21-ton bulldozer and compacted with 10-ton class tire roller in layers of 20 cm thickness before compassion.

The filter embankment is planned as a horizontal drainage mattress with a thickness of 1.0 m, which is scheduled to be placed immediately after completion of the river diversion culvert, at the beginning of June in the second year. Before placing the drainage mattress, the main dam foundation should be graded and trimmed smoothly. The filter material will be spread by 21-ton bulldozer and be compacted by 21-ton bulldozer or 10-ton tire roller. This filter material will be hauled with 11-ton dump trucks from the Noelmina and Maubesi rivers.

Riprap placement is scheduled to be made simultaneously as the homogeneous earth embankment of the main dam. The riprap volume is estimated to be 9,700 m^3 and the rock material will be quarried from the Maubesi river. The rock material will be placed by 0.6 m^3-backhoe and large voids should be filled with smaller rock fragments. The riprap protection should be finished manually to the design slope and thickness.

(4) Spillway construction

Excavation of the spillway will be scheduled to be performed about three months from March to May in the second year. As the total volume of common and weathered rocks is estimated to be 154,000 m^3, 21-ton bulldozer and 1.2-m^3 backhoe will be used for flat portion and steep slope chuteway portion of spillway, respectively. Most of the excavated materials may be used as the main dam embankment materials so that the excavated materials will be stocked in the designated area. For loading the excavated materials to 11-ton dump trucks, 1.2 m^3 wheel loaders is used.

After completion of the spillway excavation, preparation for foundation of chuteway will be commenced. For concrete placing into side-walls and shuteway slope portion, 20-ton class truck crane with concrete bucket (1.0 m^3) and concrete pump with a capacity of 20 m^3/hr will be used. Before starting the reservoir water impounding at the beginning of October in the second year, major concrete works of the spillway should be completed in order to release the flood discharge in the following wet season.

(5) Water supply system

Inlet structure of the water supply system is constructed above the sediment load disposition level of El. 567.4 m. Connecting the inlet structure, a cast iron pipe with diameter of 200 mm is installed up to the downstream end of the main dam. Construction of the river diversion conduit and water supply pipe should be completed before commencement of the main dam embankment at the beginning of July in the second year.

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

(6) Earth blanket in reservoir

After excavation of the embankment materials for the main dam in the reservoir area, the foundation of the earth blanket should be provided considering the smooth grading and trimming by using 11-ton bulldozer and a 3.7-m wide motor grader.

As shown in Dwg. - 406, the earth blanket will be provided in the reservoir area up to the F.S.L. under the condition that the blanket material should be the same material of the original ground of the reservoir area. Accordingly the original ground should be loosened by 21-ton bulldozer and 3.7-m wide motor grader, then compacted by 21-ton bulldozer or 10-ton tire roller which is subject to the result of trial embankment at the construction site.

The construction period of the earth blanket is about six months from April to September in the second year as seen in Figure 6.1.

(7) Construction materials

Quantities of the major construction materials required for constructing the Benkoko Embung are summarized below,

Construction Material Requirement

Item	Quantity	
Earthfill materials		
Main dam	221,000	m^3
Blanket in reservoir	102,000	m^3
Filter materials		
Horizontal drain	20,000	m^3
Riprap portion	2,900	m^3
Rock materials		
Riprap protection	7,800	m^3
Toe rockfill	3,100	m^3
Concrete		
Cement	950	tons
Reinforcement bars	66	tons
Aggregates	2,400	m^3

(8) Construction equipment

The minimum number of major construction equipment and plants to be used for the Benkoko Embung construction works are summarized in Table 6.1.

6.3 Construction Plan of Water Distribution and Irrigation Facilities

Construction works required for the water distribution system and irrigation facilities are summarized below:

Construction Works for Water Distribution System

Water distribution system	
- Pipe setting works of dia. 50 mm	6.4 km in total
- Construction works of the related facilities such as check valves, air valves, blow off and division boxes for inhabitants and livestock	46 Nos. in total
Irrigation facilities	
- Construction works of irrigation canal (concrete flume type canal with a base width of 0.5 m)	0.33 km in total
- Construction works for the canal related structures such as irrigation inlet box, cross drain and irrigation division boxes	5 Nos. in total

The facilities to be constructed for distributing domestic, livestock, and irrigation water are rather small in work quantities and scattering in the beneficiary area in comparison with the construction works. Therefore, almost of all the facility construction works will be executed by manual except for earth works for irrigation canal such as clearing, stripping, excavation, and embankment works. These earth works will be conducted by using heavy construction equipment including bulldozer, excavator, compactor, and so on. The construction works of water distribution facilities and irrigation canal will be carried out in parallel with the Embung construction works.

6.4 Institutional Arrangement for Project Implementation

(1) Organization for implementation

After the reorganization enforced in August 1994, the Directorate General of Water Resources Development (DGWRD) of the Ministry of Public Works (PU) is responsible for managing overall water resources development and conservation in the whole country. At the provincial level, the Provincial Water Resources Services (PRWS) of the Provincial Public Works Service (DPUP) under the direct control of the Governor is the principal organization which is responsible for planning, design, and implementation aspects regarding water resources development, operation and maintenance of water source, irrigation and flood control facilities, and watershed management. The Regional Office of PU (Kanwil PU) is established in each Province bearing the responsibility of maintaining coordination between PU and DPUP, and providing support and assistance to the DPUP as well as planning and implementing projects of a national nature.

In NTT, there are four provincial service offices; Water Resources (Pengairan), Road/Bridge (Bina Marga), Water Supply/Building (Cipta Karya) and Technical Quality Management (Tata Laksana Teknik). In terms of domestic water supply to urban and rural areas in NTT, PRWS is responsible for creating and supplying raw water and Cipta Karya has to treat and distribute clean water to end-users in urban areas.

The organizational structure of PRWS consists of a general administrative unit and four technical sections for design, construction, and operation and maintenance (O&M), and project benefit promotion. Under the chief of DPUP, there are nine functional project offices established for the specific purposes. Of these, Embung development is handled by the both Timor Water Resource Construction and Conservation Project Office (Proyek PKSA Timor) and Flores-Sumba Water Resources Construction and Conservation Project Office (Proyek PKSA Flores-Sumba) in case of the Central Government's financing projects and the Provincial Embung Development Project Office (Embung APBD) in case of the Provincial

Government's financing projects. After completion of Embungs, O&M works are transferred to the O&M Section according to the direction from the Minister for Home Affairs to the Governor in response to the request by the Minister for PU. The present organization chart of PRWS and two PKSAs are shown in the Volume 4.

In implementing Benkoko Embung Project as one component of the package development program, it is proposed that PRWS is in charge of overall arrangement and the PKSA Timor Project Office is responsible for all of the actual management works. Under the Project Office, one special section or sub-project office needs to be established to represent the following functions:

- Design and construction supervision of all the Project works including water distribution system; and
- Accounting and management of construction works.

(2) Expatriate assistance

In NTT, accumulation of technical know-hows to construct a larger Embung are still insufficient resulting in that the implementation of Benkoko Embung requires experienced professional manpower, especially management of supervision on the construction works. For the successful prosecution of the Project, therefore, it is proposed to introduce appropriate expatriate assistance.

A vital part of the functions of expatriate assistance will be the training of the local professional and sub-professional staff on effective management to supervise the earth and construction works and further to provide substantial experience and techniques to the PKSA Timor Project Office.

(3) Organization for O&M

After completion of the proposed Benkoko Embung, the O&M Section of PRWS is responsible for operating and maintaining Embung as well as water intake and distribution facilities. Among various O&M works to be done by this Section, the reservoir operation is the main function and needs to be conducted on the basis of operation rule to be established. In order to operate and maintain the Project facilities effectively according to the said rule, it is prerequisite to upgrade the capability of O&M staff and the level of O&M equipment.

As for maintenance works of water distribution facilities, it is proposed for PRWS to organize the beneficiary people aiming at their participation in routine works such as cleaning of water division boxes, clearing of animal excreta around water division boxes, repairing of fence along the reservoir and so on.

7. COST ESTIMATE

7.1 Basic Assumption of Cost Estimate

Project cost of the proposed works for development of the Benkoko 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 10% 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 NTT area as of June 1994 and the data collected from the on-going projects in NTT. 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 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 recent other project costs in NTT;
- Land acquisition cost including the purchase of the Embung site, reservoir area, borrow area and land for pipe line and other permanent structure is estimated at 0.5% of the direct construction cost taking into considerations 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 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 Benkoko scheme is estimated at Rp. 9,526 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 for this scheme is shown in Table 7.2 together with work quantities of the main work items and unit prices.

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

Summary of the Project Cost for Benkoko Embung

Unit : Rp. million

Item		Project cost
I.	Direct construction cost	5,705
1.1	Preparatory works	272
1.2	Embung construction	5,050
1.3	Domestic water supply	198
1.4	Operation & maintenance road	111
1.5	Irrigation facilities	74
II.	Administration cost	285
III.	Engineering services	856
IV.	Physical contingencies	1,027
V.	Contract tax	759
VI.	Land acquisition	29
VII.	Price contingency	866
	Grand Total	9,526

7.3 Operation and Maintenance Cost

The O&M costs consist of salaries for O&M staff, cost for maintaining the Project facilities, materials and labor cost for repairing works, and running cost of Project facilities. The annual O&M costs are assumed at Rp. 47.63 million, which is equivalent to 0.5% of the Project cost.

8. PROJECT JUSTIFICATION

8.1 Satisfaction of BHN

In general, it is impossible to quantify benefits attributable to improvement of the existing water supply system for the domestic and livestock use in rural areas of NTT. The water supply benefits anticipated in the beneficiary area of Benkoko Embung comprise two main portions: reduced time fetching water from distant sources and reduced health problems or morbidity. It is also hard to evaluate the values of gains prospected in newly available working time and those of decreased incidence of water borne diseases in quantitative manner.

Under the Study, thus, the benefits to be born from satisfaction of BHN by creating a new water source facility are to be indicated as the value of water and the investment amount to each beneficiary inhabitant. The investment amount is given by deducting the administration and land acquisition costs from the Project cost, because these could not be defined as the direct construction cost due to the mode of payment. The value of effective storage water is obtained by dividing the investment amount by the effective storage capacity, while that of supplied water is given by dividing the investment amount by the annual supply amount of domestic and livestock water.

The total Project cost for constructing the Benkoko Embung with the effective storage capacity of 0.17 MCM is estimated to be Rp. 9,526 million. The total number of beneficiary water users is 935 inhabitants and 657 heads of cows with the annual water demand of 0.03008 MCM. The investment amount estimated is Rp. 9,134 million. This amount can be allocated to two portions; domestic and livestock water portion and irrigation water portion based on the required cost for developing the Benkoko Embung as the Case-1 with the effective storage capacity of 0.01 MCM. Thus, the investment amount is split into Rp. 4,255 million for the domestic and livestock water portion and Rp. 4,879 million for the irrigation portion.

The value of effective storage water to be created by the Benkoko Embung is estimated to be Rp. 25,029/m^3, while that of supplied water is estimated to be Rp. 141,456/m^3. The estimated investment amount to the respective beneficiary people is Rp. 4.55 million. As the prospected unit water consumption rate of cow is equivalent to that of 0.67 inhabitant, the estimated investment amount to the respective beneficiary people and livestock is Rp. 3.09 million.

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) taken up in the Second Provincial Irrigation Project by the World Bank. The ECFs applied are 0.71 for civil works and tertiary irrigation system development, 1.00 for O&M equipment, 0.90 for engineering service and supporting works, 0.80 for O&M costs. All the transfer payments are not included into the economic cost. As the financial investment amount allocated to the irrigation water portion is Rp. 4,879 million, the economic cost is estimated to be Rp. 2,960 million following the above procedure.

(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. Tables 8.1 to 8.5 show price structure of paddy, Palawija crops and fertilizers, economic crop budget and net production value. The annual net incremental benefit estimated amounts to Rp. 92.2 million and is Rp. 2,635,000/ha. In the proposed reservoir area, there is no loss of productive and foregone benefits due to inundation of the reservoir area after completion of the Benkoko Embung. The benefits will accure from

the initial year after completion of the Project. Taking the present agricultural situation and farmers capability into account, build-up period is assumed to be five years.

(3) Economic evaluation

The economic internal rate of return (EIRR) is examine as shown in Tables 8.6 and 8.7 based on costs and benefits as at July 1994. Although the result of economic analysis shows that EIRR is less than 1%, the proposed Benkoko Embung Project would still have a significant positive impact on the development of economically depressed area in NTT. Furthermore, the both water values can be reduced by 13% compared with the case that Benkoko Embung is developed at the minimum scale only for meeting the BHN.

(4) Farm budget analysis

With the implementation of the Benkoko Embung Project, the net on-farm income of farmers holding a unit farm size of 1.0 ha can be expected to increase by Rp. 1,308,500/year from Rp. 18,500/year under the "Without Project" condition to Rp. 1,327,000/year under the "With Project" condition. Such improvement of their farm budget would give much incentive for farmers to invest in further development and increase their payment capacity which enables them to pay some portion of irrigation water charge.

8.3 Environment Impact Assessment

(1) Environmental features of the Project area

Principal human and physical environment feature in the Project area are summarized below.

Human and Physical Environmental Features

Items		Descriptions
Human environment		
Social	:	Insufficiency of reliable water sources and facilities for domestic use
Human use	:	Use of spring water and well water
Health and sanitation	:	Prevalence of waterborne diseases
Physical environment		
Geology/land	:	Bobonaro Formation / Coral Limestone
Surface/ground water	:	Surface water is stably observed in the dry season
Endemic fauna and flora	:	none
Others	:	none

(2) Environmental impact assessment

In the Project area, environmental issues assessed as negative environmental problems are only human activities of using trees in the catchment area. Trees in both the reservoir and the catchment areas have been utilized by inhabitants for their economic activities producing water-carriers and other baskets, firewood, timber, alcoholic beverage, sap of sugar, and so on. Decrease of vegetation caused by logging has severely incurred a deterioration of water conservation and acceleration of soil erosion in the catchment area.

The countermeasures to eliminate this environmental impact is to establish an effective watershed management rule and conduct a campaign for participation of inhabitants in forest conservation activities. Additional incentives are required to encourage inhabitants to diversify their economic activities on on-forest basis.

(3) Primary information of environmental assessment

To support undertaking of environmental analysis presentation for the proposed Project on the Indonesian rule, primary information on environmental assessment is compiled in Attachment 4.

8.4 Contribution to Women in Development

With provision of permanent water source facilities, women and children of 201 families can be quite free from their daily hard job to carry their domestic water at the average distance of 6.5 km. 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 family income would encourage women in investing surplus in improvement and diversification of their economic activities.

9. CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

The Benkoko Embung development plan has been formulated as one of the six urgent water resource development schemes in NTT aiming to meet BHN for upgrading the living standard and to support the economic activities in the Project area. The present Study is made to confirm technical feasibility and socio-economic impact of the Project in conformity with this concept.

The Project consists of such structural components as main dam, water leakage protection measure and domestic, livestock and irrigation water distribution system. All of these components have to be implemented without any missing components for the purpose of achieving the development concept.

As the results of the Study, it is clarified that each of the Project components are technically possible and the Project is socially and socio-economically desirable for enabling 935 inhabitants of 201 families to get permanent water source, to be quite free from daily hard job to carry their domestic water at the average distance of 6.5 km, to decrease frequency of water born disease and to increase their farm income.

It is therefore concluded that the construction of Benkoko Embung is worthy of urgent implementation.

9.2 Recommendations

As the conclusion of the Study is aforementioned, it is recommended that necessary steps for the implementation of the Benkoko Embung Project are to be taken. Such steps will be composed of administrative issues and technical matters.

Main issues of the administrative matters to be taken up will be the determination of executing agency, the procurement of necessary fund in foreign currency and the preparation of budget in domestic currency as a counterparts fund.

Necessary technical matters to be made are composed of introduction of advanced technology and management know-hows in terms of smooth construction of higher Embung on permeable foundation for shorter period. As the development of Benkoko Embung aims to supply raw water for domestic and livestock use, it is recommended to take necessary action for appropriate watershed management including afforestation and for no entry of inhabitants and livestock to the reservoir area so as to keep water quality.

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

Feasibility Study on
Benkoko Embung Development Project

Tables

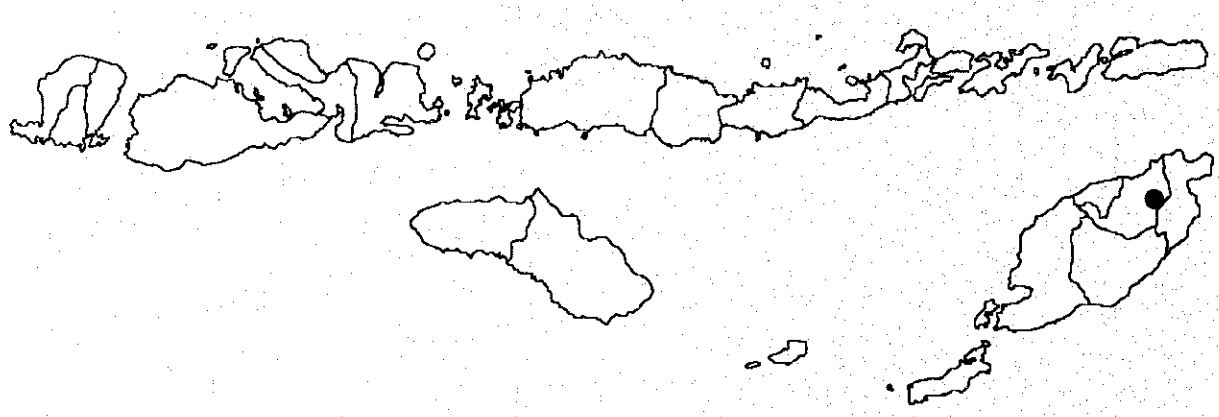


Table 1.1 Monthly Rainfall Record

Station : Kefamenanu 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	
1975																					17	34	30	88	
1976	62	11	19	31	126	82	0	14	5	2	17	12	0	12	1	2	0	0	0	59	29	90	50	132	755
1977	142	30	123	133	187	54	55	16	26	11	12	2	6	3	0	0	0	0	0	0	0	0	133	118	1.049
1978	115	133	142	126	71	19	24	4	95	126	39	2	88	5	28	1	1	10	2	2	3	53	111	129	1.328
1979	17	55	101	143	125	118	22	0	16	90	16	4	4	4	0	0	0	0	2	0	0	10	54	78	859
1980	182	210	115	198	44	34	8	65	23	16	0	11	2	2	1	0	0	0	0	2	42	80	116	120	1.269
1981	175	89	96	36	67	25	27	9	63	33	25	9	32	23	0	2	20	92	0	0	33	138	159	133	1.284
1982	42	142	106	76	119	67	32	36	9	43	0	13	6	0	11	1	0	0	0	0	4	4	41	72	823
1983	59	100	232	160	74	59	167	54	36	0	67	0	0	0	0	0	0	0	57	88	70	45	32	49	1.348
1984	93	52	100	130	97	99	31	38	60	29	40	4	2	17	2	5	12	26	0	28	0	21	53	125	1.065
1985	89	130	133	134	48	48	61	14	0	7	45	0	0	0	0	0	0	27	0	76	2	37	74	123	1.049
1986	55	179	42	81	87	35	30	0	0	33	6	18	0	61	0	0	0	0	0	29	9	15	28	44	753
1987	151	135	61	86	9	96	4	19	5	58	33	13	32	0	4	0	0	0	0	0	0	60	138	63	969
1988	112	116	82	73	66	142	74	4	2	5	1	0	42	12	0	3	20	0	12	0	15	101	83	94	1.061
1989	54	66	103	45	249	84	50	131	33	5	14	26	5	19	16	1	3	0	0	0	94	0	38	30	1.066
1990	145	143	86	59	71	19	7	165	64	89	4	9	0	5	0	1	0	0	0	0	0	0	196	93	1.156
1991	22	78	98	221	23	5	119	10	8	7	3	15	4	0	0	0	0	0	0	0	122	81	94	113	1.023
1992	116	27	43	53	154	67	28	20	2	134	13	4	0	0	0	0	0	0	0	0	0	0	0	0	662
1993	197	185	99	52	0	0	0	0	0	23	8	17	9	8	0	0	0	0	0	6	0	40	13	67	721
1994	69	75	147	32																					
Average	100	103	101	98	90	59	41	33	25	39	19	9	13	9	3	1	3	9	4	16	23	43	76	88	1.005

Source : Data Klimatologi di Nusa Tenggara Timur, Tahun - 1992, Bagian Proyek Hidrologi, Kantor Wilayah Propinsi NTT

Table 1.2 Climate Data

Station: Kefamenanu **Latitude : 9.4000S**
Island : Timor **Longitude : 124.4667E**
Kabupaten : TTU **Elevation : 450 m**

Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Year	Average
Temperature (mean)	26.1	25.9	25.9	25.6	25.1	23.9	23.1	23.8	24.7	26.7	27.7	26.8	1975-1992	25.4
Temperature (max)	29.2	30.2	29.2	29.8	30.2	30.8	29.2	27.0	30.8	29.8	31.0	29.8	1975-1992	29.8
Temperature (min)	22.8	22.2	22.2	20.2	21.1	17.2	18.2	19.8	15.0	19.5	22.0	22.5	1975-1992	20.2
Relative Humidity (mean)	89.8	89.9	90.2	87.5	90.7	89.4	87.7	83.7	80.7	83.6	81.0	89.3	1975-1992	87.0
Relative Humidity (max)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.0	100.0	1975-1992	99.9
Relative Humidity (min)	43.0	0.0	0.0	56.0	68.0	56.0	57.0	0.0	1.0	0.0	0.0	62.0	1975-1992	28.6
Sunshine Hours (hr/day)	5.1	5.2	6.7	7.5	6.7	6.2	7.2	8.4	8.7	9.0	7.7	6.1	1975-1992	7.0
Wind Velocity (km/day)	51.1	54.3	36.6	28.4	27.5	42.0	58.7	71.9	55.8	61.9	43.9	34.3	1975-1992	47.2

Source : Data Klimatologi di Nusa Tenggara Timur, Tahun - 1992, Bagian Proyek Hidrologi, Kantor Wilayah Propinsi NTT

Table 1.3 Present and Projected Demographic Condition

Village	Sub-village	Population			Household		
		1994	1999	2004	1994	1999	2004
Oinbit	Oinbit RT 04	233	254	275	48	53	57
	Oinbit RT 05	261	284	308	52	57	62
	Ekafalo RT 02	298	325	352	69	76	82
	Beneficial Area Total	792	863	935	169	186	201
	Ekafalo RT 03	281	306	332	62	68	74
	Ekafalo RT 06	294	320	347	55	56	65
	Maonmuti	412	449	487	70	77	83
	Total	1,779	1,938	2,101	356	387	423

Source : Provincial Statistic Office, NTT

Table 1.4 Present and Projected Livestock Population

Year and Village	Sub-villaga	Cow & Buffalo	Horse	Sheep & Goat	Pig	Chicken & Duck	Equiv't Total
1994							
Oeltua	Oinbit RT 04	116	17	57	23	153	146
	Oinbit RT 05	142	21	69	28	187	179
	Ekafalo RT 02	95	64	36	130	36	183
Beneficial Area Total		353	102	162	181	376	508
	Ekafalo RT 03	90	60	34	121	34	173
	Ekafalo RT 06	95	64	36	130	36	183
	Maonmuti	187	86	23	110	138	295
	Total	725	312	255	542	584	1,159
1999							
Oeltua	Oinbit RT 04	132	18	69	29	211	166
	Oinbit RT 05	163	22	83	36	257	205
	Ekafalo RT 02	108	69	44	165	50	208
Beneficial Area Total		403	109	196	230	518	579
	Ekafalo RT 03	103	64	41	153	47	196
	Ekafalo RT 06	108	69	44	165	50	208
	Maonmuti	214	92	28	139	190	333
	Total	828	334	309	687	805	1,316
2004							
Oeltua	Oinbit RT 04	150	20	82	37	289	190
	Oinbit RT 05	183	24	101	45	354	232
	Ekafalo RT 02	123	74	52	207	68	235
Beneficial Area Total		456	118	235	289	711	657
	Ekafalo RT 03	116	69	50	196	64	222
	Ekafalo RT 06	123	74	52	207	68	235
	Maonmuti	242	99	34	176	261	376
	Total	937	360	371	868	1,104	1,490

Source : Provincial Livestock Office, NTT and JICA Study Team

Table 1. 5 Summary of Farm Economic Survey

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	Average
1 Sex and Age		Male 60	Male 50	Male 57	Male 51	Male 50	Male 50	Male 44	Male 61	Male 52	Male 64	54
2 No. of Family Member		M-1/F-5	M-3/F-3	M-1/F-5	M-1/F-4	M-1/F-5	M-1/F-3	M-1/F-4	M-1/F-4	F-1	M-3/F-2	M-1/F-4
3 Type of Side Job		None	None	Civil Serv.	None	None	None	None	None	None	None	
4 Own Farmland	ha	0.85	1.44	9.80	4.25	1.00	0.75	0.90	0.80	1.75	1.35	2.29
(Paddy field)	ha	0.25	0.25	5.00	2.00	0.25	0.25	0.00	0.25	0.50	0.25	0.90
5 Cropped Area	ha	1.75	1.25	9.00	3.00	1.00	0.70	0.90	0.85	2.75	1.25	2.25
(Paddy)	ha	0.25	0.25	5.00	2.00	0.25	0.25	0.00	0.25	0.50	0.25	0.90
(Palawija)	ha	1.00	0.66	1.00	0.50	0.75	0.30	0.90	0.40	2.00	0.80	0.83
(Others)	ha	0.50	0.34	3.00	0.50	0.00	0.15	0.00	0.20	0.25	0.20	0.51
6 Cow/Buffalo	head	3	2	6	6	2	3	2	2	2	4	3.2
Horse	head	0	1	0	2	2	0	0	0	0	0	0.5
Goat/Sheep	head	2	2	4	1	3	0	0	0	3	3	1.8
Pig	head	2	3	4	1	4	2	2	3	4	1	2.6
Chicken/Dug	head	4	7	8	2	4	2	3	7	3	3	4.3
7 Gross Income	Rp/yr	867,250	1,756,250	3,297,200	1,435,000	675,750	1,337,500	804,250	270,000	910,000	1,667,500	1,302,070
(Crop)	Rp/yr	87,250	36,250	97,200	35,000	165,750	57,500	44,250	0	0	137,500	66,070
(Livestock)	Rp/yr	780,000	1,720,000	2,000,000	1,400,000	510,000	1,280,000	760,000	270,000	910,000	1,530,000	1,116,000
(Side job)	Rp/yr	0	0	1,200,000	0	0	0	0	0	0	0	120,000
8 Expenditure	Rp/yr	520,000	1,180,250	2,189,000	1,258,750	906,500	1,327,328	1,008,250	1,148,100	881,125	1,118,250	1,153,755
(Food/Drink)	Rp/yr	204,000	450,000	1,044,000	594,000	528,000	786,000	570,000	774,000	540,000	456,000	594,600
(Living)	Rp/yr	291,000	588,750	710,000	539,000	327,000	502,078	409,000	345,850	296,500	350,000	435,918
(Education)	Rp/yr	0	125,000	300,000	30,000	35,000	24,000	18,000	0	0	300,000	83,200
(Production)	Rp/yr	25,000	16,500	135,000	95,750	16,500	15,250	11,250	28,250	44,625	12,250	40,038
9 Surplus/Deficit	Rp/yr	347,250	576,000	1,108,200	176,250	-230,750	10,172	-204,000	-878,100	28,875	549,250	148,315

Source : JICA's Agro-economy Survey

Table 2.1 Projected Domestic and Livestock water Demand

Unit : m3

Village	Sub-village	1999			2004		
		Domestic	Livestock	Total	Domestic	Livestock	Total
Oinbit	Oinbit RT 04	5,563	2,426	7,989	6,023	2,776	8,799
	Oinbit RT 05	6,220	2,988	9,208	6,745	3,383	10,128
	Ekafalo RT 02	7,118	3,037	10,155	7,709	3,439	11,148
	Beneficial Area Total	18,901	8,451	27,352	20,477	9,598	30,075
	Ekafalo RT 03	6,701	2,858	9,559	7,271	3,236	10,507
	Ekafalo RT 06	7,008	3,037	10,045	7,599	3,439	11,038
	Maonmuti	9,833	4,865	14,698	10,665	5,483	16,148
	Total	42,443	19,211	61,654	46,012	21,756	67,768

Source : Provincial Statistic Office, NTT

Table 2.2 Estimated Evapotranspiration (Eto)

Site : Benkoko
Meteorological Station : Kefamenanu Station

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
T mean	C	26.20	25.90	25.90	25.60	25.10	23.90	23.10	23.80	25.30	26.80	27.70	26.90
RH mean	%	89.90	89.80	90.20	87.50	90.70	89.20	87.80	83.70	80.80	83.80	82.10	89.70
U km/day	km/day	51.10	54.30	36.60	28.40	27.50	42.00	58.70	71.90	55.80	61.90	43.90	34.30
ea	mbar	33.81	33.22	33.22	32.65	31.70	29.46	28.10	29.29	32.08	35.07	36.96	35.28
RH/100		0.90	0.90	0.90	0.88	0.91	0.89	0.88	0.84	0.81	0.84	0.82	0.90
ed	mbar	30.40	29.83	29.96	28.57	28.75	26.28	24.67	24.52	25.92	29.39	30.34	31.65
(ea-ed)	mbar	3.41	3.39	3.26	4.08	2.95	3.18	3.43	4.77	6.16	5.68	6.62	3.63
f(u)		0.41	0.42	0.37	0.35	0.34	0.38	0.43	0.46	0.42	0.44	0.39	0.36
(1-W)		0.25	0.25	0.25	0.26	0.26	0.27	0.28	0.27	0.26	0.24	0.23	0.24
(1-W)f(u)(ea-ed)	mm/day	0.35	0.36	0.30	0.36	0.26	0.33	0.41	0.60	0.67	0.60	0.60	0.32
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	5.10	5.20	6.70	7.50	6.70	6.20	7.20	8.40	8.70	9.00	7.70	6.10
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)		0.45	0.46	0.53	0.57	0.54	0.52	0.56	0.61	0.61	0.62	0.56	0.49
Rs	mm/day	7.42	7.49	8.17	8.06	6.90	6.23	6.95	8.18	9.07	9.79	9.00	7.94
Rns	mm/day	5.94	5.99	6.53	6.45	5.52	4.99	5.56	6.54	7.25	7.83	7.20	6.35
f(T)		15.94	15.85	15.85	15.80	15.65	15.36	15.20	15.36	15.70	16.06	16.22	16.06
f(ed)		0.09	0.10	0.09	0.10	0.10	0.11	0.12	0.12	0.11	0.10	0.09	0.09
f(n/N)		0.46	0.48	0.60	0.67	0.62	0.59	0.66	0.74	0.75	0.76	0.65	0.53
Rnl=f(T)f(ed)f(n/N)	mm/day	0.69	0.72	0.90	1.07	0.97	0.99	1.18	1.34	1.32	1.18	0.98	0.75
Rn =Rns-Rnl		5.25	5.27	5.63	5.38	4.55	4.00	4.38	5.20	5.93	6.65	6.22	5.60
W		0.75	0.75	0.75	0.75	0.74	0.73	0.72	0.73	0.74	0.76	0.77	0.76
W Rn		3.94	3.94	4.21	4.01	3.37	2.91	3.16	3.78	4.40	5.03	4.76	4.25
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	4.72	4.73	4.97	4.81	3.99	3.56	3.92	4.82	5.58	6.20	5.90	5.02

Source : JICA Study Team estimation by Modified Penman Method based on the meteorological data at Kefamenanu station (19~~ to 19~~)

Table 2.3 Effective Rainfall (ER)

Site : Benkoko
Meteorological Station : Kefamenanu

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	146	220	17.8%	139	97	96
February	132	219	17.7%	138	97	93
March	154	190	15.4%	120	84	85
April	144	92	7.4%	58	41	44
May	124	79	6.4%	50	35	36
June	107	37	3.0%	23	16	17
July	122	28	2.3%	18	12	14
August	149	9	0.7%	6	4	0
September	167	10	0.8%	6	4	0
October	192	26	2.1%	16	11	14
November	177	112	9.1%	71	49	58
December	156	215	17.4%	136	95	97
Total	1,770	1,237	100.0%	781	547	554

Note ;

[1] : Estimated by modified Penman method based on Kefamenanu station in this study
[2] : Rainfall data in Kefamenanu station compiled by P3SA (1925-1992)
[3] : Percentage of monthly rainfall to annual rainfall, calculated from column [2]
[4] : 781 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 Kefamenanu station (1925 - 1992)

Table 2.4 Irrigation Water Requirement (1/2)

Site : Benkoko
Crops : Wet Season Paddy

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
		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	4.72	4.72	4.73	4.73	4.97	4.97	4.81	4.81	3.99	3.99	3.56	3.56	3.92	3.92	4.82	4.82	5.58	5.58	6.20	6.20	5.90	5.90	5.02	5.02	
	mm	71	76	66	66	75	80	72	72	60	64	53	53	59	63	72	77	84	84	93	99	89	89	75	80	1,771
II. Wet Season Paddy																										
(1) Proposed cropping pattern / Crop coefficient																										
- WP-1		LP	1.10	1.10	1.05	1.05	0.95	0.00																	LP	
- WP-2		LP	LP	1.10	1.10	1.05	1.05	0.95	0.00																	
- WP-3			LP	LP	1.10	1.10	1.05	1.05	0.95	0.00																
(2) Crop consumptive use (Etc)																										
- WP-1	mm		83	73	70	78	76	0																		379
- WP-2	mm			73	73	78	83	69	0																	376
- WP-3	mm				73	82	83	76	69	0																383
(3) Land preparation (IR)																										
- WP-1	mm	186																							202	388
- WP-2	mm	186	198																							384
- WP-3	mm		198	174																						372
(4) Percolation																										
- WP-1	mm		32	28	28	30	32																			
- WP-2	mm			28	28	30	32	30																		
- WP-3	mm				28	30	32	30	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	47	50	48	49	41	43	21	20	17	18											24	25	46	49	
(7) Field water requirement																										
- WP-1	mm	139	65	103	49	117	65	0																	153	690
- WP-2	mm	139	148	53	102	67	122	78	0																	709
- WP-3	mm		148	126	52	121	72	135	79	0																733
(8) Diversion requirement	mm	143	185	144	104	157	133	109	40																78	1,093
	m3/ha	1,430	1,850	1,440	1,040	1,570	1,330	1,090	400																780	10,930

Source : JICA Study Team estimate based on the meteorological data at the Kefamenanu station

Table 2.4 Irrigation Water Requirement (2/2)

Site : Benkoko
Crops : Dry Season Palawija (Red onion)

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
		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	4.72	4.72	4.73	4.73	4.97	4.97	4.81	4.81	3.99	3.99	3.56	3.56	3.92	3.92	4.82	4.82	5.58	5.58	6.20	6.20	5.90	5.90	5.02	5.02	
	mm	71	76	66	66	75	80	72	72	60	64	53	53	59	63	72	77	84	84	93	99	89	89	75	80	1,771
II. Red onion																										
(1) Proposed cropping pattern / Crop coefficient(Kc)																										
- DO-1												0.50	0.60	0.95	0.75											
- DO-2													0.50	0.60	0.95	0.75										
- DO-3														0.50	0.60	0.95	0.75									
(2) Crop consumptive use(Etc)																										
- DO-1	mm											27	32	56	47											
- DO-2	mm												27	35	60	54										
- DO-3	mm													29	38	69	58									
(3) Effective rainfall (ER)	mm	46	50	47	46	41	44	22	22	17	19	9	8	7	7	0	0	0	0	7	7	29	29	47	50	
(4) Field water requirement																										
- DO-1	mm											18	24	49	40											131
- DO-2	mm												19	28	53	54										154
- DO-3	mm													22	31	69	58									180
(5) Diversion requirement	mm										0	12	28	66	82	82	39	0								309
	m3/ha										0	120	280	660	820	820	390	0								3,090

Source : JICA Study Team estimate based on the meteorological data at Kefamenanu station

Table 3.1 Estimated Half Monthly Discharge at Proposed Embung Site

Embung Benkoko

Unit : 1000 m3

	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	
1976	56.00	13.00	13.00	34.00	100.00	70.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	54.00	33.00	75.00	48.00	104.00	769.00
1977	111.00	34.00	98.00	105.00	142.00	50.00	51.00	13.00	31.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	105.00	94.00	1,003.00
1978	92.00	105.00	111.00	100.00	62.00	13.00	30.00	13.00	79.00	100.00	40.00	13.00	74.00	13.00	32.00	13.00	13.00	13.00	13.00	13.00	13.00	50.00	89.00	102.00	1,196.00
1979	13.00	51.00	82.00	111.00	99.00	95.00	28.00	13.00	13.00	75.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	50.00	67.00	853.00
1980	138.00	158.00	93.00	150.00	43.00	36.00	13.00	58.00	29.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	42.00	68.00	93.00	96.00	1,160.00
1981	134.00	74.00	79.00	38.00	59.00	30.00	31.00	13.00	56.00	36.00	30.00	13.00	35.00	29.00	13.00	13.00	27.00	76.00	13.00	13.00	35.00	108.00	122.00	105.00	1,182.00
1982	42.00	111.00	86.00	65.00	95.00	59.00	35.00	38.00	13.00	42.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	42.00	62.00	846.00
1983	54.00	82.00	173.00	123.00	64.00	54.00	128.00	51.00	38.00	13.00	59.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	52.00	74.00	62.00	44.00	35.00	46.00	1,243.00
1984	77.00	49.00	82.00	103.00	80.00	81.00	35.00	39.00	54.00	33.00	41.00	13.00	13.00	13.00	13.00	13.00	13.00	31.00	13.00	32.00	13.00	28.00	50.00	99.00	1,018.00
1985	74.00	103.00	105.00	105.00	46.00	46.00	55.00	13.00	13.00	13.00	44.00	13.00	13.00	13.00	13.00	13.00	13.00	32.00	13.00	65.00	13.00	39.00	64.00	98.00	1,019.00
1986	51.00	136.00	42.00	69.00	73.00	37.00	34.00	13.00	13.00	35.00	13.00	13.00	13.00	55.00	13.00	13.00	13.00	13.00	13.00	33.00	13.00	13.00	32.00	43.00	796.00
1987	117.00	106.00	55.00	72.00	13.00	79.00	13.00	13.00	13.00	53.00	36.00	13.00	35.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	55.00	108.00	57.00	942.00
1988	91.00	93.00	70.00	64.00	58.00	111.00	64.00	13.00	13.00	13.00	13.00	13.00	42.00	13.00	13.00	13.00	27.00	13.00	13.00	13.00	13.00	83.00	70.00	78.00	1,007.00
1989	50.00	59.00	84.00	44.00	185.00	71.00	48.00	104.00	36.00	13.00	13.00	31.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	78.00	13.00	39.00	34.00	1,006.00
1990	113.00	111.00	73.00	54.00	62.00	13.00	13.00	127.00	57.00	74.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	148.00	77.00	1,078.00
1991	28.00	67.00	81.00	165.00	29.00	13.00	95.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	97.00	69.00	78.00	91.00	982.00
1992	93.00	32.00	43.00	50.00	119.00	60.00	32.00	13.00	13.00	105.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	742.00
1993	149.00	140.00	81.00	49.00	13.00	13.00	13.00	13.00	13.00	29.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	13.00	41.00	13.00	59.00	769.00
Average	82.39	84.67	80.61	83.39	74.56	51.72	40.61	31.83	28.33	38.11	22.56	14.00	20.44	16.22	14.06	13.00	14.56	18.56	15.17	23.72	27.94	41.72	66.61	73.61	978.39

Table 3.2 Estimated Flood Discherge

Benkoko Scheme

Characteristics of the catchment area								
Catchment Area	(km2)	2.30						
Eelevation at Dam Site (1)	(m)	560						
Maximum elevation in the catchment area (2)	(m)	930						
Height (3)=(2)-(1)	(h)	370						
Length of Catchment Area (l)	(m)	2,200						
Flow velocity	W2 (km/hr)	24.71						
Time of concentration	T2 (hrs)	0.09						
Estimate of the Design Flood Discherge								
Return Period	(years)	2	5	10	20	50	100	200
Rainfall	(mm/day)	53	73	87	102	124	141	160
Rainfall intensity within the time of concentration	(mm)	37	50	60	70	85	96	109
Designed Flood	(m3/s)	19	26	31	36	43	49	56
Specific Discharge	(m3/s/km2)	8	11	13	16	19	21	24

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

Table 3.3 Result of Water Quality Test

Benkoko Scheme

DESCRIPTION	UNIT	1 Upstream of proposed embung	2 Embung Site	3 Embung Site	4 downstream of proposed embung	Max. Limit of B Class by GR. NO. 20/1990
I. PHYSICS						
1 Temperature	C	24.00	23.00	24.00	26.50	Normal water temperature
2 Dissolved solid matter	mg/liter	519.00	419.00	382.00	321.00	1000
3 Electric Conductivety	umhos/cm	706.00	570.00	520.00	437.00	-
II. CHEMISTRY						
a. Unorganic chemistry						
1 Mercury	mg/liter	0.00	0.00	0.00	0.00	0.001
2 Ammonia	mg/liter	0.00	0.00	0.00	0.00	0.5
3 Aroenic	mg/liter	-	-	-	-	0.05
4 Barium	mg/liter	-	-	-	-	5
5 Ferro	mg/liter	0.00	0.00	0.00	0.00	1
6 Fluoride	mg/liter	0.80	0.90	0.90	1.00	1.5
7 Cadmium	mg/liter	0.00	0.00	0.00	0.00	0.005
8 Chloride	mg/liter	33.40	31.90	34.10	31.90	600
9 Chronium, valense-6	mg/liter	0.00	0.00	0.00	0.00	0.05
10 Manganese	mg/liter	0.00	0.00	0.00	0.00	0.5
11 Nitrate, N	mg/liter	0.00	0.50	0.00	0.00	10
12 Nitric, N	mg/liter	0.00	0.00	0.00	0.00	1
13 Dissolved Oxygen	mg/liter	6.35	6.14	7.03	6.58	*
14 pH	-	6.80	7.50	8.00	7.80	5-9
15 Selenium	mg/liter	-	-	-	-	0.01
16 Zinc	mg/liter	0.00	0.00	0.00	0.00	5
17 Cyanide	mg/liter	0.00	0.00	0.00	0.00	0.1
18 Sulphate	mg/liter	8.30	9.00	12.50	12.50	400
19 Sulfide, H2S	mg/liter	0.00	0.00	0.00	0.00	0.1
20 Copper	mg/liter	0.00	0.00	0.00	0.00	1
21 Lead	mg/liter	0.00	0.00	0.00	0.00	0.1
b. Organic Chemistry						
1 Aldrin and Dieldrin	mg/liter	0.00	0.00	0.00	0.00	0.017
2 Chlordane	mg/liter	0.00	0.00	0.00	0.00	0.003
3 DDT	mg/liter	0.00	0.00	0.00	0.00	0.042
4 Endrine	mg/liter	0.00	0.00	0.00	0.00	0.001
5 Fenol	mg/liter	0.00	0.00	0.00	0.00	0.001
6 Heptachlor and Heptachlor Epoxide	mg/liter	-	-	-	-	0.018
7 Carbon Cloroform Ektract	mg/liter	-	-	-	-	0.5
8 Lindane	mg/liter	0.00	0.00	0.00	0.00	0.056
9 Methoxychlor	mg/liter	-	-	-	-	0.035
10 Oil and Fat	mg/liter	0.00	0.00	0.00	0.00	Nil
11 Organofosphate and Carbomate	mg/liter	0.00	0.00	0.00	0.00	0.1
12 PCB	mg/liter	-	-	-	-	Nil
13 Senyawa atife biru (Sulfaktan)	mg/liter	0.00	0.00	0.00	0.00	0.5
14 Toxaphene	mg/liter	0.00	0.00	0.00	0.00	0.005
III MICRO BIOLOGY						
1 Coliform tinja	per 100 ml	28,000	350	350	11,000	2,000
2 Total Coliform	per 100 ml	35,000	920	540	13,000	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 5.1 Design Value of Embankment Materials

Benkoko Scheme

Item		Unit	Design Value
Natural Water Content	(NWC)	%	23.1
Bulk Density	(γ d max)	g/cm3	1.932
Maximum Dry Density	(γ t)	g/cm3	1.69
Saturated Density	(σ sat)	g/cm3	2.090
Optimum Moisture Content	(Wopt)	%	18.7
Specific Gravity	(Gs)	-	2.56
Liquid Limit	(LL)	%	45.3
Plastic Limit	(PL)	%	16.9
Plastic Index	(PI)	%	28.4
Shrinkage Limit	-	%	19.1
Angle of Internal Friction	(ϕ)	°	30.0
Cohesion (UU/CU)	(C)	kg/cm2	1.3
Permeability	(K)	cm/sec	3.00E-06
Classification of Soil	-	-	CL

Table 6.1 Summary of Construction Equipment

Benkoko Scheme

No.	Equipment	Capacity	Munimum Number
1	Bulldozer	21 ton	2
2	Wheel loder	1.2 m3	1
3	Backhoe	1.2 m3	2
4	Backhoe	0.6 m3	3
5	Dump Truck	11 ton	12
6	Dump Truck	7 ton	3
7	Type roller	10 ton	1
8	Motor grader	3.7 m	1
9	Water Tanker(Sprinkler)	6 kl	1
10	Leg drill	2.8 m3/min	2
11	Sinker	3.3 m3/min	2
12	Air compressor	14 m3/min	1
13	Batching plant	0.75 m3	1
14	Agitator (Trunk mixer)	3.0 m3	2
15	Concrete bucket	1.0 m3	2
16	Concrete vibrator	-	3
17	Truck crane	20 ton	1
18	Water pump	3,7 kw	2
19	Welder	300 A	2
20	Diesel generator	80 KVA	2
21	Truck	7 ton	4
22	Truck with crane	6 ton	1
23	Pickup car	-	4
24	Jeep	-	4
25	Concrete pump	20 m3/hr	1

Table 7.1 Summary of Project Cost

Scheme : BENKOKO

Item	Amount (Rp. million)
I. Direct Construction Cost	
1.1 Preparatory Works	272
1.2 Embung Construction	
1) Main dam	2,241
2) Spillway	1,234
3) Intake, outlet & diversion channel	280
4) Leakage protection works	836
5) Miscellaneous	459
Sub-total of 1.2	5,050
1.3 Domestic Water Supply	
1) Pipe line	81
2) Division boxes	99
3) Miscellaneous	18
Sub-total of 1.3	198
1.4 Embung Operation and Maitenace Road	111
1.5 Irrigation Facilities	74
Sub-toal of I.	5,705
II. Administration Cost	285
III. Engineering Services	856
Sub-total of I, II & III	6,846
IV. Physical Contingency	1,027
Sub-total of I, II, II, & IV	7,873
V. Contract Tax	759
VI. Land Aquisition Cost	29
Sub-total I, II, III, IV, V & VI	8,660
VII. Price Contingency	866
GRAND TOTAL	9,526

Table 7.2 Direct Construction Cost (1/3)

Scheme : BENKOKO

Item	Unit	Unit Price Rp.	Quantity	Total 1000 Rp.
I. Embung				
1. Main Dam				
1.1 Earth/stone works				
1) Clearing	m2	400	21,000	8,400
2) Excavation	m3	5,500	21,000	115,500
3) Embankment	m3	8,000	221,000	1,768,000
4) Rip-rap protection	m3	15,000	9,700	145,500
1.2 Other miscellaneous works				203,740
Sub-total of 1.				2,241,140
2. Spillway				
2.1 Earth works				
1) Clearing	m2	400	6,500	2,600
2) Excavation	m3	5,500	28,000	154,000
3) Backfill	m3	5,200	5,000	26,000
2.2 Concrete works				
1) Concrete - A	m3	250,000	300	75,000
2) Concrete - B	m3	170,000	3,000	510,000
3) Reinforcement bar	ton	1,500,000	66	99,000
4) Form	m2	15,000	17,000	255,000
2.3 Other miscellaneous works	L.S			112,160
Sub-total of 2.				1,233,760
3. Intake, Outlet & Diversion Channel				
3.1 Earth works				
1) Clearing	m2	400		0
2) Excavation	m3	5,500	3,000	16,500
3) Backfill	m3	15,000		0
3.2 Concrete works				
1) Concrete - A	m3	250,000		0
2) Concrete - B	m3	170,000	1,400	238,000
3) Reinforcement bar	ton	1,500,000		0
4) Form	m2	15,000		0
3.3 Other miscellaneous works	L.S			25,450
Sub-total of 3.				279,950
4. Leakage Protection Works				
4.1 Earth works				
1) Clearing	m2	400	51,000	20,400
2) Earth blanket works	m3	8,000	102,000	816,000
4.2 Concrete lining works	m2	170,000		0
Sub-total of 4.				836,400
5. Miscellaneous & Others				459,125
Total of I.				5,050,375

Table 7.2 Direct Construction Cost (2/3)

Scheme : BENKOKO

Item	Unit	Unit Price Rp.	Quantity	Total 1000 Rp.
II. Domestic Water Supply				
1. Pipe line				
1.1 Earth works				
1) Clearing	m2	400	12,900	5,160
2) Excavation	m3	5,000	2,090	10,450
3) Backfill	m3	5,200	2,080	10,816
1.2 Pipe line setting works				
1) Dia 40 mm	m	5,300		0
2) Dia 50 mm	m	7,400	6,420	47,508
3) Dia 65 mm	m	9,200		0
5) Dia 75 mm	m	13,300		0
6) Dia. 400 mm	m	218,000		0
1.3 Pipe line related structures				
1) Check valve	nos.	624,000	5	3,120
2) Air valve	nos.	506,000	3	1,518
3) Drainage valve	nos.	1,036,000	2	2,072
Sub-total of 1.				80,644
2. Division Boxes				
1) Division box for inhabitants	nos.	6,990,000	10	69,900
2) Division box for livestock	nos.	1,130,000	26	29,380
Sub-total of 2.				99,280
3. Miscellaneous & Others	L.S			17,992
Total of II.				197,916
III. Embung Operation and Maintenance Road				
1. Road Works				
1.1 Earth works				
1) Clearing	m2	400	22,300	8,920
2) Excavation	m3	5,000		0
3) Embankment	m3	6,300	100	630
4) Pavement (lime stone)	m3	15,000	3,580	53,700
2. Related structures				
2.1 Cross drain	nos.	4,700,000	8	37,600
3. Miscellaneous and others	L.S			10,085
Total of III				110,935

Table 7.2 Direct Construction Cost (3/3)

Scheme : BENKOKO

Item	Unit	Unit Price Rp.	Quantity	Total 1000 Rp.
IV. Irrigation Facilities				
1. Canal works				
1.1 Earth works				
1) Clearing	m2	400	3,300	1,320
2) Excavation	m3	5,000	1,100	5,500
3) Embankment	m3	6,300	1,000	6,300
1.2 Concrete works				
1) Concrete - A	m3	250,000	110	27,500
2) Concrete - B	m3	170,000	15	2,550
3) Reinforcement bar	ton	1,500,000	3	4,500
4) Form	m2	15,000	790	11,850
2. Related structures				
2.1 Irrigation inlet box	nos.	1,600,000	1	1,600
2.2 Aqueduct	nos.	2,750,000		0
2.3 Cross drain	nos.	4,700,000	1	4,700
2.4 Irrigation division box	nos.	600,000	3	1,800
3. Rehabilitation of existing canal				
3.1 Weir rehabilitation	L.S			
3.2 Canal rehabilitation	L.S			
4. Miscellaneous & Others	L.S			6,762
Total - IV				74,382
GRAND TOTAL				5,433,608

Table 8.1 Price Structures for Paddy in NTT (June 1994 price level)

	Item	Import Parity			Export Parity		
		Operation	US$/ton	Rp./kg	Operation	US$/ton	Rp./kg
1	Export price of Thai 5% broken, FOB Bangkok 1)		283			283	
2	Quality adjusment 2)	x 0.9	255		x 0.9	255	
3	Shipping and insurance cost	+	35		+	0	
4	Import price, bagged milled rice, CIF Surabaya	=	290		=	255	
5	Convert to Rupiah	x 2,117		613.3	x 2,090		539.2
6	Port handling, storage and losses 3)	+		25.0	-		25.0
7	Handling and transportation cost to Kupang	+		50.0	-		50.0
8	Ex-wholesaler	=		688.3	=		464.2
9	Conversion to price of dried paddy 4)	x 0.65		447.4	x 0.65		301.7
10	Milling charge 5)	-		12.0	-		12.0
11	Handling and transportation cost to farm gate 6)	-		30.0	-		30.0
12	Economic farm gate price of dried paddy	=		405.4	=		259.7
		≠		(405)	≠		(260)
	Average farm gate price of Import-Export parity			333 Rp./kg			

Note: 1) Based on "Quarterly Review of Commodity Markets, IBRD Third Quarter 1993" with 1990 constant prices infrated to 1994 prices using factor of 1.1085 based on MUV index.
2) 90% of world price.
3) Includes port costs, transport to warehouse, spraying and fumigation, unloading, warehouse rents, losses at unloading and at the warehouse.
4) Standard coversion rate at DOLOG
5) Net of value of by-products at includes milling/storage losses.
6) Includes 1% losses.

Table 8.2 Price Structures for Palawija Crops in NTT (June 1994 price level)

	Item	Operation	US$/ton	Rp./kg
Maize				
1	Export price, FOB US Gulf port 1)		116	
2	Freight and insurance	+	35	
3	Import price, maize, CIF Surabaya	=	151	
4	Convert to Rupiah	x 2,117		319.7
5	Port handling and storage	+		29.2
6	Internal transportation cost (Surabaya-Kupang)	+		50.0
7	Ex-wholesaler (Kupang)	=		398.9
8	Handling and transportation cost to project site	-		30.0
9	Local transport and handling losses	-		5.0
10	Economic farm gate price of maize	=		363.9
		≠		(364)
Mungbean				
1	Import price, CIF Jakarta 2)		427	
2	Convert to Rupiah	x 2,117		904.0
3	Port handling and storage	+		40.7
4	Transport to wholesaler (Jakarta)	+		5.0
5	Ex-wholesaler (Kupang)	=		949.7
6	Internal transportation cost (Jakarta-Kupang)	-		50.0
7	Handling and transportation cost to project site	-		30.0
8	Local transport and handling losses	-		5.0
9	Economic farm gate price of mungbean	=		914.7
		≠		(915)

Note: 1) Based on "Quarterly Review of Commodity Markets, IBRD Third Quarter1993"
2) Estimated on the basis of CIF Jakarta prices for last 5 years.

Table 8.3 Price Structures for Fertilizer in NTT (June 1994 price level)

Item	Operation	US$/ton	Rp./kg
Urea			
Export price FOB Europe, bagged 1)		160	
Transport premium	+	15	
FOB Palembang	=	175	
Conversion to Rupiah	x 2,117		370.5
Cost of shipping to Surabaya	+		8.0
Port handling charges	+		19.3
Handling and transportation cost to project area	+		65.0
Economic cost of bagged urea at farm gate	=		462.8
	≠		(463)
TSP			
Export price, FOB US Gulf, bulk 1)		139	
Shipping and insurance cost to Surabaya	+	65	
Import price CIF Surabaya	=	204	
Conversion to Rupiah	x 2,117		431.9
Port handling charges	+		19.3
Bagging cost	+		15.0
Handling and transportation cost to project area	+		65.0
Economic cost of bagged TSP at farm gate	=		531.2
	≠		(531)
Potassium Chloride (KCl)			
Export price, FOB, Vancouver, bulk 1)		119	
Shipping and insurance cost to Surabaya	+	65	
Import price CIF Surabaya	=	184	
Conversion to Rupiah	x 2,117		389.5
Port handling charges	+		19.3
Bagging cost	+		15.0
Handling and transportation cost to project area	+		65.0
Economic cost of bagged TSP at farm gate	=		488.8
	≠		(489)

Note: 1) Based on "Quarterly Review of Commodity Markets, IBRD Third Quarter1993" with 1990 constant prices infrated to 1994 prices using factor of 1.1085 based on MUV index.

Table 8.4 Economic Crop Budget per Ha
(June 1994 price level)

Benkoko Scheme

Item		Unit	Unit Value	Without Project		With Project					
				Paddy (Rainfed)		Paddy (Irrigated)		Red Onion (Irrig.)		Mungbean (Rainfed)	
			(Rp.)	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount	Q'ty	Amount
Gross Production Value											
Paddy		kg	333	1,200	399,600	4,000	1,332,000	0	0	0	0
Red Onion		kg	690	0	0	0	0	7,500	5,175,000	0	0
Mungbean		kg	915	0	0	0	0	0	0	1,000	915,000
Production Cost											
Seed											
Paddy	Certified	kg	537	0	0	25	13,425	0	0	0	0
	Own	kg	333	60	19,980	0	0	0	0	0	0
Red Onion		kg	850	0	0	0	0	2,000	1,700,000	0	0
Mungbean	Certified	kg	1,383	0	0	0	0	0	0	30	41,490
	Own	kg	893	0	0	0	0	0	0	0	0
Fertilizer											
Urea		kg	463	50	23,150	200	92,600	300	138,900	50	23,150
TSP		kg	531	25	13,275	80	42,480	200	106,200	100	53,100
KCl		kg	489	0	0	40	19,560	100	48,900	50	24,450
Agro-chemicals		liter	10,000	0.0	0	2.0	20,000	10.0	100,000	2.0	20,000
Rodenticide		kg	5,500	0.0	0	0.5	2,750	3.0	16,500	1.0	5,500
Labor											
Family		md	1,500	60	90,000	165	247,500	250	375,000	82	123,000
Hired		md	2,000	0	0	10	20,000	250	500,000	0	0
Draft Animal		ad	5,000	40	200,000	40	200,000	40	200,000	40	200,000
Tractor		ha	20,000	0	0	0	0	0	0		0
Miscellaneous (10% of above)					34,641		65,832		318,550		49,069
Total production cost					381,046		724,147		3,504,050		539,759
Net Production Value					18,555		607,854		1,670,950		375,241

Table 8.5 Calculation of Economic Net Production Value (June 1994 price level)

Item	Tasiepah Embung	Benkoko Embung	Matasio Embung
A Harvested Area (ha)			
1. With Project			
a. Paddy	160	35	75
b. Mungbean	160	35	0
c. Red Onion	0	70	0
2. Without Project			
a. Paddy	73	35	60
b. Maize	87	0	3
B Unit Net Production Value (Rp./ha)			
1. With Project			
a. Paddy	607,854	607,854	693,053
b. Mungbean	466,741	375,241	0
c. Red Onion	0	1,670,950	0
2. Without Project			
a. Paddy	117,164	18,555	248,310
b. Maize	280,661	0	369,961
C Net Production Value (Rp.1,000)			
1. With Project			
a. Paddy	97,257	21,275	51,979
b. Mungbean	74,679	13,133	0
c. Red Onion	0	116,967	0
Sub-total for C1	171,935	151,375	51,979
2. Without Project			
a. Paddy	8,553	649	14,899
b. Maize	24,418	0	1,110
Sub-total for C2	32,970	649	16,008
D Incremental Amount (Rp. 1,000)	138,965	150,725	35,970

Table 8.6 Summary of Economic Costs and Benefits for Economic Evaluation (June 1994 price level)

(Unit : Rp. million)

Item	Tasiepah Embung	Benkoko Embung	Matasio Embung	Total
1. Cost Allocation (Financial Cost)				
1.1 Investment Cost	22,688	9,526	5,267	37,481
(a) Domestic and Livestock Water Supply	12,906	4,255	3,897	21,058
(b) Irrigation Water Supply	8,848	4,879	1,153	14,880
1.2 Administrative Cost born from Counter Budget	934	392	217	1,543
2. Economic Investment Cost for Irrigation				
1.1 Direct construction cost				
(a) Embung	3,013	2,110	361	5,484
(b) Irrigation Water Distribution System	908	53	149	1,110
Sub-total	3,921	2,163	510	6,594
1.2 Engineering services	745	411	97	1,253
1.3 Physical contingency	700	386	91	1,177
Total investment cost	5,366	2,960	698	9,024
1.5 Annual disbursement				
1st Year	285	158	44	487
2nd Year	1,591	2,802	654	5,047
3rd Year	3,490	0	0	3,490
4th Year	0	0	0	0
5th Year	0	0	0	0
3. Annual O&M cost				
3.1 Embung, intake and pipe (0.5% 0f 1.1)	20	11	3	33
4. Economic irrigation benefit				
4.1 Annual net production value (see Table 8-5)				
(a) With project net benefit	171.9	151.4	52.0	375.3
(b) Without project net benefit	33.0	0.6	16.0	49.6
4.2 Incremental net benefit (= a - b)	138.9	150.8	36.0	325.7
5. Negtive benefit	0	0	0	0

Table 8.7 Economic Costs and Benefits Flow (Benkoko Embung Development Project)

EIRR = -0.1 %

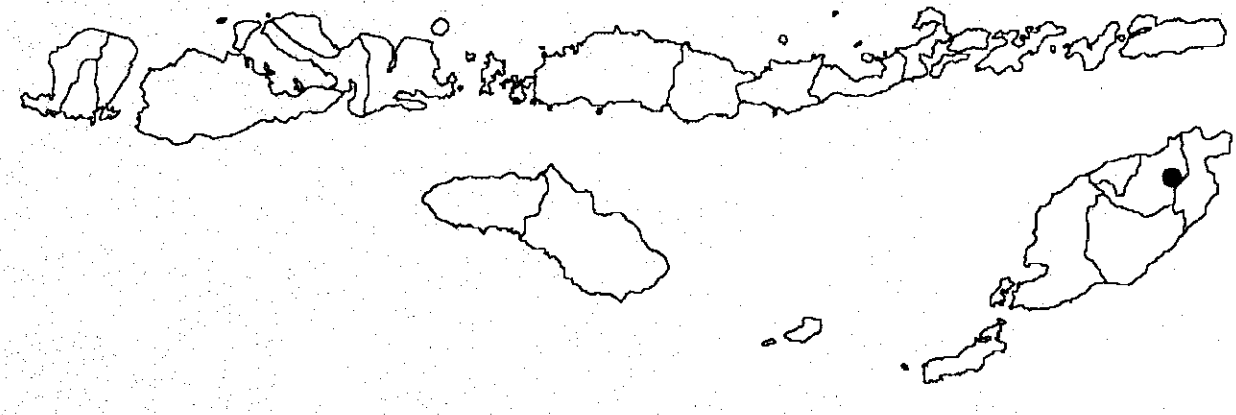
Year	Cost				Benefit			Increment
	Capital	Replace	O&M	Total	Irrigation	Negative	Total	
1.	158	0	0	158	0	0	0	-158
2.	2,802	0	0	2,802	0	0	0	-2,802
3.	0	0	0	0	0	0	0	0
4.	0	0	11	11	91	0	91	80
5.	0	0	11	11	106	0	106	95
6.	0	0	11	11	121	0	121	110
7.	0	0	11	11	136	0	136	125
8.	0	0	11	11	151	0	151	140
9.	0	0	11	11	151	0	151	140
10.	0	0	11	11	151	0	151	140
11.	0	0	11	11	151	0	151	140
12.	0	0	11	11	151	0	151	140
13.	0	0	11	11	151	0	151	140
14.	0	0	11	11	151	0	151	140
15.	0	0	11	11	151	0	151	140
16.	0	0	11	11	151	0	151	140
17.	0	0	11	11	151	0	151	140
18.	0	0	11	11	151	0	151	140
19.	0	0	11	11	151	0	151	140
20.	0	0	11	11	151	0	151	140
21.	0	0	11	11	151	0	151	140
22.	0	0	11	11	151	0	151	140
23.	0	0	11	11	151	0	151	140
24.	0	0	11	11	151	0	151	140
25.	0	0	11	11	151	0	151	140

Note: June1994 price level

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

Feasibility Study on Benkoko Embung Development Project

Figures



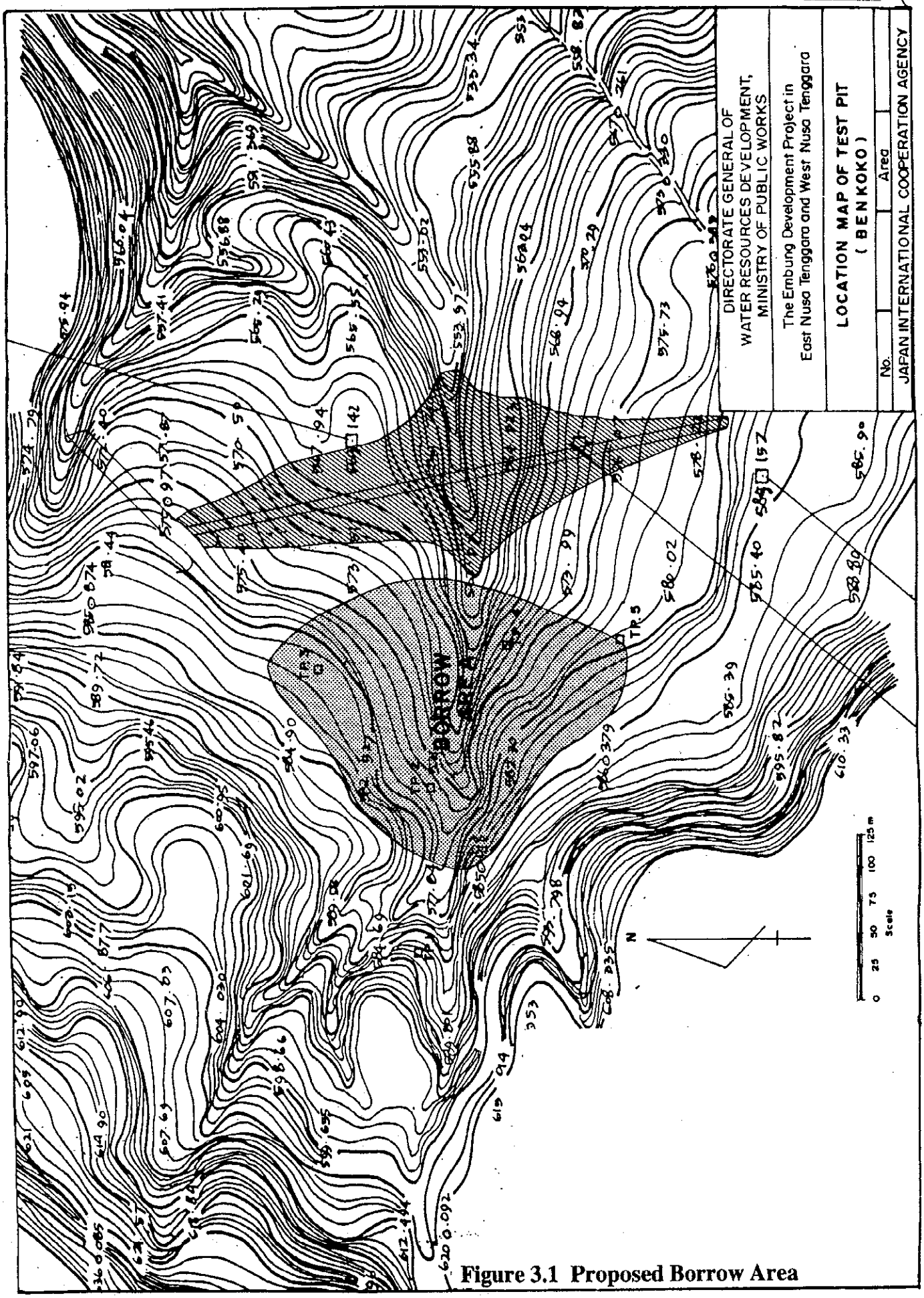


Figure 3.1 Proposed Borrow Area

LEGEND

- Rd — River deposits
- Tr — Terrace deposits
- Db — Debris
- Bc — Claystone : Bobonaro Formation
- Ml — Limestone : Maubisse Complex
- Geological boundary
- Dip and strike of bed
- Bore hole
- A — A' Geological profile line

N

0 25 50 75 100 125 m
Scale

DIRECTORATE GENERAL OF
WATER RESOURCES DEVELOPMENT,
MINISTRY OF PUBLIC WORKS

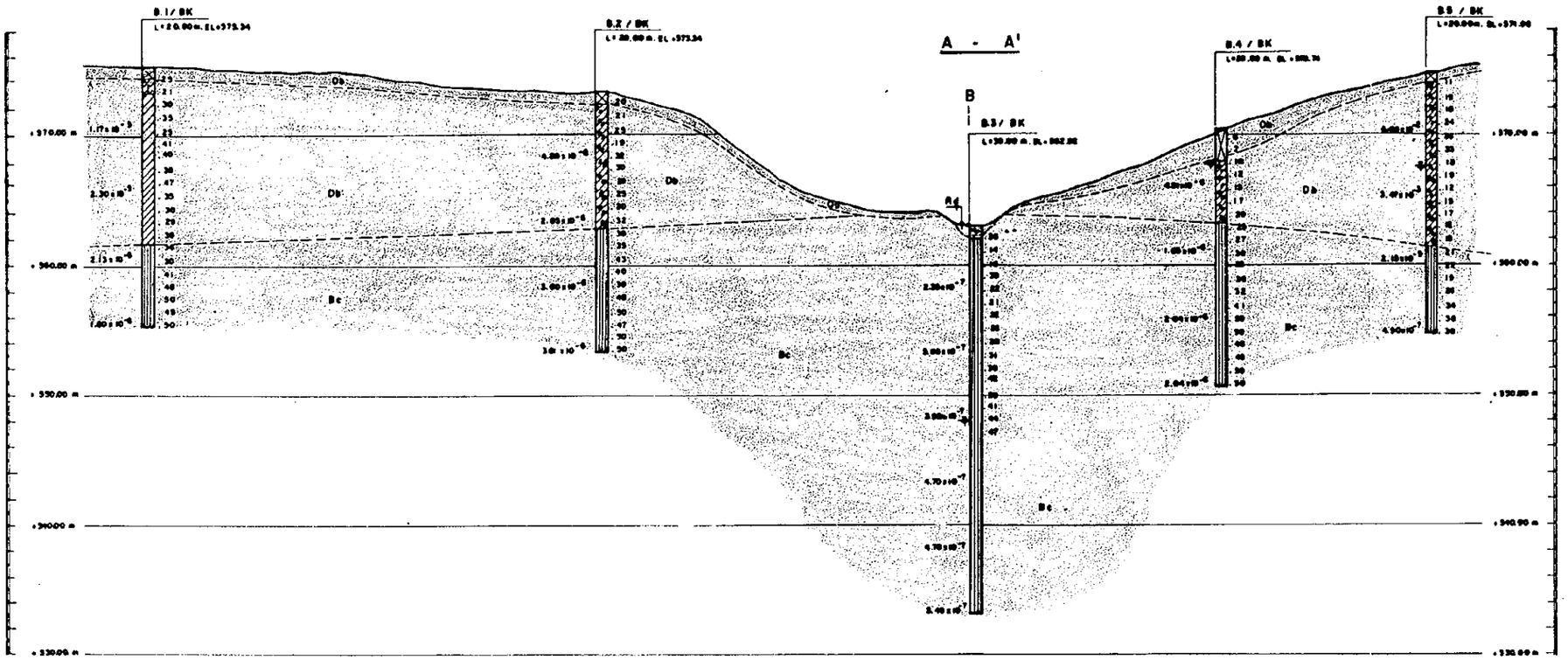
The Emburig Development Project in
East Nusa Tenggara and West Nusa Tenggara

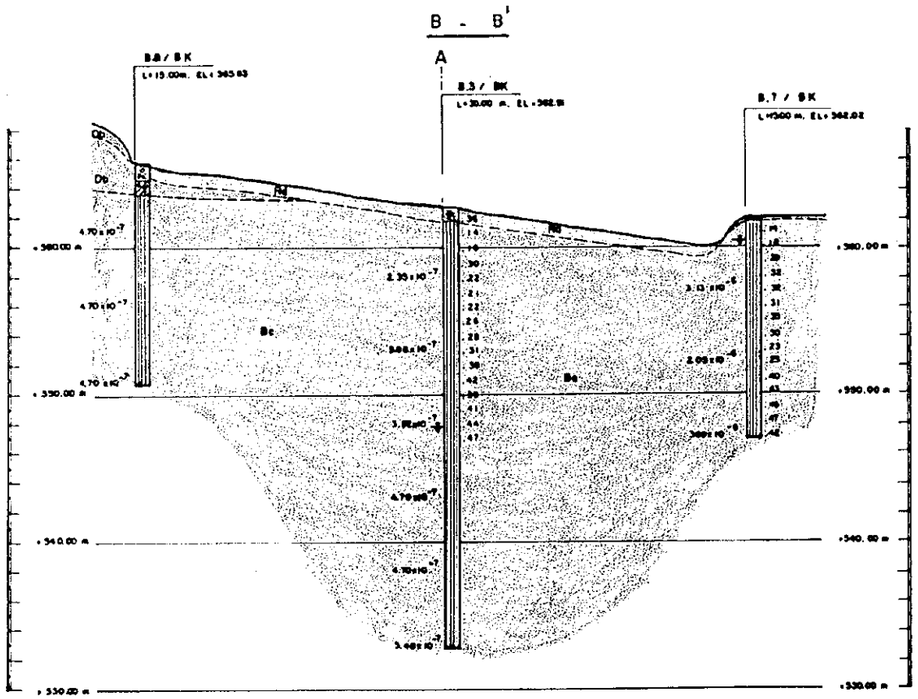
GEOLOGICAL MAP OF BENKOKO SITE

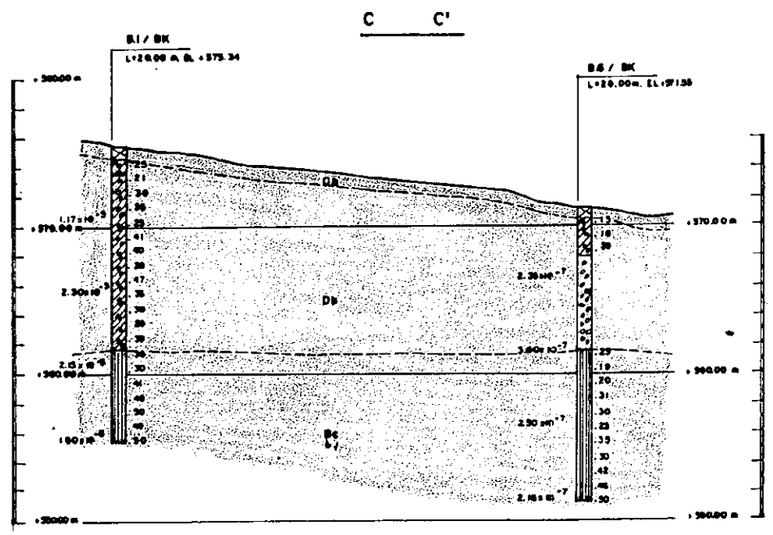
No.		Area	

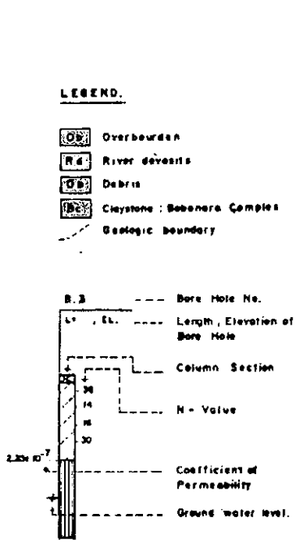
JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.2 Geological Map and Profile (1/2)









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 BENKOKO SITE

No. | Area

JAPAN INTERNATIONAL COOPERATION AGENCY

Figure 3.3 Geological Map and Profile (2/2)

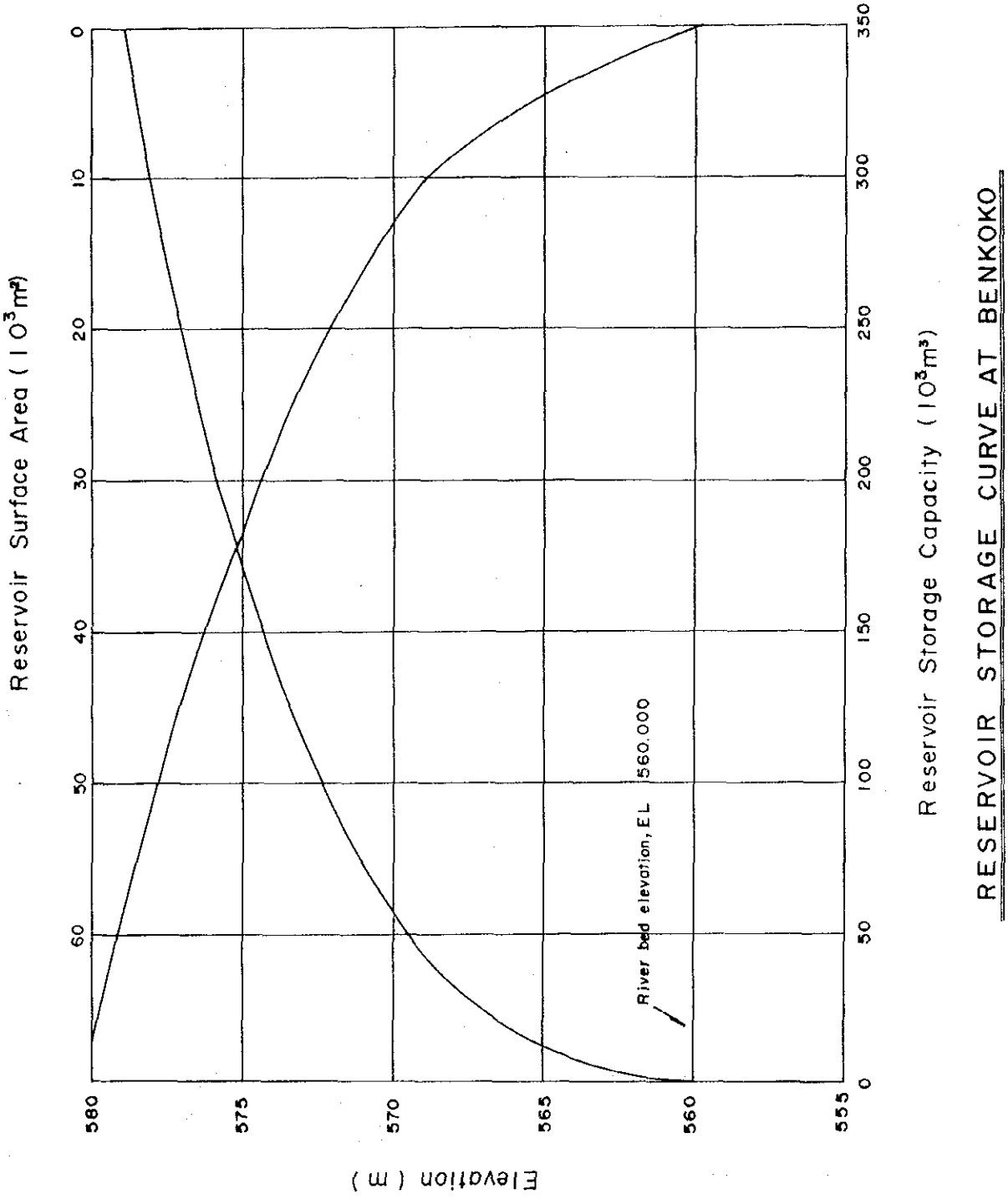


Figure 4.1 Reservoir Storage Curve

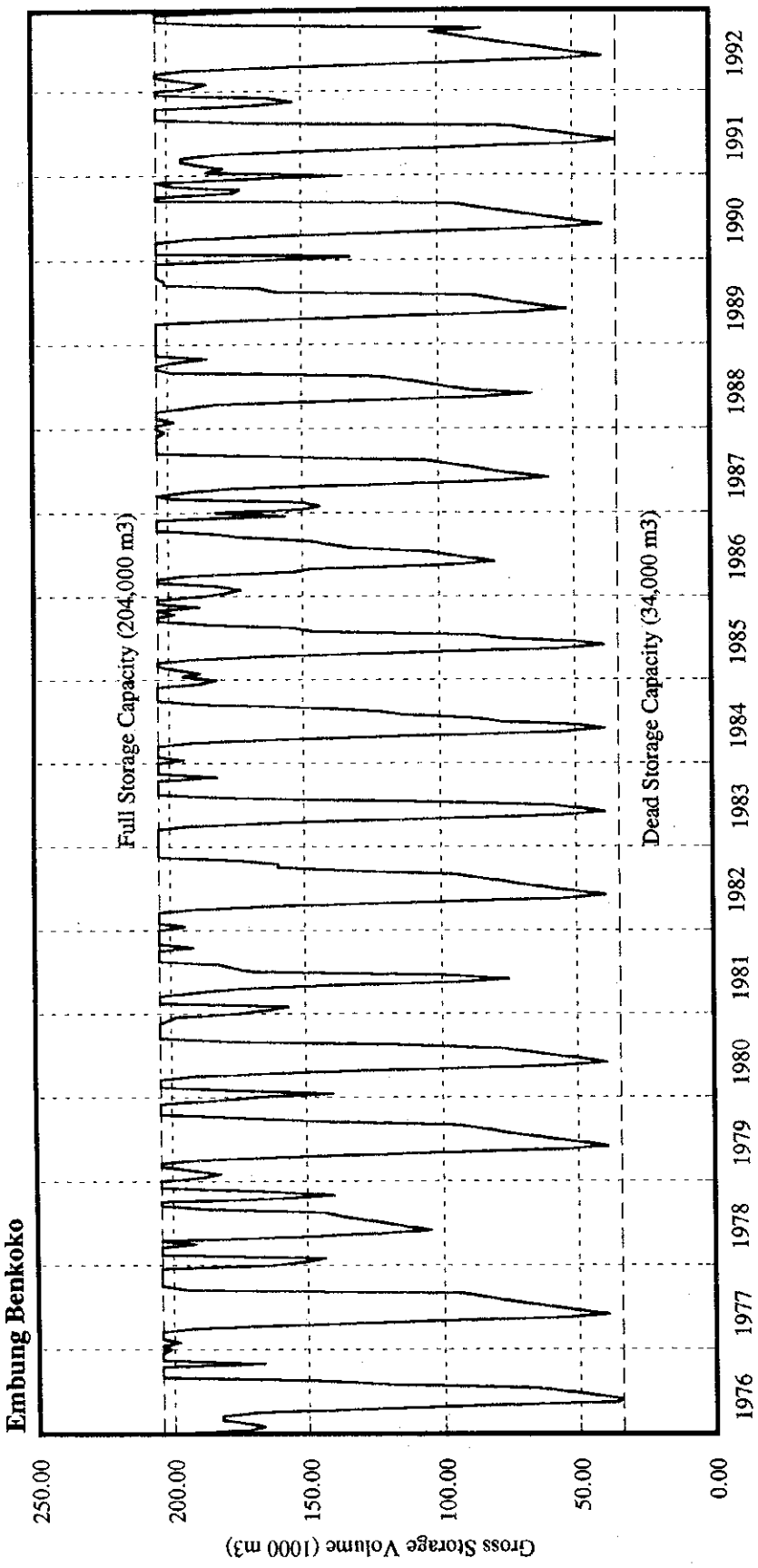


Figure 4.2 Result of Reservoir Operation

BENKOKO

縮尺 1 / 750

	Slope	Safety factor
Upstream	1: 3.5	1.23
Downstream	1: 3	1.48

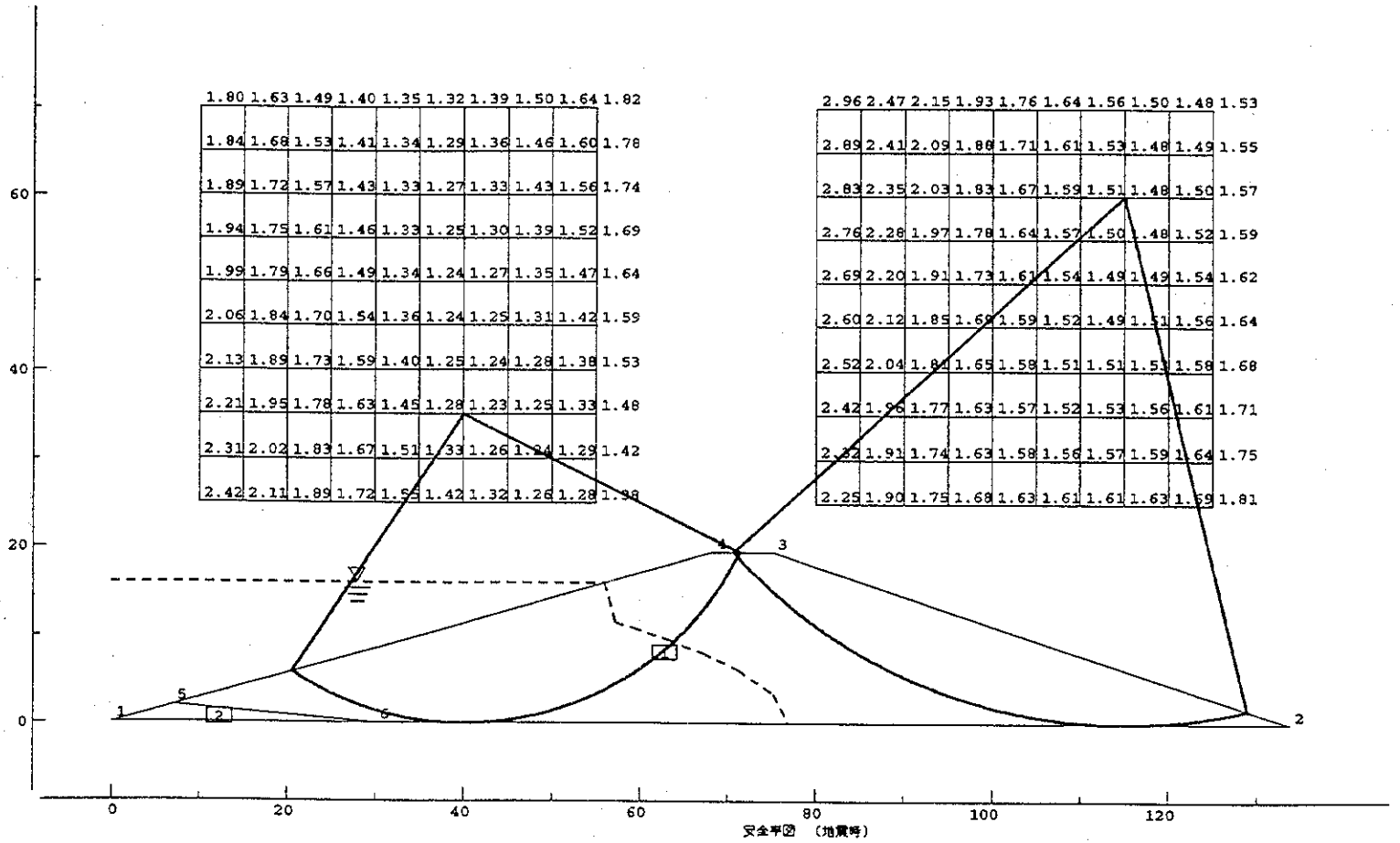


Figure 5.1 Stability Analysis

Benkoko Scheme

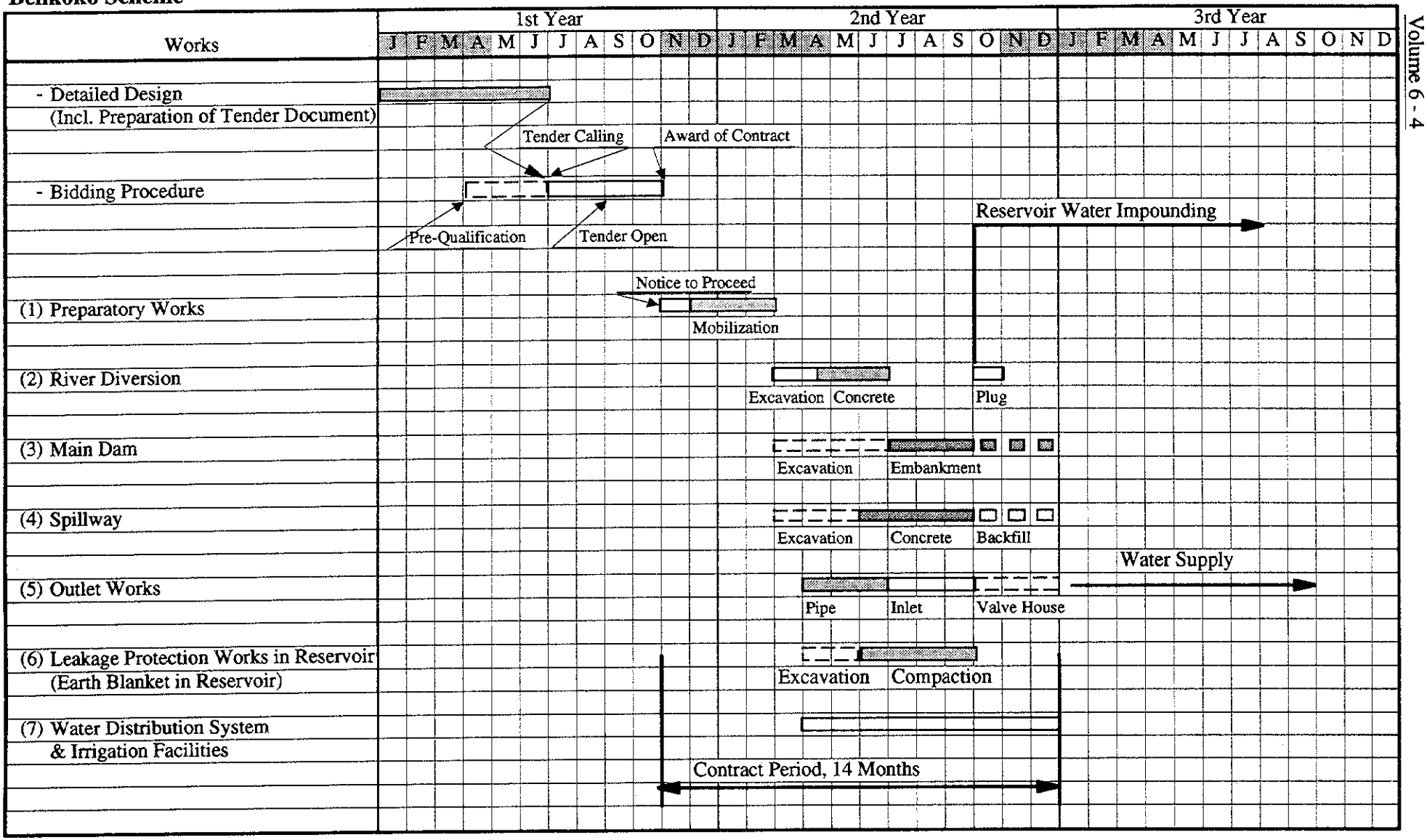
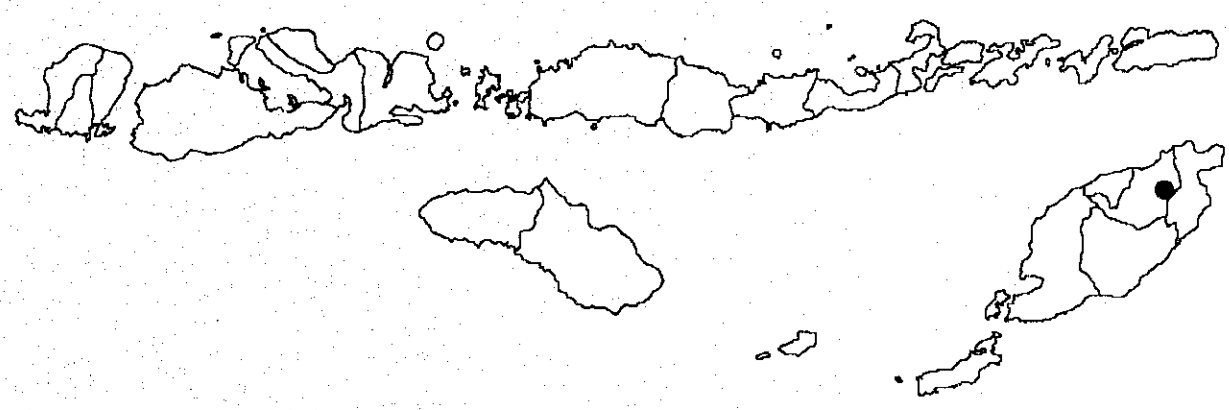


Figure 6.1 Construction Time Schedule

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

Feasibility Study on Benkoko Embung Development Project

Attachments



Irrigation Water Requirement

Irrigation water demand is estimated at unit irrigation area of one hectare in semi-monthly base in order to consider the optimization of development scale and the water resource allocation plan, and to decide the basic dimensions of the Embung for the Tasiepah scheme. First, proposed cropping pattern for this scheme is made taking into considerations of existing cropped area and cropping pattern of the Embung's beneficially area. Second, water demand calculations per hectare are made based on the established cropping patterns and climatic conditions of this scheme. Water demand is estimated by the following formula :

Irrigation Water Demand = (Etc + IR + RW + P - ER) / IE x A

Where,
Etc = crop consumptive use = Eto x kc
Eto = evapotranspiration
kc = crop coefficient
IR = land preparation water (for paddy)
RW = layer replacement water (for paddy)
P = percolation loss (for paddy)
ER = effective rainfall
IE = irrigation efficiency
A = irrigation area

(1) Crop consumptive use (Etc)

The crop consumptive use is calculated as

Etc = kc x Eto

Where,
Etc : crop consumptive use (mm/day)
Eto : evapotranspiration (mm/day)
kc : crop coefficient

The crop coefficients for paddy and beans given by FAO and Irrigation Design Standard, KP -01 by PU, DGWRD are used for the calculations as shown below :

Crop coefficient (Kc)

Month	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Paddy	1.10	1.10	1.05	1.05	0.95	0.00		
Upland Paddy	1.10	1.10	1.10	1.10	1.10	1.05	0.95	0.00
Beans	0.50	0.75	1.00	1.00	0.82	0.23		
Red onion	0.50	0.60	0.95	0.75				
Leaf vegetable	0.50	0.70	0.95	0.90				
Maize	0.50	0.59	0.96	1.05	1.02	0.95	0.60	

Source : FAO and KP-01

(2) Evapotranspiration (Eto)

Evapotranspiration can be estimated by some empirical equations using meteorological data. Major calculation methods are introduced by FAO Irrigation and Drainage Paper No.24, " Crop Water Requirement " which is quoted in the Design Criteria KP-01 by PU, DGWRD. Monthly evapotranspirations are computed in this study by using the Modified Penman method introduced in the above.

(3) Land preparation water requirement (IR)

Land preparation water requirements for paddy include a pre-saturation amount to increase moisture in the dry field to a workable condition, and water to compensate for evaporation and percolation loss during the period of land preparation. The land preparation period is assumed to be 30 days. Initial application depth for land preparation of paddy fields is taken at 250 mm, including presaturation of the soil, pudding of soil, and water requirements for nurseries.

For the calculation of the irrigation requirements during land preparation, Van de Goor and Zijlstra's formula as described in Irrigation Design Standard (KP-01) is used.

(4) Percolation (P)

Deep percolation is the water that flows through the soils occupied by the root system of the crop to underlying soils, and is therefore unavailable to the crops. Infiltration is the entry of water into the soils and is purely a surface phenomenon. The loss of water to deep percolation can be controlled by whatever is effective in limiting permeability or infiltration. Deep percolation is continuing use of water in producing paddy rice. Percolation occurs from paddy production areas due to the continuous free water surface maintained for most of the production period. This value will vary depending on the permeability, and in some cases the infiltration rates of the soil used for rice production. Percolation rate to estimate the irrigation demand in this scheme is assumed to be 2 mm/day over the rice producing area referring to the Irrigation Design Standard (KP-01).

Upland crops are not subject to submergence during production where any submergence, even for short term periods, may have a detrimental effect in crop production. Therefore, percolation is a field loss and is treated as a reduction in field application efficiencies.

(5) Water layer replacement (RW)

Twice water layer replacements, each of 50 mm at about 1 month and 2 months after transplanting, are considered according to the Irrigation Design Standards (KP-01). The normally flooded field is drawn down at these times in order to apply fertilizer and to carry out weeding operations. The water layer must then be replaced an allowance of 50 mm in the above periods. This allowance is not required for upland crops.

(6) Effective rainfall (ER)

Rains which fall directly on the irrigated area reduce the amount of supplemental water needed to meet the total water requirements. Only a portion of the total rainfall is effective in meeting crop requirements since some of it runs off the cultivated area and some percolates beyond the crop root zone. Estimation of effective rainfall for paddy rice irrigation is adopted at 70 % of once in 5 years rainfall and as for upland crops irrigation is adopted the USDA-SCS method as recommended in KP-01.

(7) Irrigation diversion requirement

Irrigation diversion requirements are calculated by considering the irrigation efficiency which is divided into following two components. :

a) a conveyance efficiency which account for losses from the main and secondary canal system.

b) a farm efficiency which account for losses from the tertiary canal system and the farm field irrigation application activities.

In this study, the following irrigation efficiencies for paddy and upland crops are adopted taking the information in the Irrigation Design Standard (KP-01), DGWRD into considerations.

Irrigation Efficiency

Canal	Irrigation Efficiency	
	Paddy	Upland crops
Main canal system	90 %	90 %
Secondary canal system	80 %	80 %
Tertiary system / Application efficiency	90 %	70 %
Over all	64.8 %	50.4 %

Source : Irrigation Design Standards, KP-01, DGWRD

Irrigation efficiencies of 65 % for paddy and 50 % for upland crops are applied.

Attachment - 2

Result of Soil Laboratory Test in Benkoko

Bor.No. (Depth)	Formation Classification	Unified Soil Content(%)	Water (g/cm3)	Unit Weight	Specific Gravity
B1(8.0m)	Debris	SM-SC	46.4	1.64	2.5
B2(7.0m)	Debris	CL	51.2	2.02	2.5
B2(14.0m)	Bobonaro claystone	CL	25.1	1.89	2.63
B3(5.0m)	Bobonaro claystone	CH	27.1	-	2.62
B4(3.0m)	Debris	CH	12.8	-	2.52
B4(9.0m)	Bobonaro claystone	CL	8.5	-	2.54
B5(16.0m)	Bobonaro claystone	CL	19.2	-	2.61
B6(5.0m)	Debris	CH	23.2	1.75	2.77
B7(4.0m)	Bobonaro claystone	CL	10.7	-	2.71

Result of Rock Test in Benkoko

Sample	Formation	Unit Weight (g/cm3)	Specific Gravity	Unconfined Compression (kg/cm3)
B4(6.0m)	Debris	2.6	2.73	186.03
B6(5.0m)	Debris	2.65	2.71	194.57

Attachment-3

SUMMARY OF LABORATORY TEST

PROJECT : Embung Benkoko
LOCATION OF PROJECT : Ds. Oenbit, Kec. Insana
DISTRICT : Timor Tengah Utara
PROVINCE : Nusa Tenggara Timur
DATE : Jun-94

			TP.1	TP.2	TP.3	TP.4	TP.5	Average
Depth of Sample		m	3.00	3.00	3.00	3.00	3.00	
Water Content	(Wn)	%	13.67	13.84	24.69	40.25	23.01	23.09
Unit Weight	(γ w)	g/cm3						
Maximum Dry Density	(γ d max)	g/cm3	1.760	1.570	1.820	1.540	1.745	1.69
Optimum Moisture Content	(Wopt)	%	15.25	22.20	15.60	23.00	17.60	18.73
Specific Gravity	(Gs)	-	2.51	2.50	2.65	2.58	2.57	2.56
Liquid Limit	(LL)	%	35.60	50.50	36.30	61.50	42.35	45.25
Plastic Limit	(PL)	%	14.38	20.75	15.66	18.74	14.86	16.88
Plastic Index	(PI)	%	21.22	29.75	20.64	42.76	27.49	28.37
Shrinkage Limit	-	%	24.99	18.87	15.59	23.08	12.91	19.09
Angle of Internal Friction	(ϕ)	°	30	21	36	25	28	28.00
Cohesion (UU/CU)	(C)	kg/cm2	2.080	1.300	1.000	2.400	1.000	1.56
Permeability	(K)	cm/sec	1.44E-06	1.29E-06	2.71E-06	2.43E-06	6.93E-06	
Passing of # 200 Sieve	-	%	48.80	38.53	64.89	67.70	65.15	
Clasification of Soil			CL	CH	CL	CH	CL	

1. Physical Environmental Impacts

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
LAND	Land use	Actual	I	not available					
		Potential	I	not available					
	Soil erosion	Actual	I	not available					
		Potential	I	not available					
	Soil fertility	Actual	I	not available					
		Potential	I	not available					
	Soil contamination	Actual	I	not available					
		Potential	I	not available					
WATER	River hydrology	Actual	III	available	· Flush floods in short duration are observed during the wet season	· no impact		1 2	
		Actual	III	available	· -ditto-	· It causes scour and erosion of river bed	III	5	-
		Potential	III	available	· River run-off is reduced by storage function of the reservoir	· no impact		1 2 5	
		Actual	III	available	· River flow discharge rapidly increase during the wet season	· It causes scour and erosion of riverbed · Sedimentation and erosion of riverbed induce reduction of flow area of the river	III	3	
		Actual	III	available	· -ditto-	· It causes scour and erosion of riverbed	III	4 6	
		Potential	III	available	· River run-off is reduced by storage function of the reservoir	· -ditto-	III	3 4 6	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
	River morphology	Actual	IV	available	· River section is stable because it composed of lime stone	· no impact		1 2	
		Potential	IV	available	· not applicable	· no impact		1 2	
		Actual	IV	available	· Erosion and collapse of river banks caused by floods and excess grazing are observed	· Sedimentation in the river reduces flow area of the river	III	3 5 6	
		Potential	IV	available	· Grazing is slightly controlled by means of the water supply for livestock	Decrease of sedimentation is expected	III	3 5 6	
		Actual	IV	available	· Erosion and slope collapse are not observed owing to the slope protection by dense vegetation along the river	· no impact		4	
		Potential	IV	available	· no applicable	· no impact		4	
	Flooding	Actual	III	IV available	· Overflow from river banks is not observed during floods	· no impact		1	
		Actual	III	IV available	· Intensive flow induces flood occurrence during the wet season.	· no impact		2 4	
		Actual	III	IV available	· Intensive flow induces flood occurrence during the wet season	· Erosion along the river banks is accelerated by floods	III	3 5 6	
		Potential	III	IV available	· Flood discharge is not reduced because the dam has not flood control purpose	· no impact		1 2 3 4 5 6	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I	II	III	IV	V	VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I	II	III	IV	V	VI	Embung Site 1	2	3	4	5	6	Mitigatory Measures
	Surface water availability	Actual					V		available	· Surface water is utilized in the wet season	· Surface water is utilized for livestock during the wet season					V		1						
		Potential					V		available	· Surface water is stored in the reservoir during the wet season	· Stored water is utilized as a water source for domestic water supply					V		1						
		Actual					V		available	· Surface water is utilized in the wet season	· Surface water is utilized for livestock during the wet season					V			2					
		Actual					V		available	· -ditto-	· Surface water is utilized for livestock during the wet season					V						5		
		Potential					V		available	· Surface water is stored in the reservoir during the wet season	· Stored water is constantly utilized for the uses of domestic water and livestock					V		2				5		
		Actual					V		available	· Surface water is utilized throughout the year	· Stored water is utilized as a water source for domestic water supply throughout the year · Stored water is supplementarily utilized for irrigation purpose during the wet season					V				3				
		Actual					V		available	· Surface water is utilized in the wet season	· Stored water is supplementarily utilized for irrigation purpose during the wet season					V					4			
		Actual					V		available	· -ditto-	· Stored water is supplementarily utilized for irrigation purpose during the wet season					V							6	
		Potential					V		available	· Surface water is stored in the reservoir	· Stored water is utilized as a water source for domestic water supply throughout the year · Stored water is supplementarily utilized for irrigation purpose					V				3	4		6	
	Surface water quality	Actual			III				not available															
		Potential			III				not available															
	Groundwater levels	Actual					V		not available															
		Potential					V		not available															
	Groundwater quality	Actual					V		not available															
		Potential					V		not available															

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
ATMOSPHERE	Dust, Odor, Noise	Actual	II	available	–	–			
		Potential	II	available	· Air contamination is generated by the construction works in the vicinity area	· Inhabitants and livestock in the vicinity area are affected by air contamination	V	1 2 3 4 5 6	· Proper supervisory works, e.g. education of laborer, construction schedule, safety control shall be performed.

2. Biotic Environmental Impacts

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur (I II III IV V VI)	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur (I II III IV V VI)	Embung Site	Mitigatory Measures
FAUNA	FAUNA	Actual	II	available	· There is not any inhabitant and its migration	· no impact		1 2 3 4 5 6	
		Potential	II	available	· not applicable	· no impact		1 2 3 4 5 6	
FLORA	Forests/trees	Actual	II	available	· There exist savanna and evergreen trees	· Logging by inhabitants is observed	II	1 2 3 4 5 6	
		Potential	II	available	· Logging in the reservoir area caused by dam construction is required	· Limitation of logging area by dam construction accelerate logging activities in the catchment area of the reservoir	I	1 2 3 4 5 6	· Vegetations in the catchment area should be protected by means of artificial remedy

3. Human Environmental Impacts

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Mutasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
SOCIAL	Human carrying capacity	Actual	V	available	· Human carrying capacity, which is attributed to low farm productivity due to unstable irrigation during the wet season, is still in low level	· Low employment opportunity in the dry season accelerate outflow of labor force from rural area to urban area · Low economic growth is not afford to satisfy the social demand derived from constant population growth	V	3 4	
		Potential	V	available	· Increase of human carrying capacity is expected by means of the provision of sufficient irrigation water supply in the wet/dry seasons	· Control of labor force outflow · Proper economic growth contributes to the social demand derived from constant population growth	V	3 4	
		Actual	V	available	· Human carrying capacity, which is attributed to low farm productivity due to unstable irrigation during the wet season, is still in low level	· Low economic growth is not afford to satisfy the social demand derived from constant population growth	V	6	
		Potential	V	available	· Increase of human carrying capacity is expected by means of the provision of sufficient irrigation water supply in the wet/dry seasons	· Proper economic growth contributes to the social demand derived from constant population growth		6	
	Settlement	Actual	V	available	· Settlement is not recommended to avoid conflict among indigenous social communities	· no impact		1 2 3 4 5 6	
		Potential	V	available	· Settlement is not composed of the project components	· no impact		1 2 3 4 5 6	
	Resettlement	Actual		available	—	—		1 2 3 4 5 6	
		Potential	II	available	· Involuntary resettlement is not applicable because any residence does not exist there	· not applicable		1 2 3 4 5 6	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
	Population growth	Actual	V	available	· Population is growing as same rate as nation's average	· Increase of water demand due to population growth causes the shortage of the water supply in coming year	V	1 2 5 6	
		Actual	V	available	· Twice of rapid annual population increase were observed due to implementation of irrigation project in latest 5 years	· Rapid increase of population causes the shortage of domestic water supply	V	3	
		Potential	V	available	· Constant population growth is maintained due to stable domestic water supply and medical and sanitary improvement of living condition	· Sufficient domestic water supply in proportion to the population growth is inevitable to maintain rural living condition in view points of health and sanitation	V	1 2 3 5 6	
		Actual	V	available	· Rapid annual population decreases caused by starvation from drought, and increases by implementation of irrigation project were observed due to in latest 5 years	· Decrease of population was occurred · Deterioration of a sense of social cohesion in their communities	V	4	
		Potential	V	available	· Improvement of living condition is attained through stable farm activities	· Mitigate a decrease of population · Retrieve a sense of social cohesion in their communities	V	4	
	Demographic structure	Actual	V	available	· Poor employment opportunity induces seasonal laborer movement to the urban area	· no impact	V	1	
		Potential	V	available	· not applicable	· no impact	V	1	
		Actual	V	available	· Composition of population ranges in national average by age and sex	· no impact		2 6	
		Potential	V	available	· not applicable	· no impact		2 6	
		Actual	V	available	· Young generation is likely to outflow to urban area	· no impact	V	3 4 5	
		Potential	V	available	· Labor force requirement due to increase of employment opportunity slightly reduces an outflow of young generation to the urban area	· no impact	V	3 4 5	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepab
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
	Social equity	Actual	V	available	· Indigenous practice regarding domestic water utilization, such as water right and distribution methods might incur inconvenience among them	· Restriction of water use might confuse their general concept on water use especially in the dry season	V	1 2 3 4 5 6	
		Potential	V	available	· Social equity regarding water utilization is realized through unification of water distribution system	· Achievement of effective water distribution system is acceptable for inhabitants and it improves social cohesion among them	V	1 2 3 4 5 6	
	Health	Actual	V	available	· Lacking of acknowledge about disease prevention, i.e. excretion in the field is social problem in the health and sanitary points of view	· It causes prevailing oral contagious and rising of waterborne intestinal disease among infant	V	1 2 3 4 5 6	
		Potential	V	available	· Prevention of disease infection is expected by means of stable domestic water supply	· Decrease of contagious disease and infant mortality rate are expected	V	1 2 3 4 5 6	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur	Embung Site	Mitigatory Measures
			I II III IV V VI				I II III IV V VI	1 2 3 4 5 6	
HUMAN USE	Cultivation	Actual	V	available	· Insufficient irrigation water, poor maintenance of irrigation facilities and water distribution management cause low productivity and cultivated area	· Unstable farm management causes low farm income, investment and increase unemployment rate	V	3 4 6	
		Potential	V	available	· High farm productivity and increase of cultivated area are attained by adequate irrigation water supply	· High farm income, investment and employment opportunity are realized by improvement of irrigation system	V	3 4 6	
	Livestock	Actual	V	available	· Surface water is used for livestock during the wet season · Ground water or spring yield are used in the dry season	· Shortage of domestic water is occurred in the dry season · Women are compelled to heavy duties, such as water conveyance	V	2	
		Actual	V	available	· Ground water and spring yield are available during the wet season · Ground water is principally utilized in the dry season	· -ditto-	V	4	
		Actual	V	available	· Spring yield is available	· -ditto-	V	6	
		Potential	V	available	· It is possible to supply stable water for livestock · Effective water distribution system is planned	· Water supply quantity for livestock is kept · Heavy duties of women, e.g. water conveyance, is mitigated	V	2 4 6	
		Actual	V	available	· Majority of water supply for livestock uses surface water throughout the year, the rest uses ground water	· Insufficiency of water supply for livestock is occurred during the dry season due to a shortage of surface flow · Over grazing induces erosion and slope collapse at the riverside	IV V	3 5	
		Potential	V	available	· Stable water supply is required · Effective water distribution system is required	· Water supply quantity for livestock is kept · Restriction of grazing in the river to control riverside erosion	IV V	3 5	
	Fisheries	Actual	IV	available	· Fisheries activities are not conducted at downstream of reservoir and at a mouth of river	· no impact		1 2 3 4 5 6	
		Potential	IV	available	· no impact	· no impact		1 2 3 4 5 6	
	Afforestation	Actual I		available	· Reforestation project is not implemented · Logging is conducted to maintain inhabitants' daily life	· Deterioration of recharge of ground water is observed in the reservoir catchment area · Logging accelerate soil erosion	I	1 2 3 4 5 6	
		Potential I		available	· Limitation of logging area contributes excess logging in the reservoir catchment area	· Excess logging accelerate soil erosion and results in deterioration of ground water recharge capacity and increase of inflow of sediment into the reservoir	I II III IV	1 2 3 4 5 6	· Increase of recharge capacity of ground water and effect of erosion control are expected by reforestation in the catchment area

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
	Domestic water supply	Actual	V	available	· Ground water is utilized for the domestic water supply · Private shallow wells are not useful during the dry season because of the decline of water level Public deep wells are useful during the dry season	· Shortage of domestic water supply is observed · Women are compelled to water conveyance	V	1	
		Potential	V	available	· Stable and sufficient domestic water supply shall be attained · Improvement of water system, e.g. distribution tank construction is planned	· Shortage of domestic water supply is reduced at a part of area · Heavy duties of women are mitigated	V	1	
		Actual	V	available	· Ground water or spring yield are available for the domestic water supply · Spring yield is perennially available in the case that well water is dried up in the dry season	· Shortage of domestic water supply is observed · Women are compelled to water conveyance	V	2	
		Actual	V	available	· Ground water or river water are available for the domestic water supply · Water shortage is occurred during the dry season	· -ditto-	V	3 5	
		Actual	V	available	· Ground water (including by pump lifting) and spring yield transmitted by pipeline are available for domestic water supply	· -ditto-	V	4	
		Actual	V	available	· Spring yield and ground water by pump lifting are used for domestic water supply · Shortage of water supply is occurred in a part of service area in the dry season in both water sources	· -ditto-	V	6	
		Potential	V	available	· Reliable water sources and distribution system are to be facilitated · Water distribution plan shall be established to attain stable water distribution	· Shortage of domestic water supply is reduced at a part of area · Heavy duties of women are mitigated	V	2 3 4 5 6	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepah
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I	II	III	IV	V	VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I	II	III	IV	V	VI	Embung Site 1	2	3	4	5	6	Mitigatory Measures
ECONOMIC	Income	Actual					V		available	· Farm income by single cropping in the wet season remains farmers in low income level	· Increase of farm productivity is not expected owing to the deficiency of investment (farm inputs)					V				3			6	
		Actual					V		available	· Increase of disposable income is not expected owing to a low productivity	· Increase of farm productivity is not expected owing to insufficiency of disposable income					V					4			
		Potential					V		available	· Slightly increase of farm income with improvement of farm productivity is expected by means of stable irrigation water supply	· Increase of investment incentive and improvement of living standard are expected with increase of farm income					V				3	4		6	
	Employment	Actual					V		available	· Employment opportunity remains in a low level due to a stagnation of agro-economy	· Outflow of labor force is incurred due to low employment opportunity in the rural area					V				3	4			
		Potential					V		available	· Increase of farm income with improvement of farm productivity is expected by means of stable irrigation water supply	· Outflow of labor force is controlled					V				3	4			
		Actual					V		available	· Employment opportunity remains in a low level because cultivation in the dry season is not enforced	· It causes unemployment					V							6	
		Potential					V		available	· Employment opportunity is created by activation of farming practice with irrigation water supply	· It affects decrease of unemployment					V							6	

Place I : Catchment area
Place II : Embung and reservoir area planned
Place III : River and riverbed
Place IV : Riverside
Place V : Beneficial area
Place VI : Downstream area other than beneficial area

Embung Site: 1: T101 : Bimoku
2: T102 : Oeltua
3: T103 : Tasiepab
4: T108 : Benkoko
5: T109 : Oebuain
6: RO13: Matasio

Positive Impact with Project

Negative Impact with Project

Environmental component	Environmental Issue	Actual or Potential	Places Environmental Issues Occur I II III IV V VI	Evaluation is available or not available	Actual and Potential Aspect	Actual and Potential Impact of Aspect	Places Environmental Impact Occur I II III IV V VI	Embung Site 1 2 3 4 5 6	Mitigatory Measures
CULTURAL	Historic/ archaeological sites	Actual	II	available	· Historic/archaeological remains and cultural assets do not exist	· no impact		1 2 3 4 5 6	
		Potential	II	available	· not applicable	· no impact		1 2 3 4 5 6	
	Lifestyle (quality of life)	Actual	V	available	· Women are imposed in heavy duties, e.g. water conveyance	· Physical disorder is observed in women	V	1	
		Potential	V	available	· Alleviation of women's heavy duties by means of stable supply of domestic water, etc.	· Release women from physical disorder	V	1	
		Actual	V	available	· Women are imposed in heavy duties, e.g. water conveyance for domestic use	· Physical disorder is observed in women · Indifference on education	V	2 5	
		Potential	V	available	· Alleviation of women's heavy duties by means of stable supply of domestic water, etc.	· Release women from physical disorder · Interest and spreading in education	V	2 5	
		Actual	V	available	· Women are imposed in heavy duties, e.g. water conveyance for domestic use · Living condition is still in low level	· Physical disorder is observed in women · Living condition is subjected to being distracted by natural disasters	V	3 4 6	
		Potential	V	available	· Alleviation of women's heavy duties by means of stable supply of domestic water, etc. · Living condition is upgraded by increase of farm income and employment opportunities	· Release women from physical disorder · Interest and spreading in education · Inhabitants live in affluent circumstances	V	3 4 6	

Japan International
Cooperation Agency
(JICA)

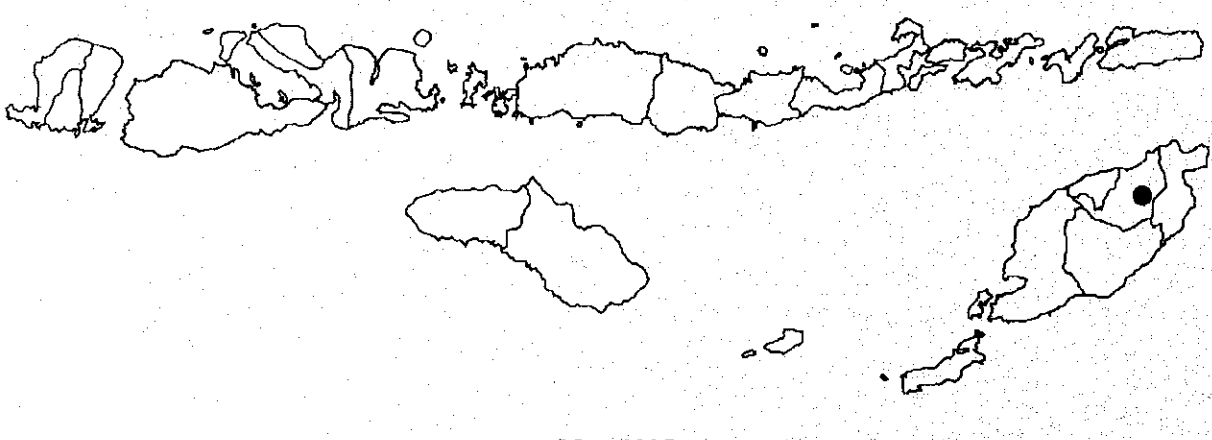
Directorate General of
Water Resources Development,
Ministry of Public Works

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

Final Report

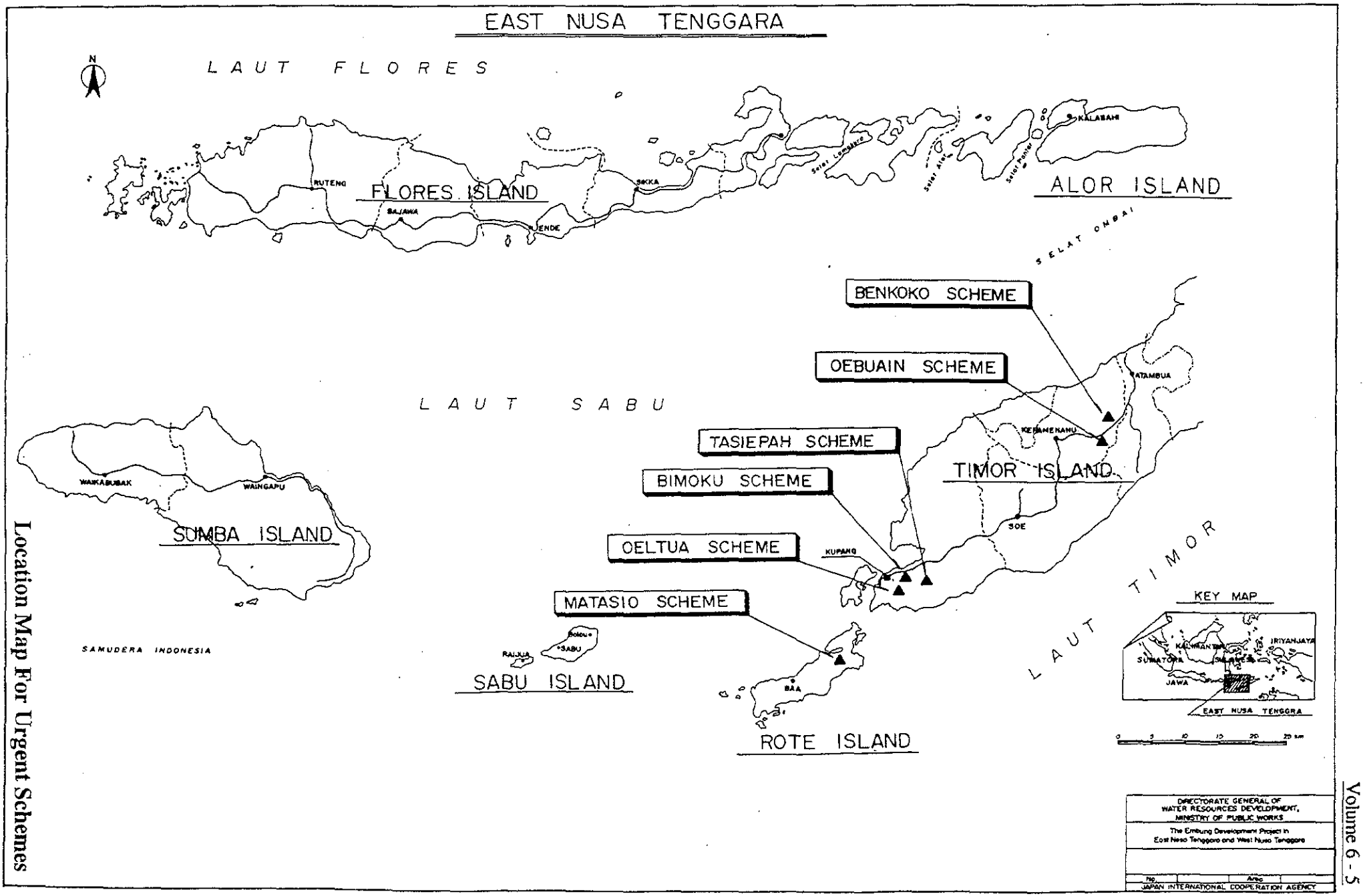
Volume 6-5

Feasibility Study
on
Oebuain Embung Development Project

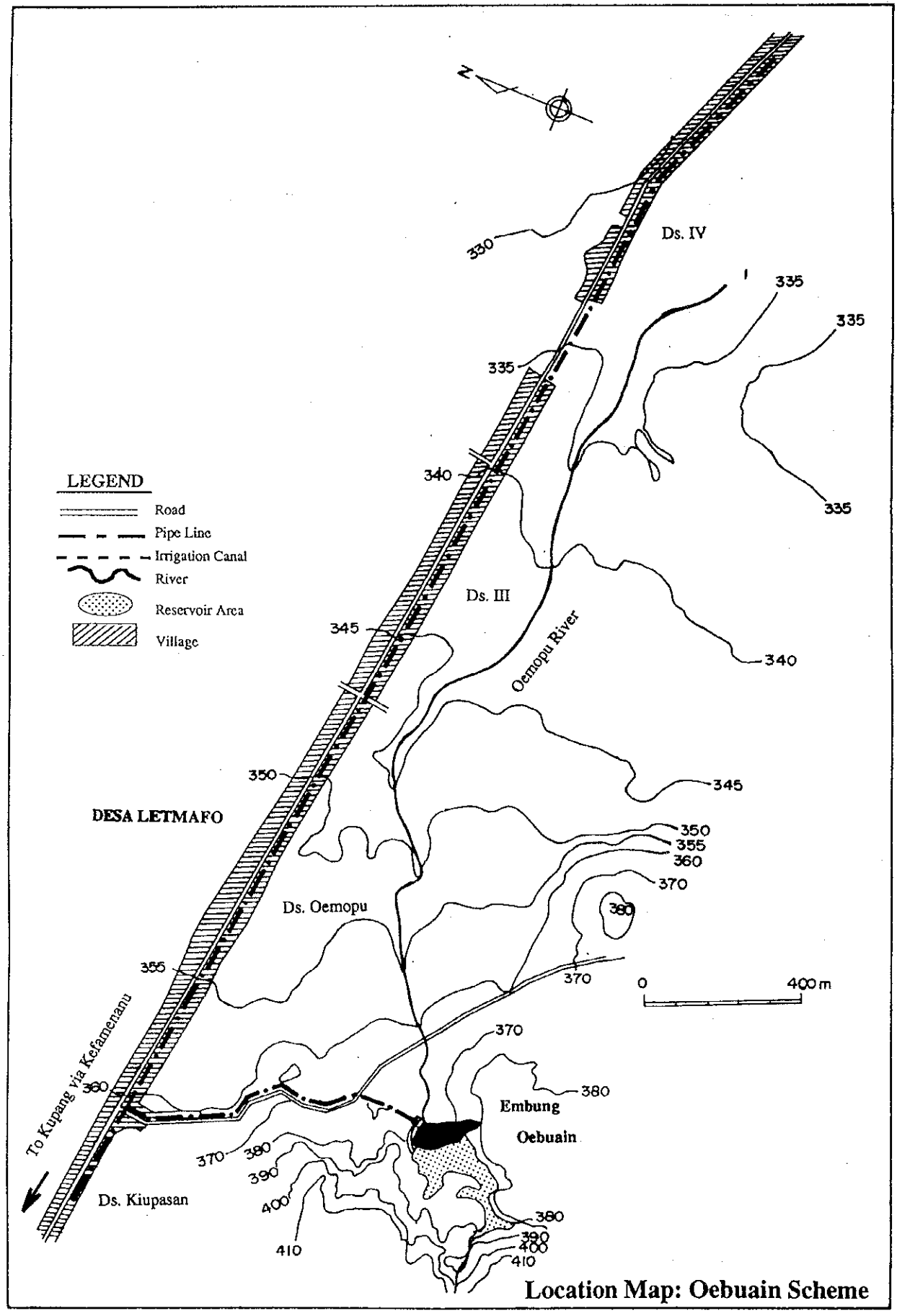


May 1995

Nippon Koei Co., Ltd.



Location Map For Urgent Schemes



Location Map: Oebuain Scheme

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 6-5

FEASIBILITY STUDY
ON
OEBUAIN EMBUNG DEVELOPMENT PROJECT

Table of Contents

List of Tables

List of Figures

List of Attachments

1. PRESENT SITUATION OF THE PROJECT AREA

1.1 Location and Topography

The Project area is located in around 140 km of northeast of Kupang, the capital of East Nusa Tenggara (NTT) Province, in the middle part of Timor island. The proposed site of Oebuain Embung has coordinates of 124°36'23" east longitude and 9° 26' 30" south latitude.

The Project area extends along the both sides of the Oemopu river, a tributary of Maubesi river. A moderately steep slope of hillock is distributed along the Oemopu river and, at the proposed Embung site, forms a rather shallow and wide valley. The Project area ranges from 330 to 360 m in elevation. The potential area for irrigated agriculture including the existing irrigation area is flat to gently rolling.

Main residential zone in the Project area is Letmafo Village (Desa) in the Sub-district (Kecamatan) of Insana of the District (Kabupaten) of Timor Tengah Utara. This villages within the Project area consists of four sub-villages (Dusun); Oemopu, Kiupasan, III and IV in Letmafo Village.

1.2 Climate and Hydrology

The wet season usually starts from late November and ends early April in the Project area with the average annual rainfall of 1,000 mm. Rainfall pattern is featured by concentrated heavy rains occurring two or three times during the wet season with the maximum 24 hours rainfall record of 58 mm. Mean annual temperature is 25.4°C with the average maximum temperature of 29.8°C and the average minimum temperature of 20.2°C. Mean relative humidity is 87.0%. Average sunshine hours are 4 to 5 hr/day during the wet season and increase to 7 to 8 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 1.97 km/hr. Tables 1.1 and 1.2 show monthly rainfall record and climate data, respectively, at the Kefamenanu station.

The Oemopu river as a potential water resource is a perennial stream with a catchment area of 0.80 km^2 at the proposed Embung site. There is no gauging station on this river. Usually, the river resume reflects the monthly rainfall pattern. Due mainly to deforestration in the catchment area, sedimentation on the river bed is common along the river stretch.

1.3 Geology

The Project area is underlain by the Tertiary and the Quaternary. The Tertiary is mainly composed of claystone called the Bobonaro Complex. The Quaternary is formed by coral limestone, alluvial terrace deposits and recent river deposits. With regard to geological formation, the Bobonaro Complex consists of massive claystone considered to be submarine landslide deposits and distributed horizontally to the river bed. Thick debris overlay the Bobonaro Complex and consist of soil with gravels of limestone and green schist. Coral limestone and sandy limestone form Coralline Limestone. Alluvial deposits comprise gravel, sand and some clay, being unconsolidated and sediments. Recent river deposits are derived from river sediments consisting of gravel, sand and clay.

1.4 Soils and Land Use

Soils in the cultivated and cultivable land in the Project area are less structured with sandy clay to sand. As low presence of exchangeable cations is common, soil reaction is slightly acid. Response to fertilizer application is high because of poor soil fertility caused by lack of organic matters in the top soil.

At present, a total land of 456 ha is used for agriculture activities comprising wet paddy field of 150 ha, dry upland of 229 ha, estate crop field of 7 ha, and grass land and idle field of 70 ha. Out of wet paddy field, 25 ha are provided with irrigation facilities diverting

seasoned flow from the Neometan river. In addition, inhabitants in the Project area possess a small piece of home yard growing vegetables and tree crops mainly for their home consumption.

1.5 Demography

The total population in the Project area as of 1993 was 1,500 and the number of households was 278 in total. The breakdown of population and household by sub-village is shown in Table 1.3. The average family size is 5.4 persons. Dominant ethnics are originated from native Timor with a few people from Belu. The majority of inhabitants are Protestant and engaged in agriculture. Their average education attainment is primary school grade.

1.6 Domestic Water Use

There exist five springs and five wells in the Project area. The Neometan river, a tributary of the Maubesi river, is supplementary used by inhabitants as water sources for domestic use. Users of these water supply sources are suffering from water shortage problem for four months every year because these go almost completely dry from September to December. The present water use in each sub-village clarified under the Study is summarized as follows:

- In Oemopu Sub-village with 75 families and 413 persons, there is a pipeline from Oeklubi spring at a distance of 1.5 km supplying water to 40 families. There exist another two springs; Ulnaet spring at the average distance of 750 m from five family users and Oenoma spring at the average distance of 1,500 m from 15 family users. These springs dry up from May in the earliest case or September in the latest case to December. Together with the remaining 15 families without any specific water source, all inhabitants carry water from the Neomtan river at the average distance of 2 km during this period. The total number of livestock is equivalent to 173 heads of cow and water for these livestock use is taken from these three springs for the wet season and the Neomtan river for the dry season;

- In Kiupasan Sub-village with 93 families and 481 persons, there are two springs; Oemopu spring at a distance of 750 m on an average from eight family users and Oenome spring at the average distance of 750 m from 20 families. These springs dry up from May in the earliest case or September in the latest case to December. Together with the remaining 65 families without any specific water source, all inhabitants carry water from the Neomtan river at the average distance of 2 km during this period. The total number of livestock is equivalent to 57 heads of cow and water for these livestock use is taken from these two springs for the wet season and the Neomtan river for the dry season;

- In No. III Sub-village with 60 families and 315 persons, there are one broken and three active public wells at the average distance of 25 m from an average from 16 family users. These wells dry up for four months from September to December. Together with the remaining 44 families without any specific water source, all inhabitants carry water from the Neomtan river at the average distance of 2 km during this period. The total number of livestock is equivalent to 31 heads of cow and water for these livestock use is taken from these two three wells for the wet season and the Neomtan river for the dry season; and,

- In No. IV Sub-village with 50 families and 291 persons, there is only one public well at a distance of 40 m on an average from 23 family users. This well goes dry for four months from September to December. Together with the remaining 27 families without any specific water source, all inhabitants carry water from the Neomtan river at the average distance of 2 km during this period. The total number of livestock is equivalent to 60 heads of cow and water for these livestock use is

taken from the public well for the wet season and the Neomtan river for the dry season.

1.7 Social Infrastructures

The access from Kupang to the Project area via Kefamenanu, the Kabupaten capital, is a paved road maintained well as it is the trans-Timor road leading to Deli from Kupang. The proposed Embung site and sub-villages are connected by unpaved gravel road to this main road. All the sub-villages in the Project area are not served yet by rural electricity supply network. In the Project area, there is no hospital but one community health sub-center and a health integrated post.

Most of 278 families have no facilities for bathing, defecating and washing inside their houses. Instead, they are using river bed and water of the Maubesi for Bathing and washing purposes, and privately their own outside toilet. Under such circumstances, inhabitants in the Project area are often suffering from various diseases like vomiting and diarrhea, malaria, dysentery and trachoma, roundworm, and so on.

1.8 Agriculture and Livestock

In the Project area, there exists farm land of 456 ha in total in which currently cultivable land of 386 ha is included. The present cropped area is dry season rainfed paddy of 25 ha, maize of 220 ha, groundnut of 5 ha, mungbean of 4 ha and coconut of 7 ha. Although paddy field of 25 ha is provided with irrigation facilities, rice cultivation is not practiced under the irrigated condition because these were damaged by flood and, instead, carried out under the rainfed condition during the dry season only. Maize is the main crop grown with various tuber crops intercropped on upland field of 215 ha under the rainfed condition. The present cropping pattern is single cropping of maize or beans for the wet season on the dry upland and rice on the wet paddy field for the dry season. The overall crop intensity is thus 67% for farm land except grassland due to existence of idle paddy field.

In the Project area, the wet paddy field is prepared by an animal-drawn plough and harrow. The high yielding rice variety of IR 64 is commonly used, while fertilizers are not applied as usual. No serious plant pests are reported under the hot and dry weather condition, and farmers put insecticide if necessary. Harvesting is principally done by family labor force with an additional input of hired labors. Farming practices for growing dry upland crops are very simple and primitive with direct sowing on harrowed field and no fertilizer application. The average yield level at present is 1.7 ton/ha for paddy, 1.1 ton/ha for maize, 8.0 ton/ha for tuber crops, 0.75 ton/ha for groundnut and 0.8 ton/ha for mungbean. Annual crop production is 42.5 tons for paddy, 242 tons for maize, 1,720 tons for tuber crops, 3.75 ton for groundnut and 3.2 tons for mungbean.

As of 1993, a total of 244 cows/buffaloes, 12 horses, 43 goats/sheep, 330 pigs and 679 chickens/ducks were raised in the Project area. The breakdown of livestock population by sub-village is shown in Table 1.4. Some pigs are marketed to and slaughtered in Kefamenanu.

1.9 Agro-economy

In terms of agricultural extension services, one rural extension center (BPP) is established in Letmafo Village directly under the District Agricultural Office (Dinas Pertanian Kabupaten) covering its own working area with field extension workers (PPL). In the Project area, however, most of the farmers have no frequent access to the PPL's extension activity at present due mainly to limited number of transportation means and amount of budget in BPP.

Farmers are organized as memberships of Agricultural Cooperative (KUD). As KUD's branch shop in the Project area is not active at present, farmers buy necessary farm inputs from local markets or merchant shops. Agricultural credits are available in the service network of the

Indonesian People's Bank (Bank Rakyat Indonesia), consisting of short-term credits to cover one crop season and a mid-term credit of five years to support farmers' small investment.

Food production in the Project area is used for home consumption of farmers themselves. They sell farm products in local markets in the Project area or middlemen for markets in Kupang when farmers need cash. The results of agro-economy survey carried out under the Study reveal that farmers in the Project area usually have some deficit in their home economy with the average annual income of Rp. 826,000 and expenditure of Rp. 1,033,000 as shown in Table 1.5.

2. DEVELOPMENT NEEDS AND CONCEPTS

2.1 Development Needs

In the Project area, it is common for 1,500 inhabitants to carry water from available water sources to their homes at the average distance of 1,560 m during the wet season and to depend their domestic water on the Neometan river flow during the dry season when all water sources dry up every year. Such water shortage condition has caused infectious diseases and damaged their health. Further, it has prevented farmers' willingness to introduce improved crop production system and to upgrade their primitive irrigation facilities.

The pressing necessity of inhabitants in the Project area is to meet basic human needs (BHN) aiming at improvement of their living conditions through solution of the water shortage problems derived from lack of perennial water sources. In addition, the inhabitants are eager to get sufficient water for maintaining their livestock which are their sources of nutrition and cash income.

The available land resources suitable for agricultural use amount to 386 ha in the Project area. Wet paddy field occupies 150 ha comprising irrigated paddy field of 25 ha and rainfed paddy field of 125 ha. However, these available land resources are located in the outside of downstream area of Oebuain Embung and there is no existing and potential paddy field being irrigable. Taking into account such less availability of irrigable land, no priority is given to develop a new irrigation water supply system in the Project area under the Study.

2.2 Water Demand

The estimated per capita domestic water consumption in the Project area is about 25 lit/day being far below the regional levels, 123 lit/day for NTT and 144 lit/day for Kabupaten Kupang. The future water demand in the Project area comprises domestic water for inhabitants, livestock water and irrigation water. In the draft Repelita VI (1993/94 to 1998/99), the Provincial Government of NTT has set the goals of meeting BHN by 1998. In terms of domestic and livestock water supply, the target is 60 lit/day/capita for rural people and 40 lit/day/head for cow.

In comparison with the present level of water consumption and taking into consideration limited availability of water resources in the Project area, the target year to reach the above water supply levels is to be set 2003/04, the last year of Repelita VII, under the Study. Also, the above per capita water supply target of 60 lit/day is to include drinking, bathing, defecating, washing, gardening and uncounted-for water. The future population of inhabitants and livestock in the target year is estimated by the Study referring to the projected population growth rates made by the Provincial Statistic and Livestock Offices.

(1) Domestic water demand

The future population in the target year of 2003/04 is projected for each sub-village located in the Project area as shown in Table 1.3 based on the projection of population growth rate mentioned in the above. The total population projected is 1,773 in the Project area. The future water demand is calculated by multiplying the target per capita water supply amount by the projected population.

The projected water demand in the Project area for the target year of 2003/04 amounts to 38,829 m^3 and the breakdown by each sub-village is shown in Table 2.1.

(2) Livestock water demand

The future livestock population in the target year of 2003/04 is projected for each sub-village located in the Project area as shown in Table 1.4 based on the projection of livestock population growth rate mentioned in the above. The livestock population projected is 317

cows/water buffaloes, 14 horses, 63 sheep/goats, 529 pigs and 1,286 chickens/ducks as a whole in the Project area.

Regarding daily water consumption of livestock other than cow, unit water requirement assumed in "The Study for Formulation of Irrigation Development Program in the Republic of Indonesia" is employed; 40 lit/head/day for cow/buffalo, 5 lit/head/day for sheep/goat, 6 lit/head/day for pig and 0.6 lit/head/day for poultry. That for horse is assumed to be 40 lit/head/day. The future water demand is calculated by multiplying the target unit water supply requirement by the projected livestock population.

The projected water demand in the Project area for the target year of 2003/04 amounts to 9,735 m^3 and the breakdown by each sub-village is shown in Table 2.1.

2.3 Development Constraints

In and around the Project area, there are no perennial spring and groundwater resources which can constantly meet BHN throughout a year. The only one potential water resource in the Project area is thus the Oemopu river with the possibility of developing Embung as water reservoir.

In developing water resource potential of the Oemopu river, it is said that there are not so much serious limitations in terms of topography, geology, hydrology, environment and socio-economy. In the western part of Timor island, 92 small Embungs have already been developed for domestic and livestock water supply, and another 11 Embungs in Sumba and Rote islands for domestic and irrigation water supply. The average height of these Embungs is 7.15 m for the case of domestic water supply and 8.75 m for the case of irrigation water supply. Under such situation, therefore, technical know-how to construct higher Embung has not been accumulated yet in both the public and private sectors in NTT.

2.4 Development Concepts and Approach

In order to correct economic imbalance between NTT and other Provinces in harmony with the national policy, it is prerequisite to give the highest priority over improvement of infrastructures related to BHN and the second priority to betterment of agricultural production base in rural areas of NTT. Among others, special attention should be paid to how to solve chronic water shortage problem under the dry weather condition being characteristic of NTT.

The objective of the Project is a part of the strategies of the Government of to improve BHN, to alleviate poverty of rural areas and to achieve a balanced regional development throughout the country. The objective of water resources development through construction of Embung is to supply domestic and livestock water to rural people for meeting their BHN as well as to utilize the existing farm land resources to the fullest extent by providing with irrigation water.

Through the previous identification study undertaken by the NTT Provincial Irrigation Service (PRIS) in 1992, a possible site to construct higher Embung was found on the Oemopu river nearby Letmafo Village. In the course of the Study, therefore, it is to examine water resources development potential at this site called Oebuain Embung from the viewpoints of topography, geology, soil engineering and hydrology. If the examination results reveal that there is a possibility of creating new permanent water source facility, development strategies of the Oebuain Embung are to be worked out including the optimization of development scale and then technical feasibility of Embung development is to be confirmed. In the end, development impacts are to be assessed from social and environmental viewpoints as well as from an economic consideration if necessary.

3. EXAMINATION OF EMBUNG DEVELOPMENT POTENTIAL

3.1 Topographic Condition

The original site of Oebuain Embung was identified by the PRIS through its identification study done in 1992. Under the present Study, the original site as shown in Figure 3.1 is reviewed from topographical and geological points of view including mapping and geological investigations. As a result, it is reconfirmed that selection of the original site by PRIS is topographically appropriate. Thus, the original site is taken up as the proposed Embung site for the Study. At the proposed site, the Oemopu river flows through shallow and rather narrow valley on the moderate steep slope of hillock. The width of valley is around 200 m and the elevation of riverbed is El. 366 m. The left bank shapes steep slope of about 15° up to around El. 385 m and then becomes gentle slope of about 5° up to the top of hill of about El. 387 m. The right bank is of relatively gentle slope of about 7° up to the ridge of around El. 395 m. Elevation of the hillock surrounding the Embung and reservoir ranges from about 365 to 405 m above sea level.

3.2 Geological Condition

Under the Study, geological investigations including core drilling works have been conducted in the proposed Embung site. The results of core drilling, standard penetration test and field permeability test are presented as Attachment 1. Figures 3.2 and 3.3 depict geological map and profile of the proposed Oebuain Embung, respectively.

The proposed site of Oebuain Embung is underlain by mainly claystone of Bobonardo Complex of the Tertiary and debris of the Quaternary. The foundation rock of the proposed site is composed of debris with silty sandy clay on the both abutments and claystone of Bobonaro Complex on the bottom of riverbed. Some of terrace deposits and small amount of alluvial deposits are confirmed on the river bed portion.

The results of field permeability test reveal that the coefficient of permeability is 1×10^{-5} to 2×10^{-6} cm/sec for the claystone and varies widely between 4×10^{-3} and 4×10^{-5} cm/sec for the debris. In the design of the foundation treatment, therefore, ordinary care against for seepage or leaking the water from the reservoir through dam foundation or the abutments is not taken into consideration. According to the standard penetration test, the average N-value of bedded claystone will be expected to be more than 20, while that of will be expected to be at least 35. The result of unconfined compression test of recovered core samples of drilling works shows that the unconfined compression strength ranges from 6 to 196 kg/cm^2 and the geological formation of foundation rock is not so hard for the dam construction. In this connection, special consideration is required for determination of dam type.

The reservoir area is underlain by mainly Bobonaro Complex. Coralline limestone distributes in the limited part such as ridge of the hill over the reservoir. No major fault and landslide are recognized in the field. It is prospected that water leakage through the debris occurs in the reservoir area because bedding rock is heterogeneous in permeability. Special attention is therefore needed to introduce practical countermeasures for water leakage.

3.3 Availability of Embankment Materials

In 1992, PRIS carried out construction material survey to check embankment and concrete aggregate materials in and around the proposed Oebuain Embung site. In addition, the second material survey is performed under the Study, comprising field test pitting and laboratory tests. In due consideration of the results of the second material survey and the required quantity of embankment materials, one borrow area (Borrow Area A) is selected in the reservoir area, while the other (Borrow Area B) is selected in the downstream area of the Proposed Embung as shown in Figure 3.1. The latter is used for the earth embankment of the

main dam. The location of test pits is shown in Figure 3.1 and the results of laboratory tests are presented as Attachment 2.

(1) Embankment materials

In general, earth materials in the borrow areas are composed of relatively fine grained soils. The result of gradation analysis in the borrow area is shown below.

Result of Gradation Analysis

Test Pit No.	Passing sieves (%) No. 4	No. 200	Classification
TP. 1	94	66	CH
TP. 2	95	82	CH
TP. 3	96	80	CH
TP. 4	95	75	CH
TP. 5	95	75	CH

As physical property to oppose piping, mean value of Plastic Index (PI) is 39, being satisfied with the quality level which enables the materials to prevent the piping phenomena.

The result of compaction test of the materials in the borrow area are as follows;

- Maximum dry density (γd max.) ranges from 1.50 to 1.70 ton/m^3 and 1.58 ton/m^3 on an average, which are slightly low in comparison with 1.50 as an average of CH;
- Optimum moisture content (OMC) ranges from 20 to 26% and 23% on an average;
- The discrepancy between OMC and the natural moisture content (NMC) is approximately 40%, wetter side from OMC. Considering the sampling time of early May 1994, NMC is more favorable in respect of the moisture control which is required for the embankment works because other borrow materials are slightly drier than those OMC. Accordingly, the moisture control needs to be considered at the borrow area during the construction period; and,
- According to the shear strength test carried out by using unconsolidated-undrained tri-axial compaction test (U-U test) apparatus under the OMC condition, the average values of internal friction angle and cohesion are 29° and 1.15 kg/cm^2, respectively. The test method is however based on U-U test which is applied to get a design value for the case of just after completion of a dam.

For a design value under the full supply level (F.S.L.) and earthquake conditions, the shearing strength at consolidated-undrained test under the effective stress condition is provisionally estimated at 24° for friction angle and 0.11 kg/cm^2 for cohesion by using the standard values of soil classified as "CH" of ASTM Unified Soil Classification.

(2) Sand and gravel materials

Sand and gravel materials to be used for the filter of the dam embankment and concrete aggregates are investigated in the Maubesi river (3 km from the proposed site) and in the Noel Mina river about 5 km west from Kefamenanu. Quantity and quality of the gravel materials from the Maubesi and Noel Mina rivers are sufficient for the filter drain and the concrete aggregates.

3.4 Availability of Water Resources

(1) Catchment yield

As for the Oemopu river, there has been no record of discharge. Accordingly, runoff at the proposed Embung site is estimated by use of the rainfall record near the proposed site. Kefamenanu rainfall station which is located in the east of the Oebuain Embung catchment has rainfall record of nearly consecutive 18 years and is considered to represent catchment rainfall. A runoff coefficient of 0.30 is adopted considering the characteristics of the catchment area and previous hydrological analysis in the Timor Island. Using this runoff coefficient and rainfall record of the Kefamenanu station, river flow of the Oemopu river at the proposed Embung site is estimated.

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

- Catchment area of the proposed Embung site is 0.80 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 1976 to 1993. The estimated half monthly discharge is given in Table 3.1 and summarized below,

Mean Monthly Discharge

Unit: 1,000 m^3

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
41	49	48	35	16	14	4	4	0	2	5	15	233

(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 NTT. In this Study, 15 years rainfall data of the Kefamenanu station from 1976 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	53
1 in 5 year	73
1 in 10 year	87
1 in 20 year	102
1 in 50 year	124
1 in 100 year	141
1 in 200 year	160

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 3.2 and summarizes below.

Probable Flood

Unit : m^3/s

Return Period	Probable Flood
1 in 2 year	8
1 in 5 year	11
1 in 10 year	13
1 in 20 year	15
1 in 50 year	18
1 in 100 year	21
1 in 200 year	24

(3) Sediment load

There is no available data on sediment load on the Oemopu 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, the same value is adopted in this Study.

(4) Water Quality

On June 5, 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 3.3.

4. EMBUNG DEVELOPMENT PLAN

4.1 Optimization of Development Scale

(1) Cases for comparison

The optimum development scale of Oebuain Embung coincides with the maximum scale which can be decided by the available run-off from the catchment area and the limitation of topography at the proposed Embung site. Therefore, only one case with the dam height of 12.0 m is taken up for the optimization study.

(2) 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)
O_D : outflow needed for domestic water during the half monthly period (m^3)
O_L : outflow needed for livestock water during the half monthly period (m^3)
O_I : outflow needed for irrigation water during the half monthly period (m^3)
W_1 : volume of water in the reservoir at the beginning of the half monthly period (m^3)
W_2 : volume of water in the reservoir at the end of the half monthly period (m^3)

1) Inflow

Since there is no gauging station on the Oemopu river, discharge is generated from rainfall of the Kefamenanu 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. The probability that the spill out comes in the wet season is set at about 80%.

5) Water demand

The annual water demand for the domestic water and livestock are outlined below:

Annual Domestic and Livestock Water Demand

Description	Unit	Numbers	Demand (m^3/year)
Beneficiaries	Nos.	1,773	38,829
Livestock (equivalent to cow)	Nos.	438	6,388

The 100% dependability of the above demand shall be secured by the proposed Oebuain Embung.

The priority of water supply is to be given firstly to domestic use and secondly to livestock use.

6) Water level of reservoir

Minimum water level is estimated at El. 371.10 m considering sedimentation volume for 25 years and 0.5 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. 387.0 m.

(3) Optimum development scale

From the topographic and hydrological points of view, there is no alternative choice to develop the Oebuain Embung. The optimum development scale is thus in line with the maximum height of 12.0 m and effective storage capacity of 0.0588 million cubic meters (MCM). The result of reservoir operation is shown in Figure 4.2.

4.2 Delineation of Beneficiary Area

By developing the proposed Oebuain Embung at the maximum scale, water demand for domestic and livestock use can be met to the fullest extent. The beneficiary area of water supply from the Oebuain Embung covers Oemopu, Kiupasan, No. III and No. IV Sub-villages of Letmafo Village with 1,773 inhabitants and 438 heads in total. The beneficiary area of Oebuain Embung is shown in Dwgs. - 501 to - 503.

4.3 Embung Development Plan

Following the result of the geological and material surveys as well as the optimization study, the proposed development plan of Oebuain Embung is determined. In terms of dam type, homogeneous earthfill type is applied in due consideration of the foundation strength and the availability of embankment materials. As for the proposed countermeasures for water leakage in the reservoir, it is proposed to adopt earth blanket to cover the reservoir area up to El. 375.0 m so as to keep the water tightness of the debris layer in the reservoir.

The main components of Oebuain Embung are the main dam, spillway, river diversion conduit and water supply facility as shown Dwg. - 504. In order to provide the reservoir with the optimum storage capacity of 0.0588 MCM, F.S.L. is set at El. 375 m. Taking overflow depth of spillway and freeboard into account, the dam hight of Oebuain Embung becomes 12 m above the river bed. In order to release the flood discharge during the construction period, a river diversion conduit with a concrete pipe of 1200 mm 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 50 m^3/sec from the catchment area of 0.8 km^2. For the purpose of supplying domestic and livestock water to the beneficiary area, such related facilities are provided as an intake structure in the reservoir, water supply pipe with a diameter of 50 mm below the dam body and valve house at the downstream of the main dam.

The principal features of Oebuain Embung are summarized Below.

(1)	Reservoir	
	- Catchment area	0.8 km^2
	- F.S.L.	El. 375.0 m
	- minimum operating level	El. 371.0 m
	- Effective storage capacity	58,800 m^3
	- Dead storage capacity	13,200 m^3
	- Gross storage capacity	72,000 m^3
	- Sediment deposition level	El. 370.4 m
(2)	Main dam	
	- Type	Homogeneous earthfill
	- Height	12 m above river bed
	- Crest elevation	El. 378.0 m
	- Crest length	180 m
	- Crest width	6.0 m
	- Upstream slope	1:4.0
	- Downstream slope	1:3.0
	- Total embankment volume	80,000 m^3
(3)	Spillway	
	- Design flood (1/100 year)	21 m^3/sec
	- Type	Non gated overflow
	- Crest elevation of overflow weir	El. 375 m
	- Width of overflow weir	7.3 m
	- Discharge capacity	21 m^3/sec
	- Length	95 m
(4)	River diversion	
	- Design flood (1/5 year)	6.7 m^3/sec
	- Type	Pipe culvert
	- Diameter	1200 mm
	- Length	99 m
(5)	Water supply system	
	- Inlet structure	1.0 x 1.0 m with trashracks
	- Pipe diameter	65 mm
(6)	Blanket in the reservoir	
	- Type	Earth blanket
	- Covering area	Up to El. 375.0 m and 21,000 m^2
	- Thickness	2.0 m

5. PRELIMINARY DESIGN OF FACILITIES

5.1 Preliminary Design of Embung

(1) Freeboard

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

The following formula is applied for the design of the dam in the Oebuain Embung;

$Hf = 0.05h + 1.0$ (m)

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

(2) Stability of dam slopes

1) Design criteria

The design criteria adopted for evaluating the stability of the dam body comprises:

- Stability of a dam embankment as a whole and safety against surface sliding of the embankment slopes; and,
- Hydraulic stability of embankment materials and safety and serviceability against leakage.

The reservoir condition to be considered here is at F.S.L. of 375.0 m under seismic condition. The dam slopes for upstream and downstream are determined using the stability calculation.

The required minimum safety factor for the stability of the embankment is 1.2 for all cases. Seismic coefficient of 0.15 is applied for the stability calculation taking into consideration design seismic coefficient applied for dam and irrigation projects.

2) Design value

Considering the result of laboratory tests, the design values of the embankment materials for the stability calculation are as shown in Table 5.1.

3) Slope stability against sliding

A slip circle method is used for the stability analysis. The basic concept of the method is to check if the resisting moment of the force along a presumed slip circle line exceeds the driving moment caused by gravity and seismic forces. The ratio of those two moment gives the safety factor for sliding.

The result of the numerical calculations is summarized in Figure 5.1.

(3) Horizontal filter drain and toe rock drain

In order to reduce the seepage line within the dam body under 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 Dwg. - 504.

(4) River diversion during construction

During the dam embankment period, river flow including floods has to be diverted to avoid inundation of the Embung site. This can be effectively and economically made by providing a random-filled cofferdam and utilizing the concrete pipe culvert with diameter of 1.2 m as a diversion facility as shown in Dwg. - 506. Since the volume of flood inflows from 0.8-km^2 catchment will be quite small as compared to the storage created by constructing low cofferdams, a 2 m high cofferdam with a crest level of El. 368.0 m would suffice to contain the dry season flood inflow of 6.7 m^3/sec having a return period of five years.

(5) Spillway

The spillway is located on the left abutment of the Embung, which is composed of side channel type overflow weir, throughway, chuteway and downstream channel. The overflow weir is designed to cope with the inflow design flood with a flood surcharge space provided above F.S.L. The inflow design flood is determined at 100-year probable flood having a peak discharge of 21 m^3/sec.

Based on the result of comparative study on combination of overflow depth and width of the spillway, overflow depth at 1.2 m and width of 7.3 m are decided so as to minimize the costs of spillway and the main dam.

A non-gated ogee crest would be set at El. 375.0 m to coincide with F.S.L. Spillway bridge is not provided across the crest portion of the Spillway because of no access road from the right to the left abutment of the main dam.

The profile and sections of spillway are shown in Dwg. - 505.

(6) Water supply system

In order to meet BHN to the downstream water users, the water supply system is provided to release the water of 1.43 lit/sec throughout the year, which consists of intake structure, pipe line and valve house. The intake structure is located in the reservoir area just above the sediment deposition level of El 370.4 m. Fixed trashracks are provided on the intake structure. Cast iron pipe with diameter of 50 mm is connected from the intake structure to the downstream through the main dam. The detail of water supply inlet is given in Dwg. - 506

The value house would be constructed near the downstream toe of the dam. The guard valve and control devices would be installed in the valve house. The detail of the valve house is shown in Dwg. - 507.

5.2 Preliminary Design of Water Distribution Facilities

(1) Basic concept

The following basic concepts are applied for executing the preliminary design of water distribution facilities for inhabitants and livestock in the beneficiary area :

- Distribution facilities to the beneficiary area are selected taking into consideration the effective storage capacity of the Embung, topographic condition of the Project area, village boundary and the existing water supply facilities;

- Water demand for inhabitants and livestock are fully referred to the preliminary design of pipeline and the arrangement of division boxes in the beneficiary area;

- The system of pipelines with pressure flow is used for the water distribution system from the Embung to the beneficiary area. Pipes are arranged along the

existing roads as much as possible from the viewpoint of easiness of the operation and maintenance of the pipe lines. Pipes are set at around 50 cm below the ground surface;

- Division boxes for inhabitants, of which capacity is estimated at 6,000 lit/100 persons, are arranged based on the water demand, the water conveyance distance by inhabitants from the proposed division boxes to their houses and the topographic condition at sites division box sites;

- Division boxes for livestock, of which capacity is estimated at 900 lit per 22 heads of cow /buffalo, are arranged based on the water demand and taking into consideration the locations not affecting the division boxes for inhabitants;

- Related structures of pipelines such as check valves, air valves and blow offs are planed to be set taking into considerations the locations of pipelines and their topographic conditions; and,

- The High Density PVC pipe is used for the water supply taking the safety against the unexpected high pressure to the pipe, the steep and undulating topographic condition in the area and the easiness to get the materials in Indonesia into account.

(2) Beneficiary area and design discharge for pipelines

Beneficiary area of the domestic water and livestock water supply from the Oeltua Embung covers six villages located along the paved road at around 0.6 km downstream of the proposed Embung site. The total beneficiary inhabitants to be supplied with domestic water is estimated at 1,773 persons based on the population projection. Further, the projected livestock population in the beneficiary area is estimated as shown below with unit water demand.

Projected Livestock Population in the beneficiary area of Oebuain Embung

Livestock	Numbers (heads)	Water demand (lit/head/day)
Cattle/Buffalo	331	40
Sheep/Goat	63	5
Pig	529	6
Poultry	1,286	0.6

Design discharge of pipelines is estimated at 1.46 lit/sec adding the design discharge of domestic water supply estimated at 1.23 lit/sec taking the above population and the domestic water demand of 60 lit/sec/day and livestock water supply estimated at 0.23 lit/sec taking the above numbers and water demands.

(3) Preliminary design

In due considerations of the above basic concept and the design discharge, the locations of pipelines and related facilities are planed to be set as shown in the Dwgs. - 501 to - 503. Design of pipelines is executed by using the Hazen Williams formula. Typical designs for related facilities such as check valves, air valves, blow offs and division boxes for domestic and livestock water supply and livestock water supply are shown in Dwg. - 509. Required water distribution facilities for domestic and livestock water supply are summarized below :

Water Distribution Facilities Requirement

Facilities	Quantities
Pipe Line	
- Dia. 65 mm	4.0 km
- Dia. 50 mm	0.3 km
Related Facilities	
- Check valve	3 Nos.
- Air valve	2 Nos.
- Blow off	1 Nos.
- Division box for domestic water	18 Nos.
- Division box for livestock	15 Nos.

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. Some construction equipment will be purchased through international competitive bidding, if necessary.

The construction plan is based on the mode of construction and the target schedule of construction works as well as taking into consideration the construction conditions such as availability of construction labor, material and equipment as well as weather and the topographic conditions of the construction site. Generally, the mechanized construction method is assumed to be adopted although other construction methods may be practiced.

It is assumed that 200 working days per year are available for conducting the earthfill embankment works, 270 days per year for the filter drain and toe 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, one 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 Project site from the 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 culvert, and leakage protection walls would be commenced at the beginning of March in the second year.

3) Concrete works embankment works

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

4) Commencement of reservoir water impounding

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

5) Water distribution system

Construction works for the water distribution system will be executed in parallel with the construction works of the Embung by using mainly manpower since those work quantities are not so much. The construction works shall be completed by the end of December in the second year before supplying the impounded 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 of 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 during four months from November in the first year to February in the second year.

1) Temporary buildings and yards

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

The temporary buildings will require a total floor area of 1,200 m^2 for an anticipated staff strength of 15 persons and labor force of 80 persons. The land required for the temporary buildings and construction facilities is estimated at 2,500 m^2. The temporary buildings and yards may be located near the construction site.

2) Water and power supply

The water required for the construction works and the daily use of 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 constructor's diesel generators with installed capacity of 200 kW to meet the requirements as shown below.

Power Requirement

Place / works	Power Requirement (kW)
Office and quarters	30
Construction plant	50
Repair shop	60
Dam site	20
Water supply	20
Others	20
Total	200

(2) River diversion works

The river flow will be released through the river diversion conduit during the dry season in the second year. The river diversion culvert would be provided along the right bank of the Oemopu river. In order to avoid the leakage or seepage water from the reservoir along the river diversion conduit across the dam body, the river diversion conduit is planned to be

installed in the excavated rock foundation so as to contact the concrete surface smoothly to the homogeneous earth materials as seen in Dwg. -. 506.

Considering very short construction period as four months from the beginning of March to the end of June in the second year, concrete pipe culvert with diameter of 1.2 m is used, and therefore the concrete placing will be made without inside-forms nor reinforcement bars in the conduit.

After completion of the main dam embankment around the end of September in the second year, the river diversion conduit shall be plugged by the concrete using concrete pump with a capacity of 20 m^3/hr for the whole length from the reservoir-side to the downstream outlet.

(3) Main dam works

Following the foundation excavation and completion of the river diversion conduit, the dam embankment will be commenced at the beginning of July in the second year. Considering a embankment volume of 80,000 m^3 and remaining dry season period of three months until the end of September in the second year, the daily embankment volume is to be 1,070 m^3 which is quarried from the borrow area in the reservoir.

Excavation of the embankment materials at the borrow area will be done with D-7 class (21 ton) bulldozers and the excavated materials will be loaded with 1.2-m^3 wheel loader and be hauled to the dam site by 11-ton dump trucks. The embankment materials will be spread at the dam site will be spread with 21-ton bulldozer and compacted with 10-ton class tire roller in layers of 20 cm thickness before compassion.

The filter embankment is planned as a horizontal drainage mattress with a thickness of 1.0 m, which is scheduled to be placed immediately after completion of the river diversion culvert, at the beginning of June in the second year. Before placing the drainage mattress, the main dam foundation should be graded and trimmed smoothly. The filter material will be spread by 21-ton bulldozer and be compacted by 21-ton bulldozer or 10-ton tire roller. This filter material will be hauled with 11-ton dump trucks from the Maubesi river, about 3 km from the construction site.

Riprap placement is scheduled to be made simultaneously as the homogeneous earth embankment of the main dam. The riprap volume is estimated to be 3,000 m^3 and the rock material will be quarried from river bed of the Maubesi river. The rock material will be placed by 0.6 m^3-backhoe and large voids should be filled with smaller rock fragments. The riprap protection should be finished manually to the design slope and thickness.

(4) Spillway construction

Excavation of the spillway will be scheduled to be performed about three months from March to May in the second year. As the total volume of common and weathered rocks is estimated to be 16,200 m^3, 21-ton bulldozer and 1.2-m^3 backhoe will be used for flat portion and steep slope chuteway portion of spillway, respectively. Most of the excavated materials may be used as the main dam embankment materials so that the excavated materials will be stocked in the designated area. For loading the excavated materials to 11-ton dump trucks, 1.2 m^3 wheel loaders is used.

After completion of the spillway excavation, preparation for foundation of chuteway will be commenced. For concrete placing into side-walls and shuteway slope portion, 20-ton class truck crane with concrete bucket (1.0 m^3) and concrete pump with a capacity of 20 m^3/hr will be used. Before starting the reservoir water impounding at the beginning of October in the second year, major concrete works of the spillway should be completed in order to release the flood discharge in the following wet season.

(5) Water supply system

Inlet structure of the water supply system is constructed above the sediment load disposition level (El. 370.4 m). Connecting the inlet structure, a cast iron pipe with diameter of 65 mm is installed up to the downstream end of the main dam. Construction of the river diversion conduit and water supply pipe should be completed before commencement of the main dam embankment at the beginning of July in the second year.

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

(6) Earth blanket in reservoir

After excavation of the embankment materials for the main dam in the reservoir area, the foundation of the earth blanket should be provided considering the smooth grading and trimming by using 11-ton bulldozer and a 3.7-m wide motor grader.

As shown in Dwg. - 508, the earth blanket will be provided in the reservoir area up to the F.S.L. under the condition that the blanket material should be the same material of the original ground of the reservoir area. Accordingly the original ground should be loosened by 21-ton bulldozer and 3.7-m wide motor grader, then compacted by 21-ton bulldozer or 10-ton tire roller which is subject to the result of trial embankment at the construction site.

The construction period of the earth blanket is about six months from April to September in the second year as seen in Figure 6.1.

(7) Construction materials

Quantities of the major construction materials required for constructing the Oebuain Embung are summarized below,

Construction Material Requirement

Item	Quantity	
Earthfill materials		
Main dam	80,000	m^3
Blanket in reservoir	56,000	m^3
Filter materials		
Horizontal drain	5,000	m^3
Riprap portion	900	m^3
Rock materials		
Riprap protection	2,400	m^3
Toe rockfill	1,100	m^3
Concrete		
Cement	380	tons
Reinforcement bars	22	tons
Aggregates	1,000	m^3

(8) Construction equipment

The minimum number of major construction equipment and plants to be used for the Oebuain Embung construction works are summarized in Table 6.1.