



Japan International  
Cooperation Agency  
(JICA)



Directorate General of  
Water Resources Development,  
Ministry of Public Works

No. 52

*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 1)**

**Executive Summary Report**



**May 1995**

**NIPPON KOEI CO., LTD.**



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## PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct the Study on the Embung Development Project in East Nusa Tenggara and West Nusa Tenggara in the Republic of Indonesia and entrusted the Study to Japan International Cooperation Agency (JICA).

JICA sent to the Republic of Indonesia a study team headed by Dr. Yasuhiko Kunihiro, Nippon Koei Co., Ltd., four times from February 1994 to March 1995.

The team held discussions with the officials concerned of the Government of the Republic of Indonesia, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

May, 1995

A handwritten signature in cursive script, reading "Kimio Fujita", is written over a solid horizontal line.

Kimio Fujita

President

Japan International Cooperation Agency

May, 1995

Mr. Kimio Fujita  
President,  
Japan International Cooperation Agency  
Tokyo, Japan

## Letter of Transmittal

Dear Sir,

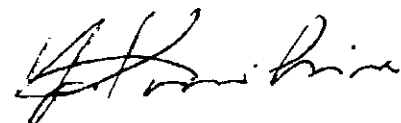
We have pleasure of submitting the study report for the Study on the Embung Development Project in East Nusa Tenggara and West Nusa Tenggara in the Republic of Indonesia, in accordance with the Scope of Work agreed upon between the Ministry of Public Works and the Japan International Cooperation Agency (JICA).

The study was carried out for a total period of 17 months from January 1994 to May 1995. The Plan for the Embung Development was basically formulated with principal aim of increase of agricultural production and improvement of rural life conditions, paying attention to environmental aspects in the study area.

The development plans of the project consist of three aspects : (1) a Master Plan including Mid and Long Term Embung Development Plan in East Nusa Tenggara and West Nusa Tenggara Provinces, (2) a Feasibility Study for the priority Embung Development Projects which are selected by the Master Plan. and (3) a Guideline which outlines flow and procedure of investigation and planning for the Embung Development Project. We would recommend that the projects will be soon implemented in line with the conclusions presented in this report.

We wish to express our deep appreciation and gratitude to the personnel concerned of your and other Agencies, your Indonesia Office, the Embassy of Japan in the Indonesia, and the Authorities concerned of the Government of Indonesia for the courtesies and cooperation extended to us during our field surveys and studies.

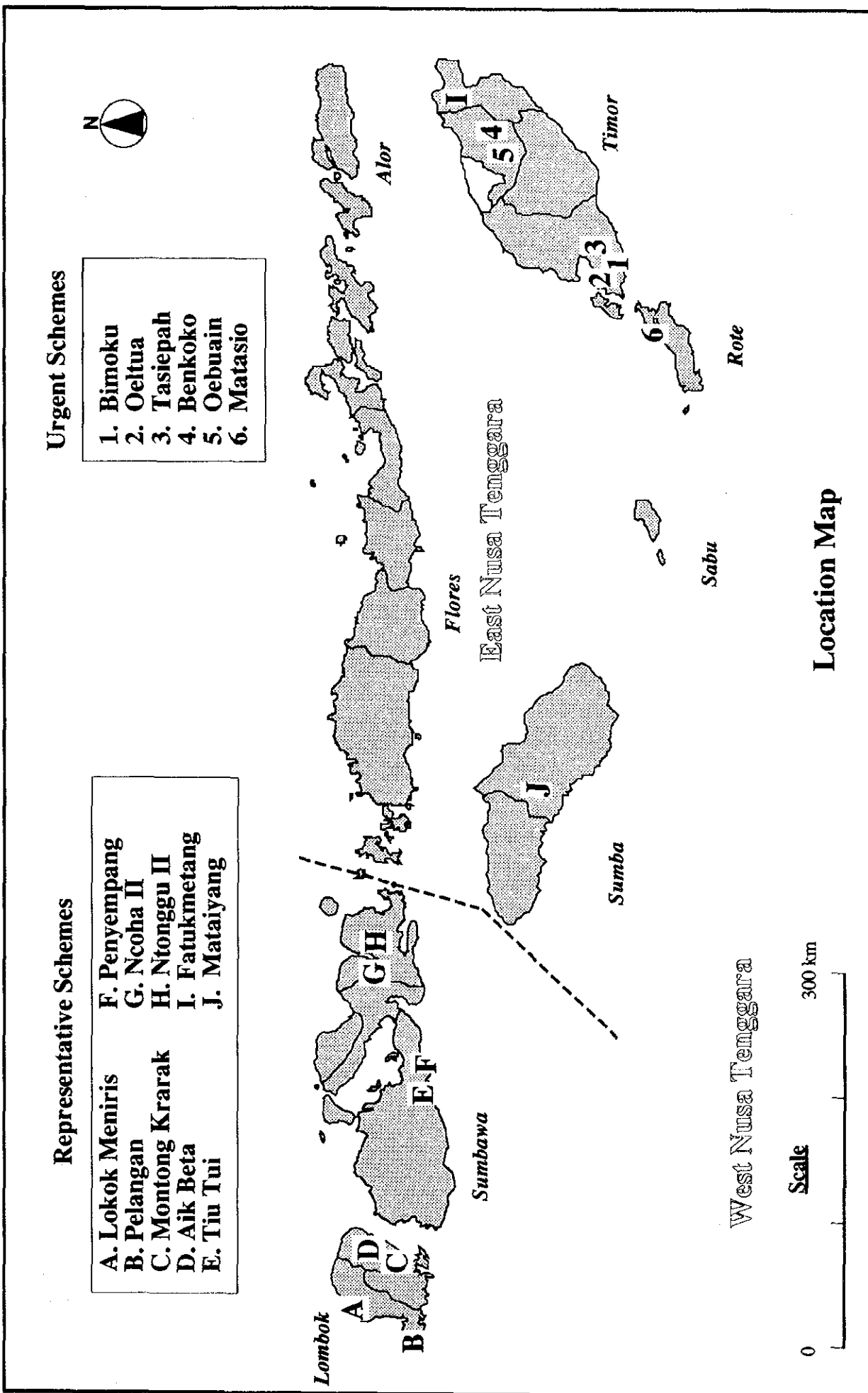
Very truly yours



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Yasuhiko KUNIHIRO

Team Leader of the Study Team for Study on  
the Embung Development Project  
in East Nusa Tenggara and West Nusa Tenggara  
in the Republic of Indonesia







## **A. GENERAL**

### **A-1 Background of the Study**

1. Under Pelita I to IV, the Provinces of West Nusa Tenggara (NTB) and East Nusa Tenggara (NTT) were largely left out of the national development program due to their remote location coupled with a lack of potential for development. In 1993, the Gross Regional Domestic Product (GRDP) at current market prices was Rp. 2,190 billion for NTB and Rp. 1,630 billion for NTT. Per capita GRDP was Rp. 630,000 for NTB and Rp. 490,000 for NTT ranked 25th and 27th, respectively, among the 27 provinces in the country.

2. To correct this large gap in regional development, it is necessary to upgrade rural infrastructures and to improve agricultural production bases to encourage rural inhabitants to participate in economic activities. A drier climate than any other part of Indonesia is the limiting factor in the poor level of living and production in the rural areas of NTB and NTT at present. To quickly improve the regional economy, it is prerequisite to concentrate public investment in implementing countermeasures to reduce the chronic water shortage problem. In regard to this, the "Poverty Alleviation" and the "Development of the Eastern Part of Indonesia" were firstly taken up as the main components of the development targets in Pelita V aiming to improve the lower productivity of the agricultural sector and living standards of urban and rural inhabitants in depressed areas. This principle of development is maintained in Pelita VI (1994/95 to 1998/99).

3. Up to date, a total of 401 Embungs (small scale impounding pond) has been constructed in NTB and NTT as the principal means of water source creation for securing domestic, livestock, and irrigation water supply. Recently, three dams were newly completed in NTB under the economic assistance of the Asian Development Bank and the Overseas Economic Cooperation Fund. The Government of Indonesia (GOI), considering the importance of the maximum utilization of limited water resources through construction of Embungs as an effective measure to develop the NTB and NTT Provinces, requested the Government of Japan (GOJ) in May 1993 to extend technical cooperation for undertaking a feasibility study on the Embung development project. At the same time, GOI also requested GOJ to provide grant aid for constructing six Embungs in NTT.

4. In response to these two requests, GOJ decided to conduct a development study. In the preliminary study in October 1993, the Scope of Work for "the Study on the Embung Development Project in NTB and NTT in the Republic of Indonesia" (the Study) was agreed upon between the Japan International Cooperation Agency (JICA) and the Directorate General of Water Resources Development (DGWRD). The Study commenced in January 1994.

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5. Both Provincial Public Works Services (DPUP) selected 157 candidate Embung development schemes in total for the Study based on their previous identification studies of Embungs and taking into account the maturity of Embung development plans and the urgency of implementing Embung development. The objectives of the Study are:

- To formulate a mid- and long-term action program for Embung development in NTB and NTT;
- To assess technical soundness of six Embung development schemes and prepare an implementation program for urgent development;
- To conduct a feasibility study on representative Embung schemes to be chosen through categorization of 157 candidates; and
- To prepare a technical guideline for investigating, planning and designing Embung schemes in NTB and NTT.

6. This Final Report presents the results of the Study completed in January 1995. It consists of five volumes: the summary of the Study is described in Volume 1; the mid- and long-term action program for Embung development in NTB and NTT is given in Volume 2; the results of the detailed technical feasibility and project justification study on the six Embung development schemes in NTT are presented in Volume 3; the results of the feasibility of 10 representative candidate schemes are described in Volume 4; and the technical guideline for developing plans for Embungs in NTB and NTT is given in Volume 5; and detail of the feasibility studies are given in Volumes 6 to 10.

### **A-2 Present Condition**

7. The Provinces of NTB and NTT consist of 614 small to medium size islands of which about 70 are inhabited. These islands form two distinct arcs; the Inner Island Arc comprising Lombok, Sumbawa, Flores, Lomboken, and Alor islands, and the Outer Island Arc comprising Sumba, Rote, and Timor islands. The total area is 67,503 km<sup>2</sup>, occupying 3.5% of the country's territory.

8. The Inner Island Arc is volcanic in origin and featured with a mountainous and hilly topography, while the Outer Island Arc is formed of uplifted marine sediments and coral reefs with characteristics of barren limestone plains and sparse savannas.

9. The wet season generally starts from December and lasts four months up to March. The mean annual rainfall varies from 700 to 3,000 mm according to location and elevation of the islands. The main usable water resources are rivers, springs and lakes. There are 40 rivers longer than 30 km and only 46 rivers among these have catchment areas of larger than

200 km<sup>2</sup>. Most rivers have small watersheds and dry up during the later part of the dry season.

10. Soils are very heterogeneous and considerably different between islands. Soils with parent materials of marine sediments on the Outer Island Arc tend to be less fertile and more drought prone than those originating from volcanic materials on the Inner Island Arc. As expansion of the shifting cultivation and human settlement have seriously affected the natural vegetation for the last two to three decades, the existing forest areas cover 31% of the total land area, while grassland accounts for 12%.

11. At present, both Provinces administratively total 2 Municipalities, 18 Regencies (Kabupaten), 173 Districts (Kecamatan) and 2,267 Villages (Desa). The total population in 1993 was 6.86 million density of 102 person/km<sup>2</sup> and growth rate of 2.15% in NTB and 1.79% in NTT during the 1980's. The total number of households in 1993 was 1.42 million. The inhabitants' religious background is distinguished into predominant Islamic in NTB and Christians forming the sociological majority in NTT.

12. There are 17 airports and 16 seaports. The total length of roads as at 1993 was 19,449 km comprising 38% of asphalt roads, 19% of gravel roads, 43% of earth roads and 12% for unspecified roads. Electricity supply is limited to urban areas with rural electrification on-going.

### **A-3 Agricultural Situation**

13. Farm land amounted to 1.79 million ha in 1993 consisting of 19% of wet paddy fields, 44% of dry upland fields, and 37% of estate crops and fruit fields. In addition, there is a shifting cultivation area of 0.19 million ha, idle farm land of 0.57 million ha, and grassland of 0.82 million ha. The shifting cultivation area mainly distributing in NTT forms the main cause of soil degradation and deforestation.

14. Staple food crops grown are wet paddy in NTB, and maize and upland paddy in NTT. The total harvested area of wet paddy was 0.25 million ha with a cropping intensity of 1.26 in NTB and 0.08 million ha and a cropping intensity of 0.65 in NTT. Soybean is a popular Palawija crop in NTB, while cassava is planted for food security purposes in NTT. Annual food crop production in NTB and NTT for 1993 was 1.56 million tons of wet and upland paddy, 0.42 million tons of maize, 0.84 million tons of cassava, and 0.14 million tons of soybean.

15. Typical estate and fruit crops are coconut and tobacco in NTB, and cashew nut, candle nut, mango, and orange in NTT.

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16. Sumbawa and Timor islands have traditionally played an important role in functioning as cattle feeder stock areas for other regions of Indonesia. To meet the increasing demand of beef in Jakarta and Surabaya, this area has recently supplied live cattle to these domestic markets. Availability of foodstuffs reduces sharply in quantity and quality during the dry season. Further, shortage of drinking water for the dry season results in loss of cattle weight. Livestock population in 1993 was 1.58 million cows and buffaloes followed by 1.48 million pigs, 0.94 million goats and sheep, and 0.25 million horses, while domestic hens, layers and ducks amounted to 12.2 million. The importance of inland fisheries is very low.

17. Though various agricultural supporting services are available and functioning in NTB and NTT, farmers' access to such services and visiting from such service agencies to farmers are both limited due to the remote location of the farmers and the agencies' insufficient budget for field operations.

18. In each Province, the head of DPUP controls, through the head of the Water Resources Services, development of water resources, supply of raw water for domestic and irrigation use, construction and improvement of irrigation facilities, and operation and maintenance of water source facilities under the direction of the Governor. Under both DPUPs, four Water Resources Construction and Conservation Project (PKSA) Offices are established in charge of the implementation of Embung development in Lombok, Sumbawa, Flores-Sumba, and Timor, respectively.

## B. MID- AND LONG-TERM DEVELOPMENT PLAN OF EMBUNG

### B-1 Present Condition of Water Resource Utilization

19. In NTB and NTT, there are no any remarkable river basins with ample surface runoff and discharge. The available water source facilities are two inter-basin transfer canals, High Level Diversion and Jurang Sate, and two dams, Batujai and Pengga, in Lombok and two dams, Mamak and Tiu Kulit, in Sumbawa, but dams have not yet been constructed in other islands.

20. Uneven distribution of annual rainfall and unpredictable interruptions of rainfall sometimes for several weeks during the wet season cause a lack of irrigation water sources even in the wet season resulting in unstable and poor crop harvests. In South Lombok, villagers have overcome such problems by constructing small scale Embungs to collect the rain water and to use the surplus for the following dry season. There are two types of Embung, individual and village. A total of 218 village Embungs have been rehabilitated and maintained by DPUP of NTB since 1980. Further, DPUP has improved another 45 old Embungs and constructed 33 new Embungs in line with GOI's policy to use the limited water resources to the maximum extent for increasing agricultural and livestock production as well as public prosperity.

21. To reduce chronic and serious water shortage problems caused by limited rainfall and seasonally available discharge in most rivers, DPUP of NTT has constructed 13 irrigation Embungs and 92 small Embungs. In the development of small Embungs, the Government of Australia granted technical guidance, construction equipment and office and workshop facilities for five years from 1984.

22. General features of the existing Embungs are shown below.

Embung	Nos.	Average Height (m)	Average Storage Capacity (m <sup>3</sup> )	Average Irrigation Area (ha)	No. of Beneficial Family	
NTB	Newly constructed	33	10.4	428,000	305	-
	Rehabilitated	45	6.1	96,300	260	-
	Village	218	-	15,500	4	-
NTT	Irrigation	13	8.8	708,900	261	-
	Small	92	7.2	16,930	-	62

23. In NTB and NTT, 403 irrigation schemes are presently under operation with a total designed irrigation area of 0.22 million ha. The average size of each scheme is 553 ha and the irrigation area of 107 schemes is below 200 ha. Of the total designed irrigation area, 83% is provided with natural river flow diverted through weirs and 2% is irrigated using spring water or groundwater, the remaining 15% is benefited by regulated flow from dams and

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Embung. As for the irrigation facility level, 29% of the total command area is technical and the rest are semi-technical.

Province	NTB	NTT	Total
No. of Project	270	133	401
Total Command Area (ha)	148,996	73,942	222,938
Command Area by Water Source Facility (ha)			
-Weir	118,921	66,780	185,701
-Embung / Dam	30,075	3,392	33,467
- Spring / Groundwater	0	3,770	3,770
Irrigation Area by Facility Level			
-Technical	44,505	27,425	71,930
-Semi-Technical	96,696	7,296	103,992
-Non Technical	7,795	39,221	47,016

24. According to the 1992 National Socio Economic Survey, 55% of 0.66 million households in rural NTB obtain their drinking water source from wells, 17% from springs, 13% from pumps, 10% from piped water, 4% from rivers, 1% from rain water and others. While in NTT 38% of 0.57 million households is served with spring water, 15% with river flow, and 1% with rain water, and they usually spend their productive time fetching water at least 1 km or more from their homes. The remaining 27% gets water from wells near their users' houses, 15% from piped supply systems and 4% from pumps. Purified water supply services through a pipeline system are operated in municipal areas by water supply companies, using groundwater and part surface runoff as raw water sources. The total volume of water distributed has increased year by year in conjunction with a rather sharp increase in urban population and per capita water consumption.

	1989	1990	1991	1992	1993
NTB	5,678	6,094	7,497	7,839	9,203
NTT	7,344	7,962	8,077	8,635	9,839
Total	13,022	14,056	15,574	16,474	19,042

Unit: 1,000 m<sup>3</sup>

### **B-2 Future Water Demand**

25. Citing "The Study for Formulation of Irrigation Development Program in the Republic of Indonesia", the projected irrigation area is 97,600 ha in NTB by 2005 and 66,700 ha in NTT by 2020. The future water demand in 2020 is estimated to be: 3,179 MCM in NTB and 2,018 MCM in NTT for irrigation use; 138.6 MCM in NTB and 121.1 MCM in NTT for domestic, municipal and industrial use; and 21.6 MCM in NTB and 33.6 MCM in NTT for livestock use.

### **B-3 Investment in Embung Development under Pelita VI**

26. During the period of Pelita VI, DPUP of NTB is planning to invest Rp. 52.6 billion in development of 17 Embung schemes for irrigation water supply and another 17 for irrigation,

and domestic and livestock water supply on Lombok Island, and 31 for irrigation water supply and seven for multiple water supply on Sumbawa Island.

27. According to "The Poor Village Identification Survey" conducted by the Central Bureau of Statistics in 1993, around 60% of 1,743 villages in NTT are located in the dry weather zone where an insufficient supply of domestic and livestock water is common. Targeting these villages, DPUP of NTT has a long-term plan to construct small scale Embungs for every 100 households as a domestic and livestock water supply source with the final goal of developing Embungs at 2,700 sites throughout the Province.

28. For the period of Pelita VI, DPUP of NTT is considering to invest Rp. 119.5 billion in the development of 200 Embung schemes, comprising eight for irrigation water supply and 84 small scale schemes for domestic and livestock water supply on Timor and Rote Islands, and 20 for irrigation water supply and 88 for domestic and livestock water supply on Flores, Alor, and Sumba Islands.

#### **B-4 Inventory Survey Results and Features of Candidate Embung Schemes**

29. As the 157 candidate Embung schemes selected by the both DPUPs of NTB and NTT, include 27 existing Embung schemes which need to be rehabilitated, the objective schemes of the Study are limited to 130 potential Embung development schemes. Taking into account the wide variation in quantity and quality of information available in DPUPs' previous Embung identification study, the inventory survey was conducted under the Study for the purpose of reconfirming the reliability of the basic planning materials for the 130 potential Embung schemes in collaboration with the both DPUPs and the Indonesian consulting firm.

30. Tables S-1 to S-7 present the classification results of 130 potential Embung schemes confirmed by the inventory survey, on the basis of maturity of the project formation, catchment area, Embung development scale indicated by dam type, dam height, dam volume and storage capacity, and irrigation area. Figures S-1 to S-4 depict the location of each potential Embung scheme.

#### **B-5 Categorization of Candidate Schemes and Selection of Representative Schemes**

31. Based on the information obtained by the inventory survey, special attention is paid to three major factors: (1) type of farm land in the respective Embung scheme areas; (2) present condition of irrigation water intake in the candidate scheme areas; and (3) rural inhabitants' intention on water use in order to choose principal factors to categorize the 130 potential Embung schemes. The categorization criteria for these three factors are established below.

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- Type of farm land
  - a : Wet paddy field where rainfed cultivation of wet paddy occurs due to absence of or malfunctioning irrigation facilities, dry upland;
  - b : Wet paddy field where irrigation water is supplementally distributed to the wet season paddy or irregularly supplied to the dry season Palawija crops due to unstable water supply condition of the existing irrigation facilities; and,
  - c : Wet paddy field with well maintained irrigation system by which irrigation water is partly or fully supplied to the dry season paddy and Palawija crops.
- Type of irrigation water source
  - A : Irrigation system is not available in the irrigable area;
  - B : Irrigation water is withdrawn through an intake weir from a river which is the water source of proposed Embung; and,
  - C : Irrigation water is transferred from a neighboring river which is different from the water source river of the proposed Embung.
- Beneficiary inhabitants' intention on use of the storage water of the new Embung
  - 1 : Irrigation, domestic and livestock water use;
  - 2 : Irrigation and livestock water use;
  - 3 : Irrigation and domestic water use;
  - 4 : Irrigation water use; and,
  - 5 : Domestic and livestock water use, livestock water use, or domestic water use.

32. Based on the above criteria, the 130 candidate Embung schemes are categorized and the result is as shown in Table S-8. Aiming to establish a new standard for assessment of Embung development potential, a feasibility study was conducted for sample cases representing the respective combinations of 11 categories of three factors. From 130 candidate Embung schemes, a total of 16 sample schemes were selected for the feasibility study including six schemes taken up for urgent project implementation. The list of 16 sample schemes with representing categories and locations is shown below.



Category	Project	Province	Regency (Kabupaten)
<b>10 Representative Schemes</b>			
a-A-1	Fatukmetang	NTT	Belu
a-A-4	Aik Beta	NTB	Lombok Timur
a-B-3	Mataiyang	NTT	Sumba Timur
b-B-2	Tiu Tui	NTB	Sumbawa
b-B-3	Montong Krarak	NTB	Lombok Timur
b-B-4	Ncoha II	NTB	Bima
c-B-2	Ntonggu II	NTB	Bima
c-B-3	Pelangan	NTB	Lombok Barat
c-B-4	Penyempeng	NTB	Sumbawa
c-C-3	Lokok Meniris	NTB	Lombok Barat
<b>6 Urgent Development Schemes</b>			
5	Bimoku	NTT	Kupang
	Oeltua	NTT	Kupang
	Oebuain	NTT	Timor Tengah Utara
a-A-3	Matasio	NTT	Kupang
b-B-1	Tasiepah	NTT	Kupang
b-C-1	Benkoko	NTT	Timor Tengah Utara

## B-6 Assessment of Embung Development Potential

33. To formulate a mid- and long-term action program for Embung development in NTB and NTT, it is required to assess the development potential of each candidate Embung from technical, economic, and social viewpoints. Taking into consideration the results of the above 16 feasibility studies, the Embung development potential is assessed by the following procedure.

- To decide the factor determining the development scale of Embungs paying attention to the following two types:
  - Supply-oriented type : The Embung development scale is principally decided by topographic or hydrological limitations; and,
  - Demand-oriented type: The development scale is principally decided by water demand in the beneficiary area of Embung.
- To scale down the irrigation area of supply-oriented Embungs according to the estimated runoff at the proposed Embung site.

- To estimate the benefit-cost ratio (B/C) at the discount rate of 8% and then examine the possibility of project implementation based on the following steps:

Embung with a B/C ratio of more than 1.0 can be implemented without any revision of the original development plan;

Demand-oriented Embung with a B/C ratio of less than 1.0 needs to be reassessed on the basis of the beneficiary inhabitants' intention for future water use in the following manner;

To revise the dry season cropping pattern for increasing irrigation benefit if irrigation water is secured for the dry season and then re-estimate the B/C ratio,

If the re-estimated B/C ratio is more than 1.0, project implementation is recommendable with revision of the original cropping pattern for the dry season,

If re-estimated B/C ratio is less than 1.0 for Embungs supplying only irrigation water or there is no possibility of revising the original cropping pattern for the dry season, Embung development for irrigation purposes is not recommendable, and,

If re-estimated B/C ratio is less than 1.0 for Embungs supplying both irrigation and domestic and/or livestock water, project implementation is recommendable primarily for meeting basic human needs (BHN) and irrigation water demand secondly by utilizing surplus storage water.

Supply-oriented Embungs with domestic and/or livestock water demand in their beneficiary areas need to be implemented for meeting BHN; and,

Supply-oriented Embungs with a B/C ratio is less than 1.0 and irrigation water demands only in their beneficiary areas do not have any necessity for Embung development.

34. Figures S-5 to S-9 depict the assessment results of Embung development potential on 114 candidate schemes excluding 10 representative schemes and six schemes for urgent implementation for which the feasibility study is conducted. The summary of assessment is presented below.

Type	B/C Ratio	Water Use	No. of Scheme	Re-estimated B/C > 1.0
Supply-oriented			22	
	> 1.0		6	
	< 1.0		16	
		Irrigation, livestock and domestic	8	
		Irrigation and domestic	6	
Demand-oriented		Irrigation	2	
			92	
	> 1.0		60	
	< 1.0		32	
		Irrigation, livestock and domestic	10	0
		Irrigation and livestock	2	1
		Irrigation and domestic	6	2
	Irrigation	14	11	

35. From the results of Embung development potential assessment on 114 candidate schemes, it can be judged that project implementation is recommendable for 80 schemes comprising six supply-oriented schemes and 74 demand-oriented schemes including 14 schemes with a re-estimated B/C ratio of more than 1.0. Out of the remaining 34 candidate schemes, it is necessary to implement 29 schemes to primarily meet BHN in each beneficiary area, while the other five schemes for exclusive use of irrigation water need to be developed by constructing or rehabilitating an intake weir instead of an Embung on the water source river. Adding the results from the feasibility study on the 16 schemes, implementation of Embung development is recommendable for 82 schemes to supply irrigation water exclusively and prior to BHN, and 39 schemes to supply domestic and/or livestock water prior to irrigation water, while Embung development is not recommendable for the remaining nine schemes because of beneficiary inhabitants' water use pattern which is limited to irrigation, a small irrigation area, or a very low investment efficiency. For this, it is recommended to secure irrigation water with a smaller amount of investment by rehabilitating, improving, and constructing intake weirs.

#### **B-7 Provisional Definition of Embungs**

36. In NTB and NTT, it is indispensable to practice foundation treatment works at the same standard of large dams due to the particular condition of the geology if Embungs exceed 15 m in dam height. On the other hand, in regard to economic efficiency, it is desirable to raise the upper limit of total storage capacity of Embungs to the maximum extent considering the availability of potential Embung sites with large pockets at potential sites, even if the dam heights are low. Taking into account these two factors, Embungs are provisionally defined as dams with a maximum height of 15 m and a maximum total storage capacity of 1.0 million m<sup>3</sup>. Embungs with dam heights over 15.0 m and total storage capacity over 1.0 million m<sup>3</sup> are therefore upgraded to the category of dams.

37. Among the 130 candidate schemes, 14 schemes have dam heights of over 15 m and 19 scheme shave a total storage capacity of more than 1.0 million m<sup>3</sup>. A total of nine schemes exceed the two upper limitations . Of these, the following eight schemes are recommendable for implementing as dams. The remaining Ncoha II scheme of 25.0 m in dam height and 1.22 MCM in total storage capacity needs to change its development approach to the rehabilitation and upgrade of the existing intake weir and canal network instead of constructing a storage facility in due consideration of its investment efficiency.

Water Supply Purpose	Project	Island	Dam Height (m)	Total Storage Capacity (MCM)
Irrigation water only	Gapit	Sumbawa	18.0	10.35
	Terusa	Sumbawa	18.0	2.40
	Penyempeng	Sumbawa	39.0	1.22
Irrigation water prior	Tiu Tui	Sumbawa	19.5	4.30
Irrigation water sub	Pelangan	Lombok	29.5	5.70
	Ntonggu II	Sumbawa	17.0	1.27
	Mataiyang	Sumba	20.0	2.16
	Tasiepah	Timor	26.0	2.50

Note : The maximum development potential of Tasiepah dam is 36.0 m in dam height and 7.60 MCM in total storage capacity.

### B-8 Implementation Program of Mid- and Long-term Embung Development

38. Excluding the five candidate schemes for urgent implementation, the eight candidate schemes upgraded to dam development, and the nine candidate schemes changed to alternative water source facilities, the investment for the implementation of 108 Embungs amounts to Rp. 274.6 billion of which the breakdown is Rp. 218.6 billion for NTB and 56.0 billion for NTT as shown below. Further, the annual O&M cost of Embungs and their related facilities is Rp. 1.1 billion for NTB and 0.3 billion for NTT.

Type	Water Supply	NTB		NTT	
		Scheme (No.)	Amount (billion Rp.)	Scheme (No.)	Amount (billion Rp.)
Supply-oriented	Irrigation prior	4	10.7	2	2.8
	BHN prior	1	1.8	13	22.0
Demand-oriented	Irrigation prior	67	202.5	5	10.2
	BHN prior	4	3.6	12	21.0
Total		76	218.6	32	56.0

39. In comparison with the investment in Embung development projects projected by the both NTB and NTT DPUPs for Pelita VI (1993/1994 to 1998/1999), the required investment in the above is equivalent to the annual amount for 21 years in NTB and three years in NTT. As the NTB DPUP has lined up Embung development schemes in its program for Pelita VI, the new investment in 76 candidate schemes will have to commence 20 years from Pelita VII and onward. If the whole implementation period needs to be shorted to 15 years, the annual amount of investment will have to increase by about 40%. In NTT, it is desirable to carry out detailed investigation, planning and design works of 32 candidate schemes within Pelita VI period and then to complete construction works during the period of Pelita VII. In parallel with the development of 32 candidate schemes, a long-term implementation program of 2,700 small scale Embung projects will have to be formed.

40. The required investment in eight dams amounts to Rp. 166.0 billion which is broken down to Rp. 124.8 billion for six dams in NTB and Rp. 41.2 billion for two dams in NTT.

41. The fund sources for the above-mentioned investment are expected to come from the development budget and/or foreign aid for implementation of Embung projects which supply irrigation water, both exclusive and prior, and indicate a B/C ratio of more than 1.0. In this case, part of the loan repayment will have to be born from the irrigation water charge to be collected from beneficiary water users. The whole amount of investment for implementing Embung projects for supplying domestic and/or livestock water prior to irrigation water needs to be covered with a grant from the Central Government because of the low economic soundness of the B/C ratio of less than 1.0. In case Embungs only meet BHN and have a B/C ratio of less than 1.0, the investment is expected to be fully supported by the Provincial Government.

42. In order to ensure realization of the investment target, it is a prerequisite to strengthen both DPUPs' function and capability of planning, design, implementation, and operation and maintenance of the Embung projects. Furthermore, it is indispensable to make the necessary arrangements of the ordinary budget of the Departments of Agriculture and DPUPs in NTB and NTT to provide intensive extension services and on-farm water management training to beneficiary farmers when the project planning works commence. In addition, it is necessary to ensure farmers' access to cooperative and credit services to support intensive irrigation farming with the provision of farm inputs and working capital.

**Table S-1 Classification by Project Status**

	Planning / Study Completed	Design Completed	Total
Lombok	3	2	5
Sumbawa	9	3	12
NTB Total	12	5	17
Flores,Sumba	19	3	22
Timor	18	1	19
NTT Total	37	4	41
Total	49	9	58

**Table S-2 Classification of Embung by Type**

	Homogeneous Earthfill	Zone Type Earthfill	Masonry	Total
Lombok	18	10	22	50
Sumbawa	36	3	1	4
NTB Total	54	13	23	90
Flores,Sumba	16	1	2	19
Timor	21	0	0	21
NTT Total	37	1	2	40
Total	91	14	25	130

**Table S-3 Classification of Embung by Height**

	Less than 5m	5-10m	10-15m	More than 15m	Total
Lombok	8	23	16	3	50
Sumbawa	0	10	23	7	40
NTB Total	8	33	39	10	90
Flores,Sumba	4	12	2	1	19
Timor	2	7	9	3	21
NTT Total	6	19	11	4	40
Total	14	52	50	14	130

Table S-4 Classification of Embung by Embankment Volume

## Filldam

	Less than 20000m <sup>3</sup>	20000 - 40000m <sup>3</sup>	40000 - 60000m <sup>3</sup>	60000 - 80000m <sup>3</sup>	80000 - 100000m <sup>3</sup>	More than 100000m <sup>3</sup>	Total
Lombok	21	2	2	2	0	1	28
Sumbawa	2	9	11	5	3	9	39
NTB Total	23	11	13	7	3	10	67
Flores,Sumba	10	2	2	2	0	1	17
Timor	8	5	0	1	0	7	21
NTT Total	18	7	2	3	0	8	38
Total	41	18	15	10	3	18	105

## Masonry

	Less than 2000m <sup>3</sup>	2000 - 4000m <sup>3</sup>	4000 - 6000m <sup>3</sup>	6000 - 8000m <sup>3</sup>	8000 - 10000m <sup>3</sup>	More than 10000m <sup>3</sup>	Total
Lombok	5	8	4	4	0	1	22
Sumbawa	0	0	0	1	0	0	1
NTB Total	5	8	4	5	0	1	23
Flores,Sumba	0	2	0	0	0	0	2
Timor	0	0	0	0	0	0	0
NTT Total	0	2	0	0	0	0	2
Total	5	10	4	5	0	1	25

Table S-5 Classification of Embung by Storage Capacity

	Less than 200,000m <sup>3</sup>	200,000 - 400,000m <sup>3</sup>	400,000 - 600,000m <sup>3</sup>	600,000 - 800,000m <sup>3</sup>	800,000 - 1,000,000m <sup>3</sup>	More than 1,000,000 m <sup>3</sup>	Total
Lombok	16	18	8	3	0	5	50
Sumbawa	2	13	10	2	2	11	40
NTB Total	18	31	18	5	2	16	90
Flores,Sumba	10	4	2	2	0	1	19
Timor	11	4	2	1	1	2	21
NTT Total	21	8	4	3	1	3	40
Total	39	39	22	8	3	19	130

Table S-6 Classification of Embung by Catchment Area

	Less than 5km <sup>2</sup>	5 - 10 km <sup>2</sup>	10 - 15 km <sup>2</sup>	15 - 20 km <sup>2</sup>	More than 20 km <sup>2</sup>	Total
Lombok	36	8	3	0	3	50
Sumbawa	16	14	4	1	5	40
NTB Total	52	22	7	1	8	90
Flores,Sumba	15	1	0	3	0	19
Timor	15	1	1	1	3	21
NTT Total	30	2	1	4	3	40
Total	82	24	8	5	11	130

Table S-7 Classification of Embung by Beneficiary Area

	Less than 50 ha	50 - 100 ha	100 - 200 ha	200 - 500 ha	More than 500 ha	Total
Lombok	21	11	8	9	1	50
Sumbawa	3	6	15	11	5	40
NTB Total	24	17	23	20	6	90
Flores,Sumba	8	10	0	1	0	19
Timor	11	3	5	2	0	21
NTT Total	19	13	5	3	0	40
Total	43	30	28	23	6	130

Table S-8 Result of Categorization

Agriculture	Category		NTB			NTT			Total
	Water Resources	Future Water Use	Lombok	Sumbawa	NTB Total	Flores,Sumba	Timor	NTT Total	
a	A	1	1		1	9	12	21	22
a	A	2	1	3	4				4
a	A	3	9		9	7		7	16
a	A	4	8	11	19	1		1	20
a	B	1					1	1	1
a	B	2							
a	B	3				1	1	2	2
a	B	4							
a	C	1							
a	C	2							
a	C	3							
a	C	4	1		1				1
b	A	1							
b	A	2							
b	A	3							
b	A	4							
b	B	1					2	2	2
b	B	2		1	1				1
b	B	3	1		1		1	1	2
b	B	4		2	2				2
b	C	1	1		1				1
b	C	2							
b	C	3	3		3				3
b	C	4							
c	A	1							
c	A	2							
c	A	3							
c	A	4							
c	B	1					1	1	1
c	B	2		2	2				2
c	B	3	4		4	1		1	5
c	B	4	4	14	18				18
c	C	1							
c	C	2	3		3				3
c	C	3	8		8				8
c	C	4	6	7	13				13
Total			50	40	90		18	37	127

Note:

With respect to the Bimoku, Oelua, and Oebuain Schemes, where a feasibility study has been carried out during the Phase I Study, they are categorized into 5



East Lombok

LR01	Lokok Sukun
LR02	Tibu Meong
LR03	Orak Aik
LR04	Aik Bata
LR05	Kali Seruni/Papah
LR06	Lengkong Putut
LR07	Batu Tinja
LR08	Kembar II
LR09	Petandakan
LR10	Senang
LR11	Kembang Kuning
LR12	Gunung Joget
LR13	Turun Tangis
LR14	MT. Krarak
LR15	Montong Semat
LR16	Pancor Manis
LR17	Prako
LR18	Propok
LR19	Tinu Ulik
LR20	Pemongkong
LR21	Lingkuk Kolo
LR22	Karang Lebah
LR23	Punggang

Central Lombok

LH01	Gula Liat II
LH02	Bual
LH03	Batu Tanam
LH04	Batu Tulis
LH05	Bare Julat
LH06	Tibuk Sisuk
LH07	Pengembuk
LH08	Lajut
LH09	Kelanjur
LH10	Pore
LH11	Batu Jangkih
LH12	Suare
LH13	Kelebeh
LH14	Pedeh
LH15	Ungga
LH16	Sengkereang
LH17	Beleka (Lepak)
LH18	Lomban Lauq
LH19	Bengawan
LH20	Bun Mas
LH21	Sereneng
LH22	Tempit
LH23	Gerentuk
LH24	Tajak
LH25	Selawang

LB01	Pinang Lulu
LB02	Lokok Melepah
LB03	Lokok Salut
LB04	Lengkok Menangan
LB05	Lengkok Tawah
LB06	Kleder
LB07	Lokok Timpas
LB08	Lokok Lebak
LB09	Lokok Gerasak
LB10	Lokok Kwangan
LB11	Lokok Menniris
LB12	Lokok Santeak
LB13	Tibu Sanggar
LB14	Pelangan
LB15	Lendang Guar
LB16	Lokok Salangu

West Lombok

LB01	Pinang Lulu
LB02	Lokok Melepah
LB03	Lokok Salut
LB04	Lengkok Menangan
LB05	Lengkok Tawah
LB06	Kleder
LB07	Lokok Timpas
LB08	Lokok Lebak
LB09	Lokok Gerasak
LB10	Lokok Kwangan
LB11	Lokok Menniris
LB12	Lokok Santeak
LB13	Tibu Sanggar
LB14	Pelangan
LB15	Lendang Guar
LB16	Lokok Salangu

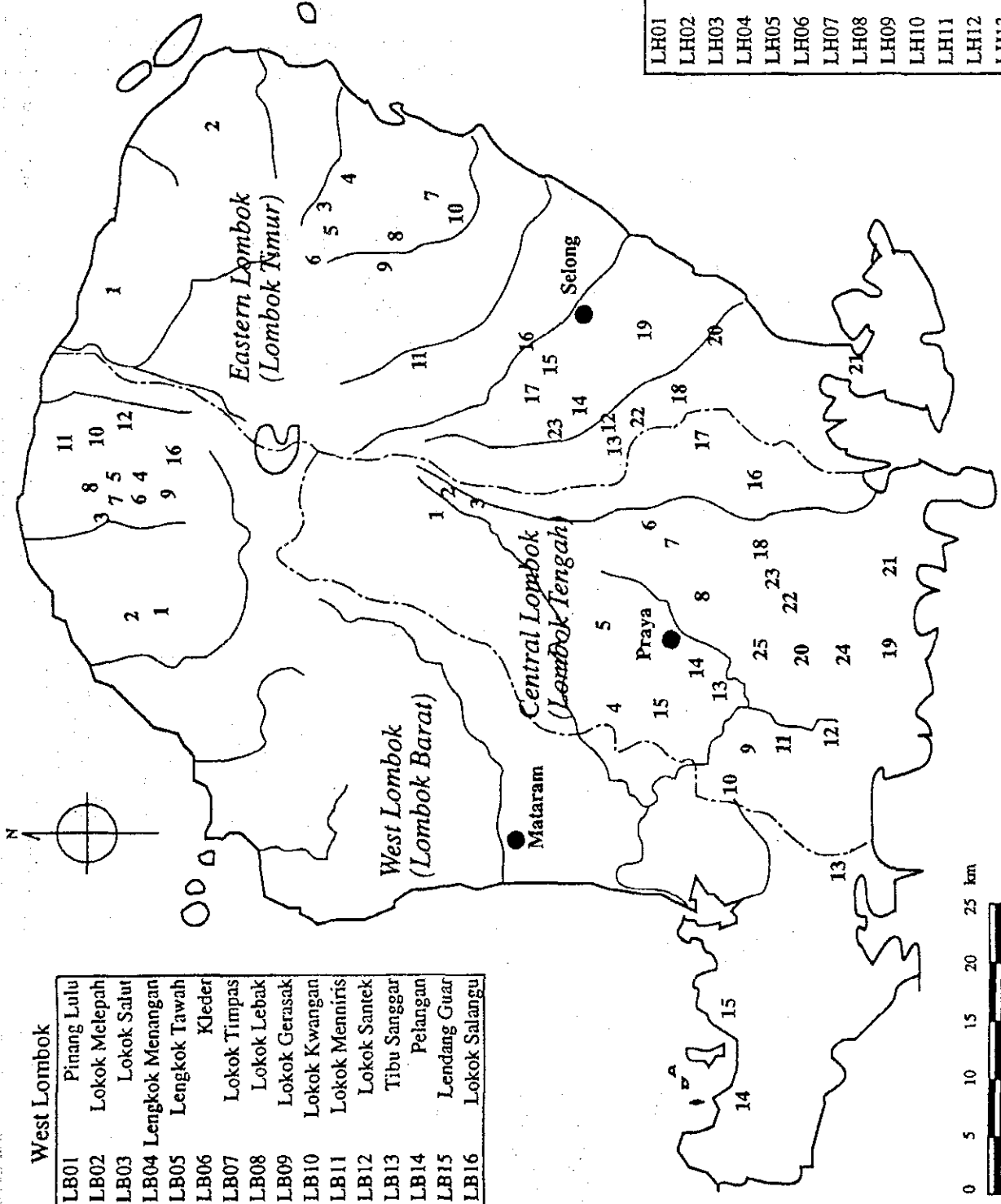
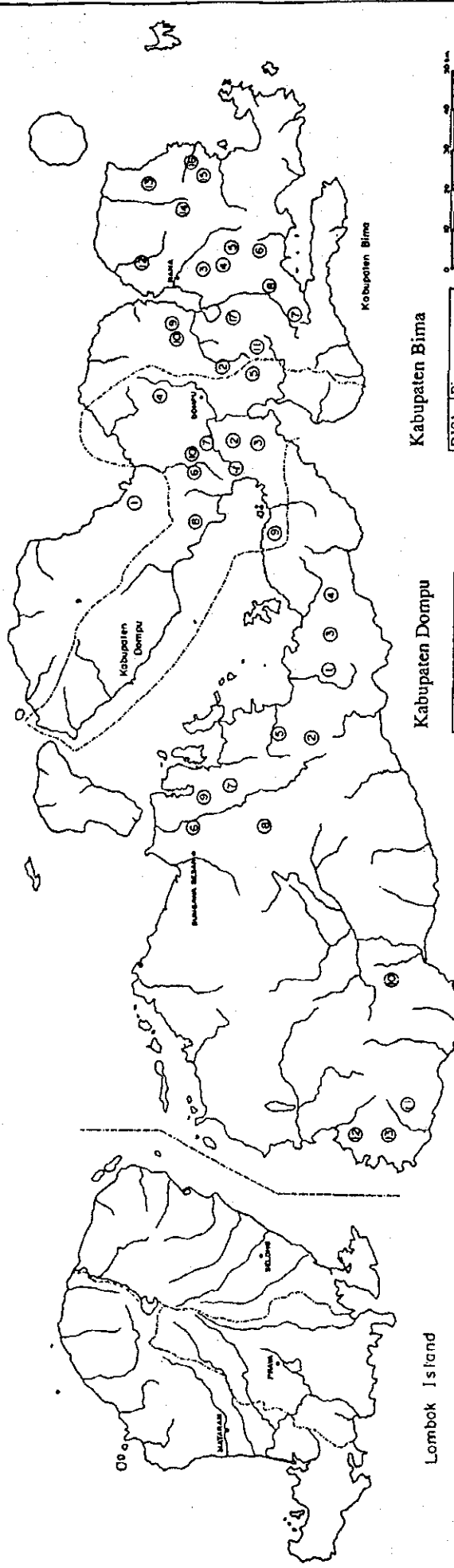


Figure S-1 Location Map of Inventoried Embung Development Projects in Lombok Island

Sumbawa Island



Kabupaten Bima

BI01	Piong
BI02	Mpuri
BI03	Nlonggu II
BI04	Lido
BI05	Ncera
BI06	Doroo'o
BI07	Sondo
BI08	Laju
BI09	Ncoha II
BI10	Ncoha I
BI11	Woro
BI12	Tolowata
BI13	Tawali
BI14	Nioke
BI15	Kowo
BI16	Buncu
BI17	Kelji

Kabupaten Dompu

DO01	Banggo Plan
DO02	Tonda Utara
DO03	Tonda Selatan
DO04	Sanco
DO05	La-Nangga
DO06	Ta'a
DO07	Parugasante
DO08	Kesi
DO09	Kuango
DO10	Sagupasante

Kabupaten Sumbawa

SW01	Gapit
SW02	Sejari
SW03	Tui Tui
SW04	Penyempeng
SW05	Jompong
SW06	Penyaring
SW07	Lopok
SW08	Serading
SW09	Olat Rawa
SW10	Jamu
SW11	Maluk
SW12	Jelenga
SW13	Benete
SW14	Terusa

COOPERATIVE BUREAU OF  
WATER RESOURCES DEVELOPMENT,  
MINISTRY OF PUBLIC WORKS  
The Embung Development Project is  
Carried out Through and with Aids Through  
THE INTERNATIONAL COOPERATION AGENCY

Figure S-2 Location Map of Inventoried Embung Development Projects in Sumbawa Island





Timor Island

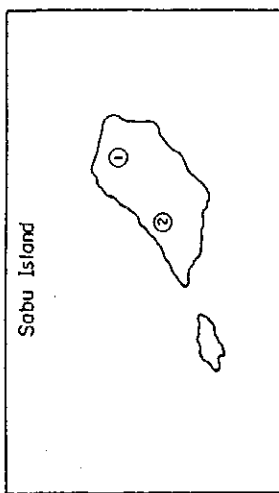
TI01	Bimoku
TI02	Oelutua
TI03	Iastepah
TI04	Biraut
TI05	Batu Panjang
TI06	Panti
TI07	Obor
TI08	Benkoko
TI09	Oebuain
TI10	Fatukmetang
TI11	Bellenmata
TI12	Nana Eklot
TI13	Maubusa II
TI14	Rairinu
TI15	Buitasik

Rote Island

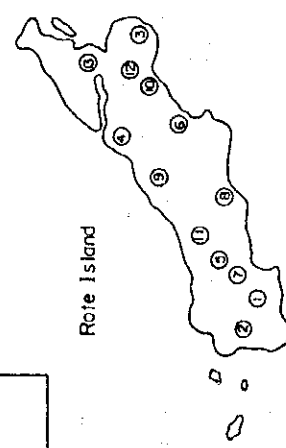
RO01	Danau Tua
RO02	Manggis
RO03	Oetele
RO04	Umakapa
RO05	Kapalangga
RO06	Lekobatu
RO07	Livuhahani
RO08	Hanendam
RO09	Manubulu
RO10	Lenggale
RO11	Livubatu
RO12	Toen Oen
RO13	Matasio

Sabu Island

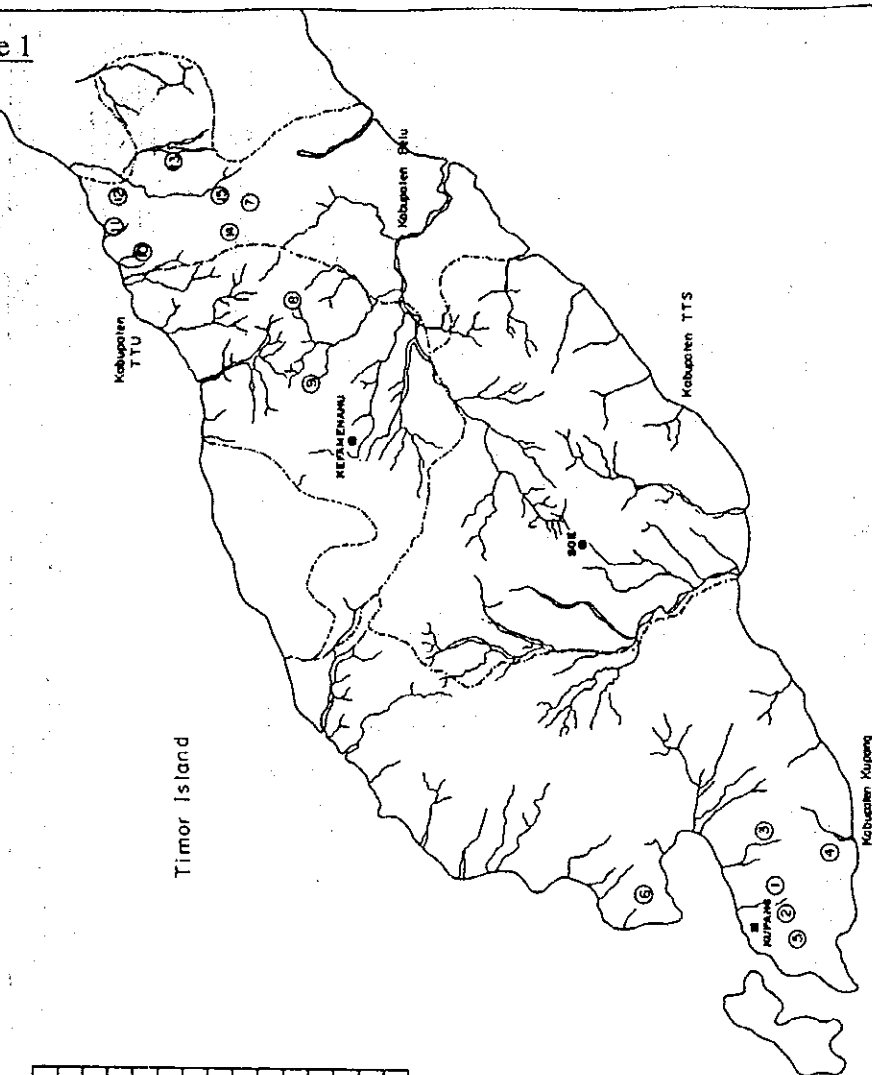
SA01	Lere
SA02	Lokoel



Rote Island



Timor Island



DIRECTORATE REGIONAL OF WATER RESOURCES DEVELOPMENT, MINISTRY OF PUBLIC WORKS	
The Embung Development Project in East-Horn Timorland and West-Horn Timorland	
No.	Area
JAWAHIR INTERNATIONAL CORPORATION ANGKAT	

Figure S-4 Location Map of Inventoried Embung Development Projects in Timor Island

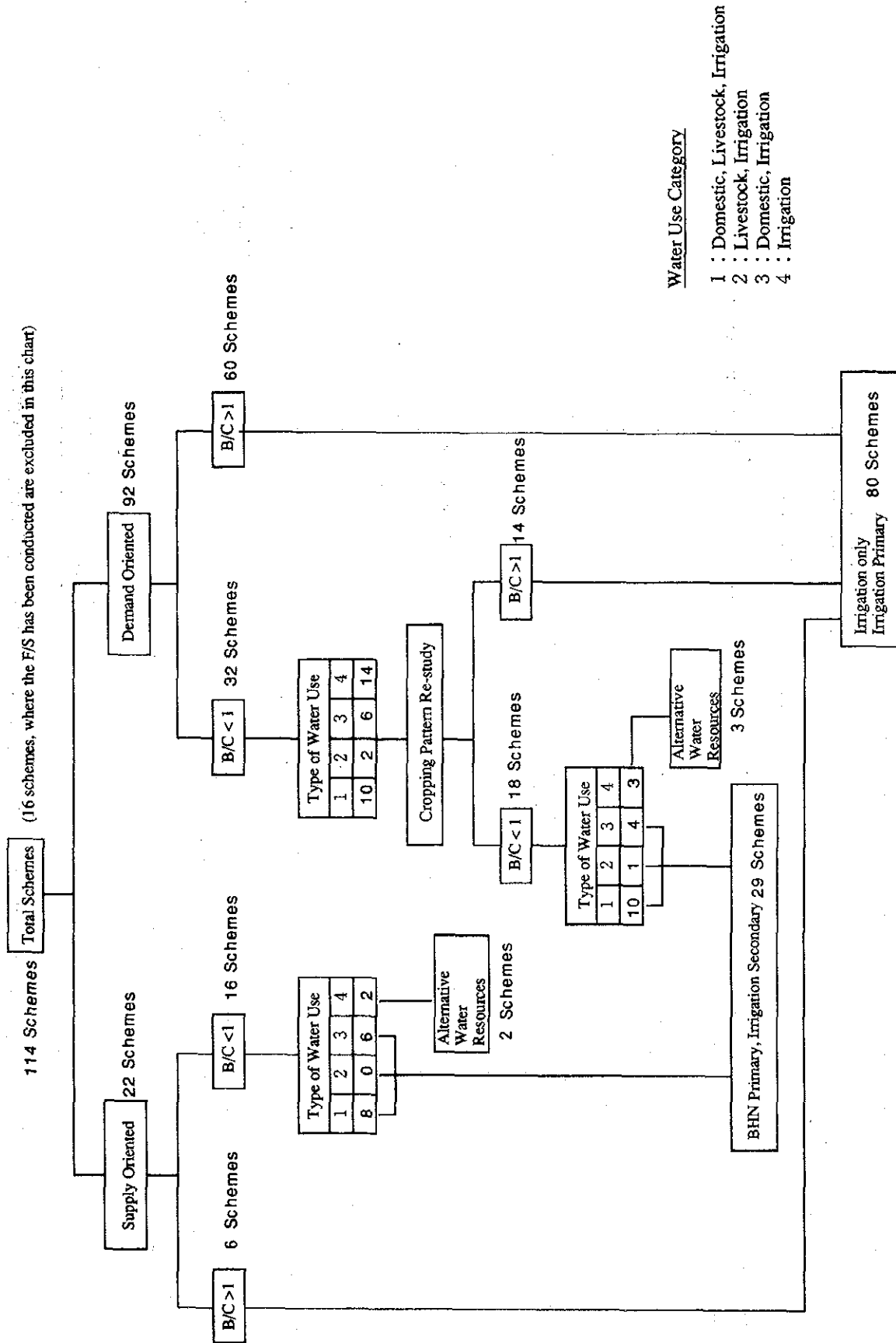


Figure S-5 Assessment Results of Embung Development Potential

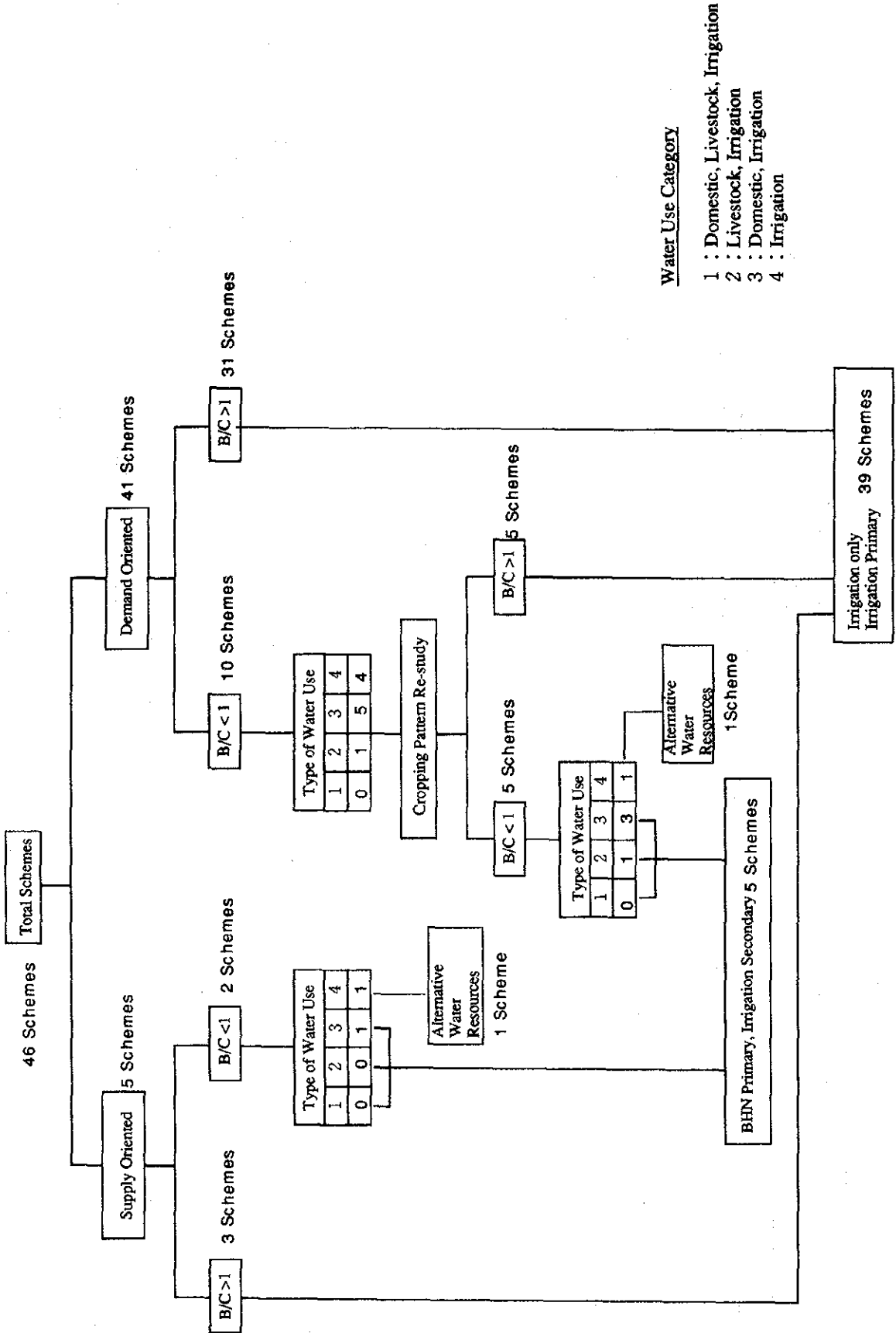
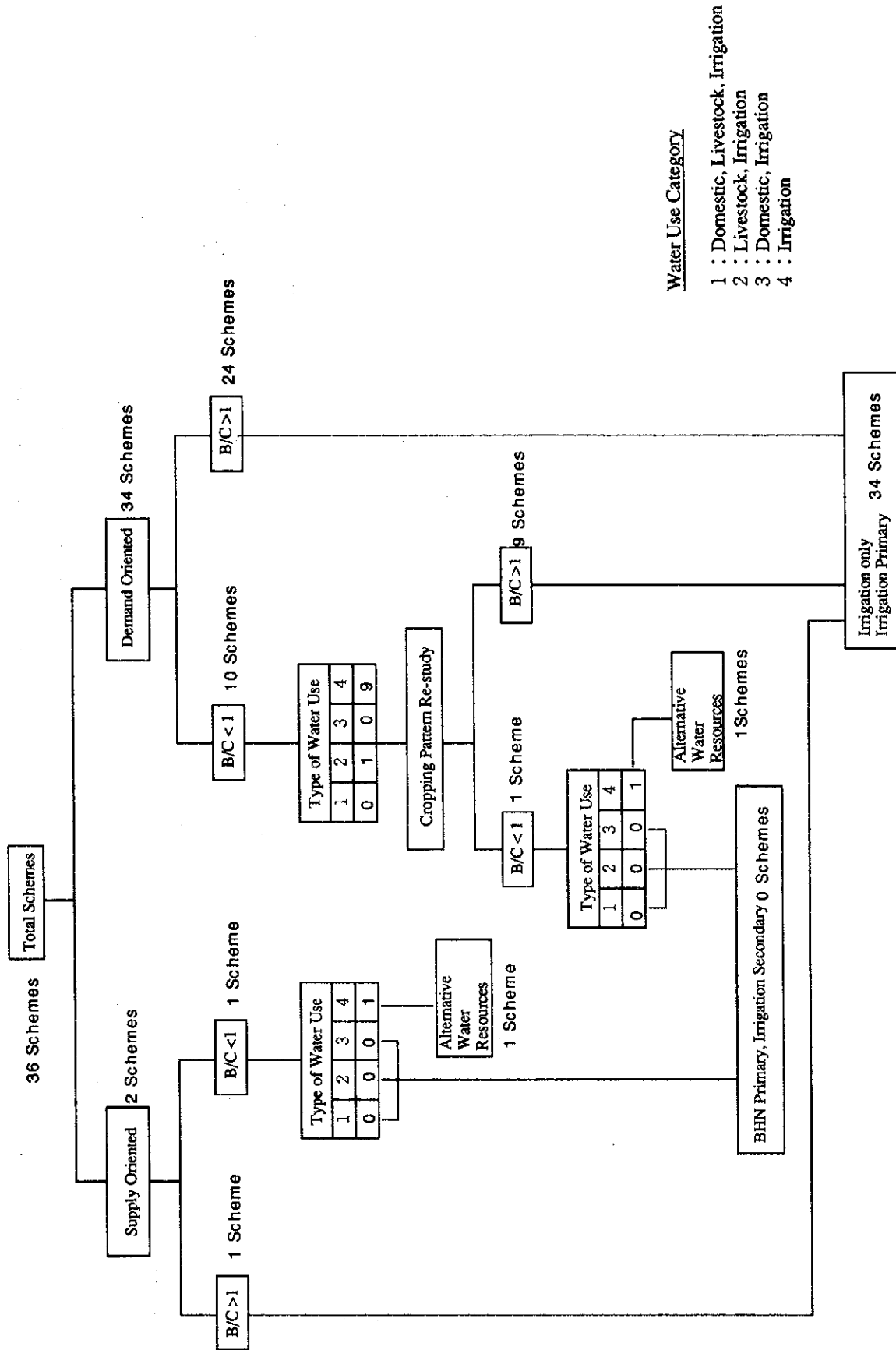


Figure S-6 Assessment Results of Embung Development Potential (Lombok)



Water Use Category

- 1 : Domestic, Livestock, Irrigation
- 2 : Livestock, Irrigation
- 3 : Domestic, Irrigation
- 4 : Irrigation

Figure S-7. Assessment Results of Embung Development Potential (Sumbawa)

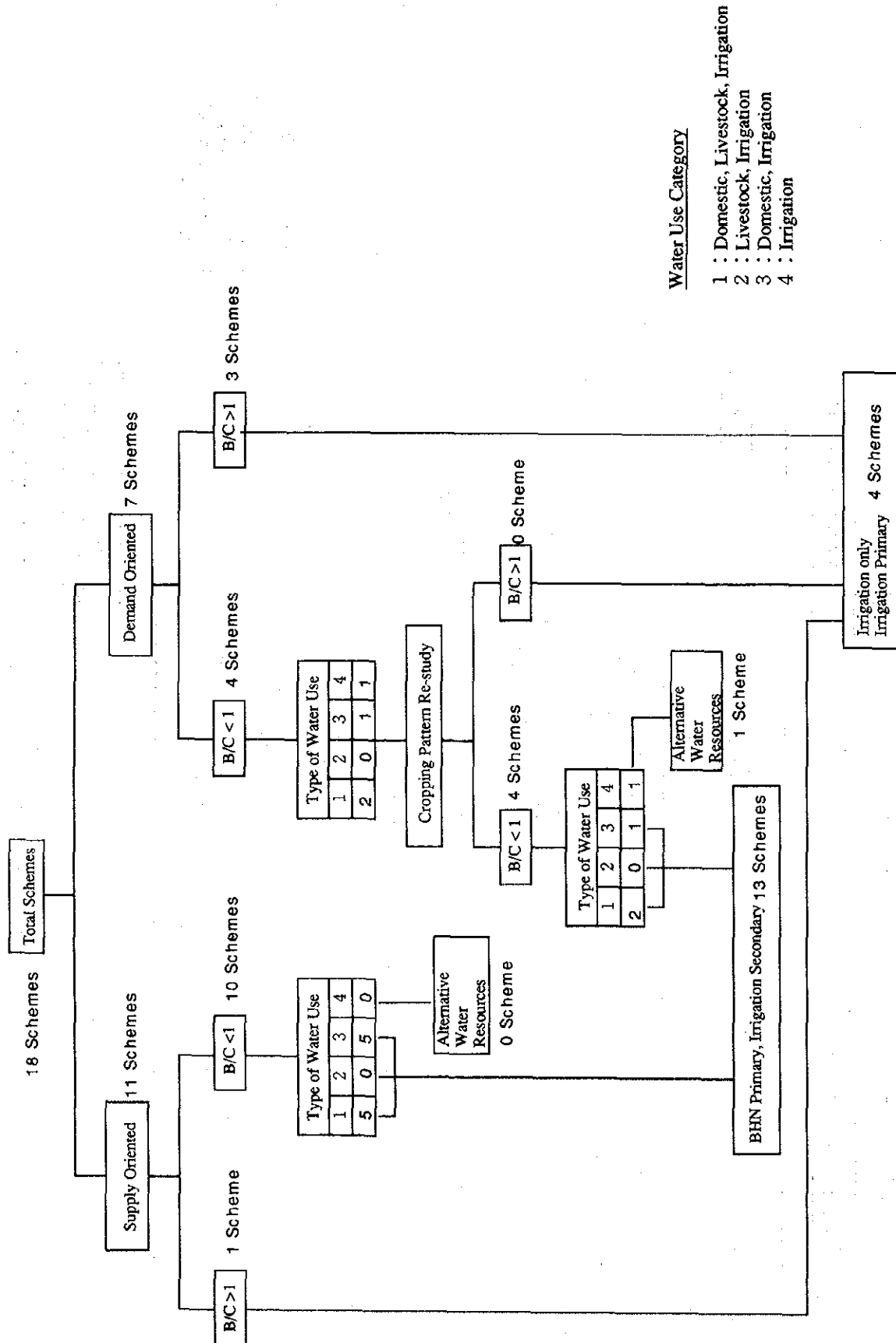


Figure S-8 Assessment Results of Embung Development Potential (Sumba and Flores)



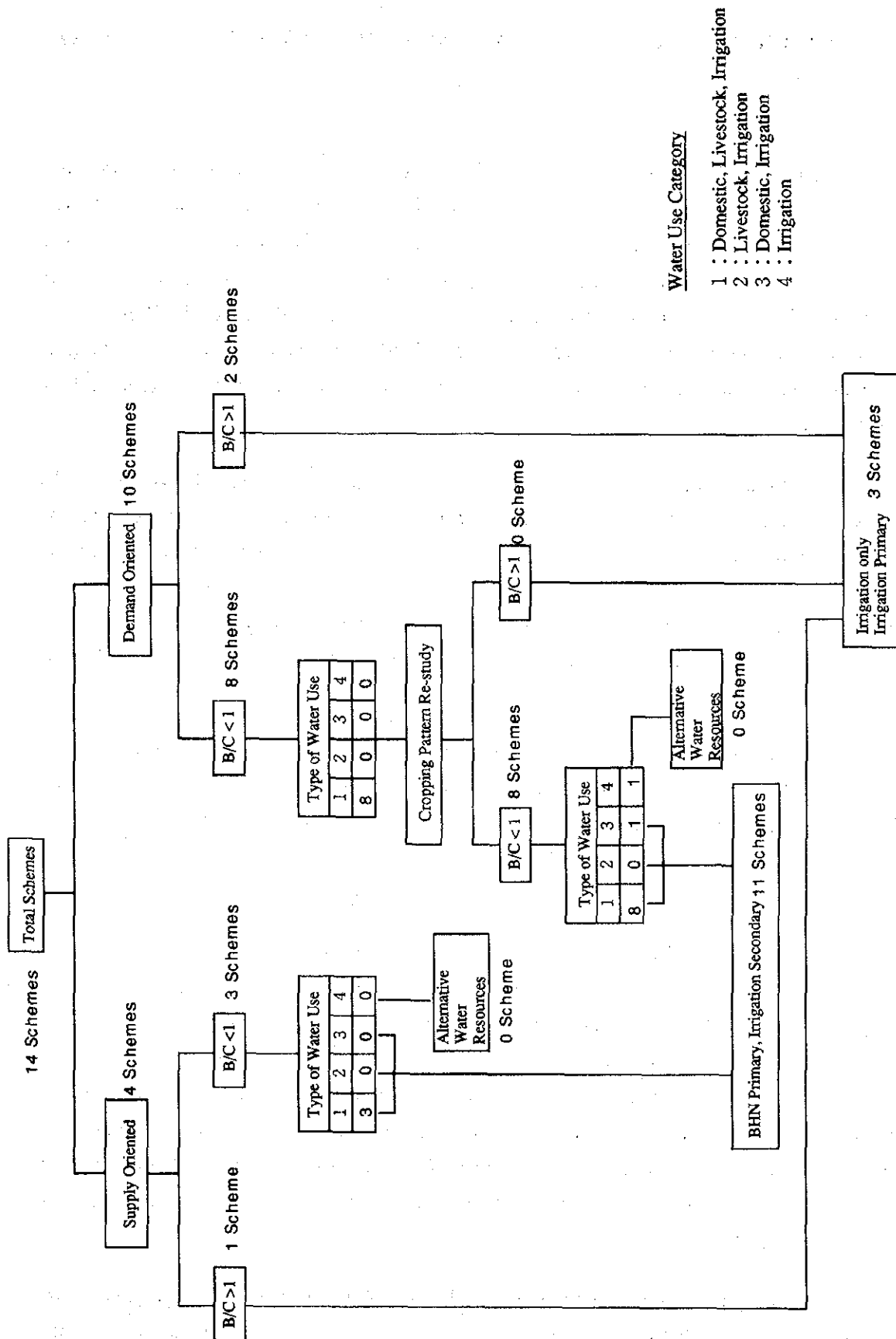


Figure S-9 Assessment Results of Embung Development Potential (Timor)

## **C. FEASIBILITY STUDY ON SIX EMBUNGS FOR URGENT DEVELOPMENT**

### **C-1 Project Area**

43. The technical feasibility and project justification study was carried out under the Study aiming to examine the development potential of the six Embungs that the GOI had requested the GOJ to provide grant aid for the urgent implementation. The proposed six Embungs are Bimoku, Oelutua and Tasiepah projects located near Kupang, the provincial capital of NTT, Benkoko and Oebuain projects situated in the eastern part of the West Timor, and Matasio project in Rote island west of Timor island. The main access from Kupang to the Matasio site is a daily ferry service and to other sites is the Trans-Timor road and its feeder roads.

44. Predominant crops in the six project areas are maize and cassava followed by paddy and beans. These are mostly grown under rainfed conditions during the wet season. Irrigation facilities are available in the Tasiepah and Benkoko project areas with a total designed command area of 206 ha. Livestock plays an important role in the provision of nutrition and income sources for inhabitants in each project area. Considering the wide varieties of animals, the livestock population is converted to number of cows according to their water consumption rate.

45. Agricultural supporting services are available, but farmers have usually less frequent access to such services due to their remote location and the limited operational budget of relevant agencies. Most farmers have difficulty covering family budgets with their farm incomes and make up deficits from allowances received from family members and relatives in other places or by extra cash income earned working away from home.

46. Water source facilities for domestic and livestock use in each project area consist of: public water basins, tanks, well, and private wells in Bimoku; public and private wells and springs in Oelutua; wells and irrigation headworks in Tasiepah; and public wells and springs in Benkoko, Oebuain, and Matasio. All water sources except for springs dry during a part or all of the dry season. When water sources dry up, inhabitants are usually provided with their drinking water by public water tankers. The average walking distance to carry water from source facilities is 36 m in Bimoku, 500 m in Oelutua, 363 m in Tasiepah, 6,500 m in Benkoko, 1,560 m in Oebuain, and 135 m in Matasio. Electricity is supplied to three sites located near Kupang.

47. No hospital is available, but community health sub center and health integrated post are established to provide inhabitants with minimum health care services. Inhabitants do not have toilet or bathing facilities in their houses and utilize rivers for bathing and washing

purposes. The rivers also provide water to their livestock. Under these circumstances, they often suffer from various waterborne diseases.

### C-2 Development Needs

48. The pressing necessity of inhabitants in the six project areas is to meet their BHN to improve their living conditions through resolving water shortage problems derived from a lack of perennial water sources. The inhabitants are also eager to obtain sufficient water for their livestock which are sources of nutrition and cash income.

49. 2,099 ha of available farm land resources, sizable wet paddy fields located downstream of each Embung is demarcated as irrigable areas; 10 ha in Bimoku, 160 ha in Tasiepah, 70 ha in Benkoko, and 140 ha in Matasio. With sufficient water resource potential to meet irrigation water demand, these irrigable areas in the Tasiepah, Benkoko, and Matasio project areas can be utilized to the maximum extent by practicing the following irrigated cropping patterns.

Project Area		Wet Season Crop Growing Period		Dry Season Crop Growing Period	
Tasiepah	(Left bank)	Paddy	Nov. 21 to Apr. 30	Beans	Apr. 16 to Aug. 5
	(Right bank)	Paddy	Dec. 21 to May 30	Beans	May 16 to Sept. 5
Benkoko	(Paddy field)	Paddy	Dec. 5 to May 15	Red onion	June 1 to Aug. 30
	(Upland)	Corn/beans (Rainfed)		Red onion	June 1 to Aug. 30
Matasio	(Paddy field)	Paddy	Dec. 5 to May 15	Maize	May 16 to Sept. 25
				Beans	May 16 to Sept. 5

50. The future water demand for domestic and livestock is estimated citing the future population of inhabitants and livestock, and the target water supply levels, 60 lit/person/day and 40 lit/cow/day, in rural areas for 2003/04, the last year of Pelita VII. The annual diversion requirement of irrigation water is estimated by referring the standard quoted in "Irrigation Design Standard, KP-01" of DGWRD. The estimated water demand is shown below.

Project Area	Unit	Domestic Water	Livestock Water	Irrigation Water
Bimoku	m <sup>3</sup> /year	66,116	9,735	-
Oelutua	m <sup>3</sup> /year	45,486	11,464	-
Tasiepah	m <sup>3</sup> /year	36,026	14,794	2,419,700
Benkoko	m <sup>3</sup> /year	38,829	21,756	598,850
Oebuain	m <sup>3</sup> /year	46,012	6,388	-
Matasio	m <sup>3</sup> /year	12,614	5,201	750,750

### C-3 Examination of Embung Development Potential

51. The selection of original sites, except for the Tasiepah site, has been reconfirmed as appropriate based on the topographic and geological investigations made under the Study.

## Volume 1

Through the initial findings of the Study, the proposed Tasiepah site was changed to 200 m upstream as this area had better geological conditions. The topographic conditions at each Embung site are shown below.

Embung	Shape of Valley	Width of Valley (m)	Topographically Maximum Height (m)
Bimoku	Rather deep/narrow	90	14.0
Oeltua	Shallow/wide	350	12.0
Tasiepah	Deep/rather wide	200	36.0
Benkoko	Rather deep/wide	400	19.5
Oebuain	Rather deep/rather wide	200	20.0
Matasio	Deep/wide	300	17.0

52. The results of the present geological and embankment material investigations reveal that leakage protection works are required for the five proposed Embung sites and reservoir areas excluding the Matasio site. Predominant foundation rocks are Noele Formation, Coralline limestone, Bobonaro Complex, and debris with a wide variation of permeability values. In the design of the foundation treatment, ordinary to special attention on seepage or leakage from the reservoir through the dam foundation or the abutments has to be paid.

53. The average annual rainfall varies from 1,000 mm in the Benkoko and Oebuain sites to 1,190 mm in the Matasio site and 1,470 mm in the other three sites. The catchment yield and probable flood of each water source river are estimated as shown below. The run-off coefficient adopted is 0.30 and the annual sedimentation rate assumed is 0.5 mm/km<sup>2</sup>.

Project Area	Water Source River	Catchment Area (km <sup>2</sup> )	Mean Annual Discharge ('000 m <sup>3</sup> )	100 Year Probable Flood (m <sup>3</sup> /s)
Bimoku	Sifbanu	0.20	86	18
Oelutua	Oeltua	0.82	353	48
Tasiepah	N. Pulti	32.10	13,814	428
Benkoko	Lis	2.30	978	49
Oebuain	Oemopu	0.80	233	21
Matasio	Kaifu	5.00	1,710	33

### **C-4 Optimization of Embung Development Scale**

54. Resulting from simulation of the reservoir operation, the optimum development scale is determined for each Embung as shown below. In carrying out the simulation, priority is placed on domestic, livestock and irrigation water use in that order. The reservoir capacity is to have 100% dependability to meet the domestic and livestock water demand and 80% dependability for the irrigation water demand. The minimum water level is assumed to coincide with 0.50 m above the lowest water level for securing capacity of the sedimentation volume for 25 years in the reservoir, while the maximum water level is equal to the crest elevation of the spillway.

Item	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Catchment area	km <sup>2</sup>	0.2	0.8	32.1	2.3	0.8	5.0
Dam height	m	14.0	12.0	26.0	19.5	12.0	11.0
Crest length	m	90.0	340.0	200.0	413.0	180.0	297.0
Reservoir area	m <sup>2</sup>	13,200	25,750	345,000	38,800	21,000	160,000
Effective storage capacity	m <sup>3</sup>	51,250	81,200	1,996,000	170,000	58,800	445,000

55. According to the optimum development scale, the water supply from Bimoku Embung is limited to domestic water, while the beneficial area is reduced to some extent in the Benkoko and Oebuain project areas. The irrigation area of the Matasio project is limited to 70 ha only for the wet season.

### C-5 Embung Development Plan and Preliminary Design

56. Homogeneous earthfill type is applied to all Embungs in due consideration of the foundation strength and the availability of embankment materials. The proposed leakage protection works are earth blanket to cover the Bimoku, Oeltua, Benkoko, and Oebuain reservoir areas and a concrete wall to protect water leaking through the coral limestone of the Tasiepah site. The height of the Embung is determined considering the full supply level, overflow depth of the spillway, and the freeboard.

57. New access roads to the Tasiepah, Benkoko, and Matasio sites with total length of 12.5 km will be constructed to facilitate operation and management after completion of the Embungs.

58. Water distribution facilities for inhabitants and livestock in the beneficial area of each Embung are composed of pipe lines and division boxes with filter systems for inhabitants, and division boxes for livestock and their related pipeline structures. The main features of the pipeline system are shown below.

Item	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Design discharge	lit/s	1.27	1.80	1.60	0.95	1.46	0.56
Total length of pipeline	km	1.47	1.63	9.63	5.40	4.22	4.04
Total number of related facilities	Nos.	24	58	68	46	39	23

59. Water distribution facilities to the beneficial irrigation areas of Tasiepah, Benkoko, and Matasio Embungs are composed of irrigation inlet boxes, concrete flume type canals, aqueducts, cross drains, and irrigation division boxes. The main features of the irrigation water distribution system are shown below.

## Volume 1

Item	Unit	Tasiepah Left bank	Tasiepah Right bank	Benkoko	Matasio
Design discharge	lit/s	130	70	50	100
Irrigation inlet box	Nos.	0	1	1	1
Concrete flume type canal	km	0	3.1	0.3	1.0
Irrigation diversion box	Nos.	0	3	3	1

### **C-6 Embung Construction Plan and Cost Estimate**

60. Embung construction works are carried out by using heavy equipment. To release the river flow during the embankment work period, a river diversion conduit is laid under the excavated foundation of the main dam. Embankment works of the main dam commence following the river diversion works and are completed within one dry season. Excavation of the spillway is performed in parallel and completed before impounding the water in the reservoir. A cast iron pipe is installed along the river diversion conduit as an outlet. An earth blanket with a thickness of 2.0 m is carpeted up to the full supply level of the reservoir area. A concrete wall with a thickness of 0.5 m and with anchor bars is constructed after the surface of coral limestone zone is stripped and excavated. Construction works of water distribution and irrigation facilities are carried out in parallel. The quantities of the major construction materials required for each Embung are shown below.

Materials	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Earthfill material							
- Main dam	m <sup>3</sup>	30,000	200,000	267,000	221,000	80,000	110,000
- Blanket	m <sup>3</sup>	34,000	68,000	0	102,000	56,000	0
Filter material							
- Horizontal drain	m <sup>3</sup>	1,500	11,500	8,000	20,000	5,000	11,000
- Riprap portion	m <sup>3</sup>	800	2,500	2,000	2,900	900	1,800
Rock material							
- Riprap protection	m <sup>3</sup>	1,700	5,500	5,200	7,800	2,400	4,800
- Toe rock fill	m <sup>3</sup>	1,000	2,500	2,000	3,100	1,100	2,200
Concrete							
- Cement	ton	600	760	3,340	950	380	660
- Reinforcement bars	ton	50	65	265	66	22	43
- Aggregates	m <sup>3</sup>	1,500	2,000	8,400	2,400	1,000	1,700

61. The required period for conducting detailed design, mobilization, and construction works is estimated to be 33 months for the Tasiepah project and 21 months for the other five projects. All the construction works are carried out by a contractor selected through competitive bidding. If the six Embungs are constructed in a form of one package, the total construction period requires five years.

62. Implementation of the proposed projects is the full responsibility of the Construction Section of the Water Resources Services and PKSA Timor Office of DPUP of NTT. For the successful prosecution of the proposed projects, appropriate expatriate assistance is required to supervise the earth and construction works.

63. The Operation and Maintenance Section of the Water Resources Services of DPUP is responsible for operating and maintaining the Embungs, and their intake and water distribution facilities. The beneficiaries need to be organized by DPUP to participate in routine works such as cleaning of water division boxes, clearing of animal excreta around the water division boxes, and repairing of fences along the reservoir.

64. The cost estimate of the projects is made on the feasibility level using the market prices of construction equipment and materials as of June 1994. The estimated project cost is summarized below.

Item	Unit : million Rp.						
	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio	Total
Direct construction cost	2,032	4,645	13,587	5,705	2,419	3,154	31,542
Preparatory works	97	221	647	272	115	150	1,502
Embung embankment	1,754	4,203	10,860	5,050	2,075	2,565	26,507
Water distribution facilities	181	221	639	198	229	147	1,615
O&M road	-	-	162	111	-	82	355
Irrigation facilities	-	-	1,279	74	-	210	1,563
Administration cost	102	232	679	285	121	158	1,577
Engineering services	305	697	2,038	856	363	473	4,732
Physical contingency	366	836	2,446	1,027	435	568	5,678
Contract tax	270	618	1,807	759	322	420	4,196
Land acquisition	10	23	68	29	12	16	158
Price contingency	308	705	2,063	866	367	479	4,788
<b>Total</b>	<b>3,393</b>	<b>7,757</b>	<b>22,688</b>	<b>9,526</b>	<b>4,040</b>	<b>5,267</b>	<b>52,671</b>

### C-7 Project Justification

65. The anticipated domestic and livestock water supply benefits comprise two portions: reduced time in fetching water from distant sources and reduced health problems or morbidity. Taking into account the difficulty to quantify such benefits, the values of water and the investment amount to each beneficial inhabitant are taken up as indicators when deciding project implementation. The definition is as follows:

- The investment amount is obtained by deducting the administration and land acquisition costs from the Project cost and then allocating to two portions: one to meet the basic human needs and the other to cover the irrigation water demand based on the result of the optimization study;
- The values of water are obtained by dividing the investment amount by the effective storage capacity and the water supplied amount; and,
- The investment amount for each beneficial inhabitant is obtained by dividing the investment amount by the number of beneficial people and livestock.

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The estimated indicators are shown below.

Item	Unit	Bimoku	Oeltua	Tasiepah	Benkoko	Oebuain	Matasio
Effective storage capacity	'000 m <sup>3</sup>	51.25	81.20	1,996.00	170.00	58.80	445.00
Beneficiaries (inhabitants)	person	1,825	2,077	1,645	935	1,773	576
Beneficiaries (livestock) (equiv. head of cow)		0	785	1,013	657	438	356
Total beneficiaries	person	1,825	2,603	2,324	1,375	2,066	815
Annual water supply amount	'000 m <sup>3</sup>	39.97	56.95	50.82	30.08	45.22	17.81
Total Project cost	million Rp.	3,393	7,757	22,688	9,526	4,040	5,267
Investment cost	million Rp.	3,254	7,437	12,906	4,255	3,873	3,897
Value of effective storage water	'000Rp./m <sup>3</sup>	63.5	91.6	6.5	25.0	65.9	8.8
Value of supplied water	'000Rp./m <sup>3</sup>	81.4	130.6	254.0	141.5	85.6	218.8
Investment amount Inhabitants only	million Rp.	1.78	3.58	7.85	4.55	2.18	6.76
Total beneficiaries	million Rp.	1.78	2.86	5.55	3.09	1.87	4.78

66. As many stock breeders who live outside of the Matasio project area depend on the existing water sources, another 975 heads of cow can be expected to get drinking water after completion of the proposed Embung. The investment amount to the total beneficiaries reduces to Rp. 2.65 million.

67. In case the proposed Tasiepah, Benkoko, and Matasio projects are developed as BHN oriented and irrigation sub type, the investment for the irrigation portion is economically not viable. However, for this investment, it would be worth taking into account the full combined utilization of the limited water and land resources and the significant increase in farm income, and also it would have a significant positive impact on the development of the economically depressed areas in NTT.

68. There will be no major negative environmental impacts by constructing Embungs in the project areas. Various activities of villagers in the attachment areas, however, result in the reduction of water conservation, acceleration of soil erosion, and further increase in sedimentation inflow into the new reservoirs. Another negative impact which may occur in the future is contamination of the reservoir water by defecating of the inhabitants and cattle. The proposed mitigatory measures to reduce these negative effects are promoting afforestation and reforestation in the catchment areas and protecting the reservoir by enclosing it with a fence.

### **C-8 Conclusion and Recommendations**

69. The technical and project justification study conducted under the Phase I Study concludes that urgent implementation of the five proposed projects except Tasiepah is



required because construction works of all project components are technically possible and project implementation is socially and socio-economically desirable.

70. The proposed Tasiepah project is also worth implementing as a BHN-oriented and irrigation sub development type to meet the water demand of the downstream area of the Embung. Through the Phase I Study, however, the maximum water resource development potential is clarified to increase from 1,996,000 to 7,096,000 m<sup>3</sup> by raising the dam height to 36.0 m and adding 60% to the project cost. Further, the Tasiepah Embung once constructed site would be unable to raise its height due to its physiological conditions.

71. Necessary administrative and technical steps for the implementation of the five projects are recommended to be immediately taken: including the determination of the executing agency, the procurement of necessary funds in foreign currency, and the preparation of a counterpart fund in domestic currency; and the introduction of advanced technology and management know-how for the smooth and quick construction of higher Embungs on permeable foundations.

72. As maximum utilization of limited water resources is a prerequisite to support the upgrade of social infrastructures to satisfy BHN and to increase agricultural production to accelerate regional economic development in NTT, undertaking of an additional feasibility study is recommended for dam construction at Tasiepah in order to supply impounded water to the surrounding areas for irrigation and urban water use.

**D. FEASIBILITY STUDY ON 10 REPRESENTATIVE EMBUNGS**

**D-1 Salient Features of Representative Schemes**

73. Out of the 10 representative Embungs selected through the categorization study on 130 candidate Embung schemes, one each is located in the northern and western parts of Lombok Island, respectively, and another two in the southern part of Lombok in NTB. On Sumbawa Island, two each are situated in the central and eastern parts. In NTT, one is located near the provincial borders of East Timor and the other lies on Sumba Island. The distance from the main town to each Embung site varies from 25 to 320 km. All the access roads to the respective Embungs are paved.

74. The average annual rainfall in the Mataiyang project area on Sumba is 2,420 mm, and between 1,000 and 1,300 mm in the other nine project areas. The smallest catchment area is 4.0 km<sup>2</sup> at the Fatukmetang Embung site on Timor Island and the largest is 46.0 km<sup>2</sup> at the Pelangan Embung site on Lombok Island. Each water source river declines in discharge or dries up completely during the dry season.

75. Soils and rocks on Lombok and Sumbawa Islands are generally volcanic. On the other hand, soils and geology are featured by parent materials composed of coral limestone. The whole areal extent is a minimum of 133 ha at Fatukmetang and a maximum of 790 ha in the Tiu Tui project area, while the existing farm land covers a minimum of 211 ha in the Lokok Meniris project area on Lombok Island and a maximum of 631 ha in Tiu Tui. The Fatukmetang project area is generally idle farm land with the dense bush and tall grasses. The gross coverage of wet paddy field varies from 64 ha in the Aik Beta project area on Lombok Island to 453 ha in Tiu Tui.

76. The total number of inhabitants ranges from 572 in Fatukmetang to 4,298 in Tiu Tui. The minimum number of households is 156 in Fatukmetang and the maximum is 982 in the Pelangan project area on Lombok Island. Around 80% of families are farm household and the number of breeding households varies from 12 in Lokok Meniris to 608 in the Penyempeng project area.

77. Irrigation facilities are available in all project areas except for Aik Beta and Fatukmetang. The present operation and maintenance conditions vary widely. Irrigation water is diverted through intake weirs constructed on the same water source rivers, but in Lokok Meniris, it is transferred from a neighboring river. The minimum irrigation area is 37 ha in Tiu Tui, while the maximum is 321 ha in the Ntonggu II project area on Sumbawa Island. The present maintenance level of irrigation facilities in the eight project areas ranges from semi-technical on Lombok and Sumbawa Islands to simple on Sumba Island.

78. The dry season wet paddy is grown under irrigated conditions in Lokok Meniris, Pelangan, and Penyempeng. Irrigated cultivation of the dry season Palawija crops is practiced in Ntonggu II, while rainfed Palawija crops are found partly on semi-technical wet paddy fields in Tiu Tui, the Montong Krarak project area on Lombok island, the Ncoha II project area on Sumbawa Island and in Aik Beta, which does not have an irrigation facility. Cropping intensity for the whole farm land ranges from 100% in Mataiyang to 166% in Lokok Meniris. Typical crops grown other than wet paddy are maize, soybean, mungbean, groundnut, red onion and tobacco.

79. The predominant draft animal is cow in the project areas on Lombok Island and buffalo in the projects on Sumbawa. The maximum breeding number is around 4,000 cows in Pelangan and more than 3,800 buffaloes in Tiu Tui. On the other hand, pig raising of 250 heads is common in Fatukmetang and Mataiyang due to a lack of religious limitations .

80. Agricultural Cooperatives (KUD) and Water Users' Associations (P3A) have been organized in each project area. The inactive performance of KUDs has forced farmers to purchase farm inputs from local markets or merchant shops. Further training of on-farm water management practices is required for P3As' members taking into account the low level of their know-how. Agricultural extension services including veterinary service are provided to farmers through field extension workers of the existing rural extension centers. Due to limitations of their operational budget, however, farmers have usually received very infrequent visits.

## D-2 Development Needs and Concept

81. Most inhabitants in the respective project areas are generally unsatisfied with the present condition of rural infrastructures to some extent as summarized below.

Project Area	Domestic Water	Livestock Water	Electricity
Lokok Meniris	4 month shortage	Rather convenient	Not available
Pelangan	500 m distance	Rather convenient	Not available
Montong Krarak	Low quality	Convenient	Available
Aik Beta	Rather convenient	Rather convenient	Not available
Tiu Tui	Rather convenient	Short for 6 months	Available
Penyempeng	Convenient	Convenient	Available
Ncoha II	Solution already planned	Rather convenient	Available
Ntonggu II	Rather convenient	Short for 3 months	Available
Fatukmetang	3 months shortage, 200 m distance	Inconvenient	Not available
Mataiyang	1,500 m distance	Rather convenient	Not available

82. In and around each project area, there are insufficient employment opportunities, forcing farmers to use their farm land more intensively in order to raise their incomes. To do this, they require all year-round irrigation water source facilities to produce crops and also to save time having to carry drinking water and remove cattle. In the existing irrigation areas,

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however, discharge of the water source rivers declines during the dry season resulting in drop of water levels dropping below the designed intake water level and limiting the irrigable areas.

83. As meeting BHN and increasing agricultural production are necessary countermeasures to fill gaps in regional development, it is indispensable to solve the water shortage problems caused by the lack of utilization of the available surface runoff of the respective river basins. Thus, the development gives the highest priority to improving the present condition of the social and economic infrastructures. The development strategies to overcome the development constraints are to regulate seasonally available water resources by means of constructing Embung and to utilize storage water during the dry season.

84. The approach to the formulation of the development plan for the potential Embungs is as follows:

- To place the first priority on supplying irrigation water and the second to domestic and livestock water in NTB, whereas in NTT the first priority is to BHN followed by irrigation taking into account the inhabitants' needs and intention;
- To project the future water demand for irrigation, domestic, and livestock use at the target year of 2008, being the last year of Pelita VIII;
- To examine the development potential of the representative Embungs from the technical viewpoints;
- To determine the optimum development scale of each Embung;
- To make a preliminary design and cost estimate; and,
- To conduct project justification from the viewpoints of economic soundness, social satisfaction, and environmental impact.

### **D-3 Development Plans for Agriculture, Livestock and Social Infrastructures with Future Water Demand**

85. The irrigable areas demarcated by their present land use, soil characteristics, crop suitability, topographic condition in relation to the proposed Embung site, layout of the existing irrigation canal, and use of a 1/5,000 topographic map newly prepared under the Study, total 83 ha in Lokok Meniris, 248 ha in Pelangan, 44 ha in Montong Krarak, 57 ha Aik Beta, 331 ha in Tiu Tui, 350 ha in Penyempeng, 157 ha Ncoha II, 210 ha in Ntonggu II, 57 ha in Fatukmetang, and 450 ha in Mataiyang.

86. In formulating the future cropping system in the respective project areas, special attention is paid to: irrigated cultivation of the wet season paddy as a base; and the selection of dry season Palawija crops which are acceptable to farmers, enable farmers to achieve higher benefits, efficiently use water, and can be grown using family laborers. Aiming to

determine the optimum development scale of each Embung, several alternative cropping patterns are established for the respective project areas.

87. The future inhabitants and livestock population in each project area for 2008 is projected as shown below.

Project Area	Inhabitant	Cow	Buffalo	Horse	Unit: person or head		
					Goat/ Sheep	Pig	Chicken /Duck
Lokok Meniris	1,285	1,508	189	23	1,047	0	1,815
Pelangan	4,800	5,274	169	107	2,414	1,838	17,816
Montong Krarak	4,584	189	120	48	48	0	1,627
Aik Beta	1,913	99	0	11	35	0	1,792
Tiu Tui	4,159	1,820	3,999	1,281	0	0	2,999
Penyempeng	4,071	27	307	161	16	0	1,605
Ncoha II	2,832	289	13	2	130	0	0
Ntonggu II	2,983	299	99	7	141	0	0
Fatukmetang	700	370	125	73	650	352	2,276
Mataiyang	5,300	313	91	63	424	242	2,000

88. The future domestic water consumption level in rural areas is set as follows:

- Domestic water demand in NTB is 80 lit/day/capita with an additional public water demand of 30 lit/day for 10% of the projected population and an unaccounted-for equivalent of 20% of the total water demand;
- Domestic water demand in NTT is 70 lit/day/capita including public water demand and unaccounted-for demand; and,
- Livestock water demand is 40 lit/day/head for cow, buffalo and horse, 5 lit/day/head for sheep and goat, 6 lit/day/head for pig and 0.6 lit/day/head for poultry according to "The Study for Formulation of Irrigation Development Program in the Republic of Indonesia". Additional water demand for buffalo's bathing is considered to be 20 lit/day/head in NTB.

89. Taking into account the inhabitants' future use of the newly constructed water source facilities, the projected domestic water demand is 46,700 m<sup>3</sup> for Lokok Meniris, 174,600 m<sup>3</sup> for Pelangan, 166,700 m<sup>3</sup> for Montong Krarak, 17,900 m<sup>3</sup> for Fatukmetang and 153,200 m<sup>3</sup> for Mataiyang. The projected livestock water demand is 133,500 m<sup>3</sup> for Tiu Tui, 6,900 m<sup>3</sup> for Ntonggu II, and 10,800 m<sup>3</sup> for Fatukmetang. The unit irrigation diversion requirement is estimated for the respective crops in each project area.

#### D-4 Assessment on the Development Potential of Embung

90. The results of the assessment on topography, geology, available embankment materials, annual runoff discharge, and probable floods are summarized below.

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Project Area	Topographically Maximum Dam Height (m)	Crest Length for Maximum Dam Height (m)	Catchment Area (km <sup>2</sup> )	Annual Runoff Discharge (m <sup>3</sup> )	Probable Flood Discharge of 1 in 100 years (m <sup>3</sup> /sec)
Lokok Meniris	20.0	200	7.4	5,019	159
Pelangan	40.0	380	46.0	23,565	522
Montong Krarak	12.0	190	5.4	2,273	35
Aik Beta	25.0	470	22.4	12,019	328
Tiu Tui	19.5	230	21.2	13,694	323
Penyempeng	40.0	380	41.1	24,415	202
Ncoha II	28.0	500	12.6	4,692	143
Ntonggu II	20.0	290	6.2	2,750	98
Fatukmetang	30.0	390	4.0	1,361	77
Mataiyang	30.0	230	19.1	15,093	231

### D-5 Embung Development Plan

91. There are two cases used to decide the development scale of Embungs: one whose development scale coincides with the maximum limitation of either topography of the proposed Embung site or runoff from the catchment area; and the other whose development scale is in line with the future water demand for domestic, livestock, and irrigation use in the prospected beneficiary area of the Embung. The former is defined as a supply-oriented type and the latter is called a demand-oriented type. The reservoir operation is simulated on a half monthly basis based on the alternative cropping patterns considering the unit irrigation diversion requirement, domestic and livestock water demand, inflow to the reservoir, evaporation losses from the reservoir, and outflow. Resulting from the simulation for each Embung, the optimum development scale of the Embung, net irrigation area, number of inhabitants to be provided with domestic water, and the equivalent head of cow to be supplied with livestock water are decided as shown below. The net irrigation areas for the respective alternative cropping patterns are shown in Table S-9.

Project	Type	Dam Height (m)	Effective Storage Capacity (m <sup>3</sup> )	Limiting Factor	Net Irrigation Area (ha)	Water- supplied Inhabitants (person)	Water- supplied Livestock (head)
Lokok Meniris	Supply- oriented	20.0	165,000	Topography	44	0	-
Pelangan	Demand- oriented	29.5	5,040,000	Irrigable area	248	4,800	-
Montong Krarak	Supply- oriented	12.0	62,000	Topography and runoff	44	0	-
Aik Beta	Supply- oriented	25.0	309,000	Topography	84	-	-
Tiu Tui	Demand- oriented	19.5	3,962,000	Irrigable area	331	-	7,145
Penyempeng	Demand- oriented	39.0	7,200,000	Irrigable area	350	-	-
Ncoha II	Demand- oriented	25.0	1,024,000	Irrigable area	157	-	-
Ntonggu II	Supply- oriented	17.0	1,159,000	Runoff	187	-	423
Fatukmetang	Demand- oriented	19.0	840,000	Irrigable area	57	700	736
Mataiyang	Demand- oriented	20.0	1,832,000	Irrigable area	450	5,300	-

91. In due consideration of the foundation strength and the availability of embankment materials at each Embung site, dam types which apply are zoned embankment dams for the proposed Lokok Meniris, Pelangan, Tiu Tui, Penyempeng, Ncoha II and Mataiyang Embung projects, masonry gravity dams for the Montong Krarak and Aik Beta Embung projects, and homogeneous embankment dams for the Ntonggu II and Fatukmetang Embung projects. Foundation treatment methods will be grout for the proposed Lokok Meniris, Pelangan, Penyempeng and Mataiyang Embung sites, and cut-off for the proposed Tiu Tui, Ncoha II, Ntonggu II and Fatukmetang Embung sites. Seepage protection work using the earth blanket method is will be done for the proposed reservoir area of Mataiyang Embung .

#### **D-6 Facilities and Construction Plan of Embung**

92. The outline of Embung facilities is shown in Table S-10 and the irrigation facilities are summarized in Table S-11. O&M road for Embungs will be provided for the Lokok Meniris, Montong Krarak, Penyempeng, Ntonggu II, Fatukmetang and Mataiyang Embung sites. The domestic water distribution facilities consisting of pipelines and division boxes will be installed in the Pelangan, Fatukmetang and Mataiyang project areas. The total length of new pipeline is 11.5 km. Livestock water is to be distributed through irrigation canal systems in the Tiu Tui and Ntonggu II project areas and through a new pipeline in the Fatukmetang project area.

93. The construction period required is 14 months for the Lokok Meniris and Montong Krarak projects, 26 months for the Pelangan, Aik Beta, Tiu Tui, Ncoha II, and Fatukmetang projects, and 36 months for the Penyempeng and Mataiyang projects.

#### **D-7 Responsible Institutions for Project Implementation**

94. Under the direction of both DPUPs, Lombok, Sumbawa, Flores-Sumba and Timor PKSA Project Offices are responsible for land acquisition and awarding contracts by tender before commencement of the project implementation. After completion of Embung, the both Provincial Project Offices for Operation and Maintenance under DPUPs are responsible for budget allocation for O&M works to be conducted by the relevant DPUP Kabupaten Offices.

95. If P3A's have not yet been established in each beneficiary area, agencies concerned at the provincial and district levels will have to promote the organization of beneficial farmers into P3A's and to train them using training materials and modules prepared by the Water User Training Program under DGWRD.

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### **D-8 Project Cost**

96. The project cost as shown below is estimated on the basis of unit prices as at June 1994. 0.5% of the Project cost is appropriated for the annual O&M cost of Embungs and other facilities:

Unit : million Rp.

Project	Direct Construc- tion Cost	Administra- tion Cost & Engineering Service	Physical Contin- gency	Other Costs	Total Cost
Lokok Meniris	2,617	523	471	1,155	4,766
Pelangan	12,982	2,596	2,337	5,733	23,648
Montong Krarak	1,472	295	265	650	2,682
Aik Beta	9,188	1,837	1,654	4,057	16,736
Tiu Tui	5,994	1,199	1,079	2,647	10,919
Penyempeng	13,889	2,777	2,500	6,133	25,301
Ncoha II	8,526	1,705	1,535	3,765	15,531
Ntonggu II	6,165	1,233	1,110	2,723	11,229
Fatukmetang	10,430	2,085	1,877	4,605	18,999
Mataiyang	10,155	2,031	1,828	4,485	18,498

Note : Other costs include contract tax, compensation and land acquisition costs, and price contingency.

### **D-9 Project Evaluation**

97. The investment in domestic water supply totals Rp. 90,900 million for the Pelangan project, Rp. 40,000 million for Fatukmetang and Rp. 30,400 million for Mataiyang, while the investment amount for each beneficiary inhabitant is estimated to be Rp. 189,375 in Pelangan, Rp. 571,429 in Fatukmetang, and Rp. 57,358 in Mataiyang. The value of domestic water is estimated to be Rp. 5,136/m<sup>3</sup> in Pelangan, Rp. 12,708/m<sup>3</sup> in Fatukmetang, and Rp. 1,737/m<sup>3</sup> in Mataiyang. The minimum investment can meet the domestic water demand for 5,300 inhabitants in Mataiyang.

98. Based on the net value indicated by additionally increasing cattle weight, either cow or buffalo, attributable to a stabilized livestock water supply condition, the prospected outputs are almost nine times against the investment amount of Rp. 145 million in Tiu Tui, around three times against Rp. 25 million in Ntonggu II, and about half of Rp. 245 million in Fatukmetang.

99. The economic internal rate of return (EIRR) is examined for the respective projects after converting the investment in the project facilities to economic costs and estimating the increment net production values attributable to the irrigation water supply from each Embung. The result reveals that the feasible Embung project is Tiu Tui with an EIRR of 14.4% and the marginal ones are Penyempeng at 6.5%, Mataiyang at 5.5%, Ncoha II at 5.0%, and Pelangan at 3.6%, while projects showing negative EIRR's are Lokok Meniris, Aik Beta, Ntonggu II and Fatukmetang.



100. With the increasing crop intensity and production attributed to irrigation water supply from each Embung, improvement of the net on-farm income of farmers can be expected to a large extent. This improvement of the farm budget as shown below would give more incentive for farmers to make further investment in improving their living standard and also could increase their payment capacity enabling them to pay irrigation water charges.

Project	Without Project		With Project	
	Cropping Intensity (%)	Net Income (Rp.)	Cropping Intensity (%)	Net Income (Rp.)
Lokok Meniris	100	449,800	200	1,879,700
Pelangan	111	499,800	300	4,772,700
Montong Krarak	100	449,800	300	2,814,600
Aik Beta	118	560,500	300	2,725,800
Tiu Tui	100	456,400	300	4,428,600
Penyempeng	139	720,300	300	4,255,500
Ncoha II	114	519,200	300	5,711,800
Ntonggu II	105	538,400	200	1,849,000
Fatukmetang	-	-	200	6,094,700
Mataiyang	100	431,000	300	2,930,400

101. By referring to "Environmental Guidelines for Agriculture and Rural Development Projects of JICA Development Study", prospected environmental impacts of the developments are assessed. The results reveal that there are no residual negative impacts using appropriate mitigatory measures nor minor potential negative impacts appreciated in the Pelangan and Aik Beta project areas.

**D-10 Conclusions of the Feasibility Study on 10 Representative Embung Projects**

102. The findings obtained from the feasibility study on 10 representative Embung projects are summarized as follows:

- From the viewpoints of engineering geology, foundation treatment is required for all Embung projects except for Montong Krarak and Aik Beta. Because of the topographic limitations at the proposed sites, the Lokok Meniris, Montong Krarak, and Aik Beta projects are not recommendable for implementation, while the Ntonggu II and Fatukmetang projects are not feasible due to a limited runoff from the catchment area and irrigable land resources, respectively. The remaining five Embung projects are technically sound;
- From the economic viewpoints, the Tiu Tui Embung project is feasible, while the Pelangan, Penyempeng, Ncoha II, and Mataiyang Embung projects are marginally feasible and the rest are not economical; and,
- From a social viewpoint, the Pelangan, Tiu Tui, and Mataiyang Embung projects are recommendable for public investment in their implementation and further the Ntonggu II and Fatukmetang Embung projects need to be implemented even though their investment efficiencies are very low.

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103. In the intensification of the farming system to the target level with the cropping intensity of up to 300%, it is recommended to improve farming practices and on-farm irrigation water management skills by the beneficiary farmers through strengthening agricultural extension services and water management training programs.

**E. TECHNICAL GUIDELINE FOR INVESTIGATION, PLANNING AND DESIGN OF EMBUNGS IN NTB AND NTT**

104. A draft technical guideline for investigation, planning and design of Embungs in NTB and NTT is prepared for the purpose of providing supporting materials to both NTB and NTT DPUPs' staff in the identification of potential sites, assessment of development potential, formulation of development plans and preparation of implementation programs in due consideration of the results of the Study.

105. The concept of the Draft Guideline is illustrated in Figure S-10. This Guideline can be utilized according to the maturity level and identification of design of the respective Embung. On the basis of new findings which can be expected to be obtained from urgent development projects of five Embung in NTT under GOJ's grant aid, all relevant issues will be able to be incorporated into the Guideline. Concerning construction management as well as operation and maintenance of Embungs and their related facilities, the Guideline will be able to be supplemented by referring to the same findings.

Table S-9 Irrigable Area per Each Alternative Cropping Pattern

Project Area	Alternative Pattern	Dam Height (m)	TSC* ('000 cu.m)	Wet Season		Dry Season			
				Crop	NPI**	1st Crop		2nd Crop	
						Crop	NPI**	Crop	NPI**
Lokok Meniris	C-12	20.0	250	Paddy	44	Paddy	0	-	-
	C-21			Paddy	44	Soybean	0	-	-
	C-22-1			Paddy	44	Soybean	0	Red onion	0
	C-22-2			Paddy	44	Soybean	0	Mungbean	0
Pelangan	C-12	23.0	2,400	Paddy	248	Paddy	90	-	-
				Paddy	248	Paddy	248	-	-
	C-21	23.0	2,400	Paddy	248	Soybean	248	-	-
				Paddy	248	Soybean	248	Red onion	54
	C-22	23.0	2,400	Paddy	248	Soybean	248	Red onion	124
				Paddy	248	Soybean	248	Tomato	124
				Paddy	248	Paddy	75	Mungbean	75
				Paddy	248	Paddy	248	Mungbean	248
Montong Krarak	B-21	12.0	125	Paddy	44	Soybean	0	-	-
				Paddy	44	Tobacco	0	-	-
Aik Beta	A-21	25.0	570	Paddy	57	Soybean	8	-	-
				Paddy	57	Tobacco	8	-	-
Tiu Tui	A-12	16.0	2,325	Paddy	331	Paddy	83	-	-
				Paddy	331	Paddy	205	-	-
	A-21	16.0	2,325	Paddy	331	Soybean	165.5	-	-
				Paddy	331	Mungbean	165.5	-	-
	A-22	16.0	2,325	Paddy	331	Soybean	90	Mungbean	180
				Paddy	331	Mungbean	90	-	-
	A-23	16.0	2,325	Paddy	331	Soybean	165.5	Mungbean	331
				Paddy	331	Mungbean	165.5	-	-
A-23	16.0	2,325	Paddy	331	Paddy	70	Mungbean	35	
			Paddy	331	Paddy	175	Red onion	35	
Penyempeng	C-12	28.0	3,100	Paddy	350	Paddy	115	-	-
				Paddy	350	Paddy	350	-	-
	C-21	28.0	3,100	Paddy	350	Soybean	350	-	-
				Paddy	350	Soybean	220	Mungbean	110
	C-22	28.0	3,100	Paddy	350	Soybean	350	Red onion	110
				Paddy	350	Soybean	350	Mungbean	175
	C-23	28.0	3,100	Paddy	350	Paddy	95	Red onion	175
				Paddy	350	Paddy	350	Mungbean	95
Ncoha II	B-12	22.0	860	Paddy	157	Paddy	30	-	-
				Paddy	157	Paddy	54	-	-
	B-21	22.0	860	Paddy	157	Mungbean	157	-	-
				Paddy	157	Mungbean	95	Red onion	95
B-22	22.0	860	Paddy	157	Mungbean	157	Red onion	157	
			Paddy	157	Mungbean	157	Red onion	157	
Ntonggu II	C-12	17.0	1,270	Paddy	0	Paddy	0	-	-
				Paddy	0	Mungbean	0	Tomato	0
	C-22	17.0	1,270	Paddy	0	Mungbean	0	Cabbage	0
Fatukmetang	C-21	17.0	1,270	Paddy	187	Mungbean	65	-	-
				Paddy	187	Mungbean	65	-	-
	A-11	15.0	380	Paddy	57	-	-	-	-
				Paddy	57	Mungbean	7	-	-
A-21	15.0	380	Paddy	57	Red onion	7	-	-	
			Paddy	57	Mungbean	28.5	-	-	
A-52	20.0	1,050	Paddy	57	Red onion	28.5	-	-	
			Paddy	57	Mango	-	-	55	
Mataiyang	A-21	20.0	2,160	Paddy	450	Soybean	225	-	-
				Paddy	450	Mungbean	225	-	-
	A-22	20.0	2,160	Paddy	450	Soybean	225	Mungbean	450
						Mungbean	225	-	-

Remarks : TSC\* ; Total storage capacity of Embung  
NPI\*\* ; Net possible irrigation area

Table S-10 Main Features of Embungs

Lombok Island

Item	Unit	L.Meniris	Pelangan	Mt.Krarak	Aik Beta
Catchment area	km <sup>2</sup>	7.4	46.0	5.4	22.4
Reservoir area	km <sup>2</sup>	0.05	0.58	0.04	0.08
Dam Type		Zone	Zone	Masonry	Masonry
Dam height	m	20.0	29.5	12.0	25.0
Crest length	m	200	360	210	470
Effective storage capacity	m <sup>3</sup>	165,000	5,040,000	62,000	309,000
Embankment volume	m <sup>3</sup>	79,500	621,900	-	-
Masonry volume	m <sup>3</sup>	-	-	11,700	86,300
Design flood discharge of spillway	m <sup>3</sup> /s	159	522	35	330
Crest width of spillway	m	40	73	35	53

Sumbawa Island

Item	Unit	Tiu Tui	Penyempeng	Ncoha II	Ntonggu II
Catchment area	km <sup>2</sup>	21.2	41.1	12.6	6.2
Reservoir area	km <sup>2</sup>	0.64	0.55	0.13	0.23
Dam Type		Zone	Zone	Zone Homogeneous	
Dam height	m	19.5	39.0	25.0	17.0
Crest length	m	230	360	400	260
Effective storage capacity	m <sup>3</sup>	3,962,000	7,200,000	1,024,000	1,159,000
Embankment volume	m <sup>3</sup>	251,700	614,600	454,600	252,200
Design flood discharge of spillway	m <sup>3</sup> /s	323	411	107	106
Crest width of spillway	m	52	85	50	20

NTT Province

Item	Unit	Fatukmetang	Mataiyang
Catchment area	km <sup>2</sup>	4.0	19.1
Reservoir area	km <sup>2</sup>	0.17	0.30
Dam Type		Homogeneous Zone	
Dam height	m	19.0	20.0
Crest length	m	370	240
Effective storage capacity	m <sup>3</sup>	840,000	1,832,000
Embankment volume	m <sup>3</sup>	460,400	188,400
Design flood discharge of spillway	m <sup>3</sup> /s	77	231
Crest width of spillway	m	13	38

**Table S-11 Main Features of the Irrigation Water Distribution System****Lombok Island**

Item	Unit	L.Meniris	Pelangan	Mt.Krarak	Aik Beta
Design discharge	lit/s	60	500	60	110
Irrigation inlet box	Nos.	1	1	1	1
Canal to be constructed	km	1.8	-	-	5.5
Canal to be rehabilitated	km	1.8	11.7	2.96	-
Type of canal		Masonry flume	Masonry Trapezoidal	Masonry flume	Concrete flume
Irrigation diversion box	Nos.	15	-	-	43
Livestock division box	Nos.	-	-	-	-

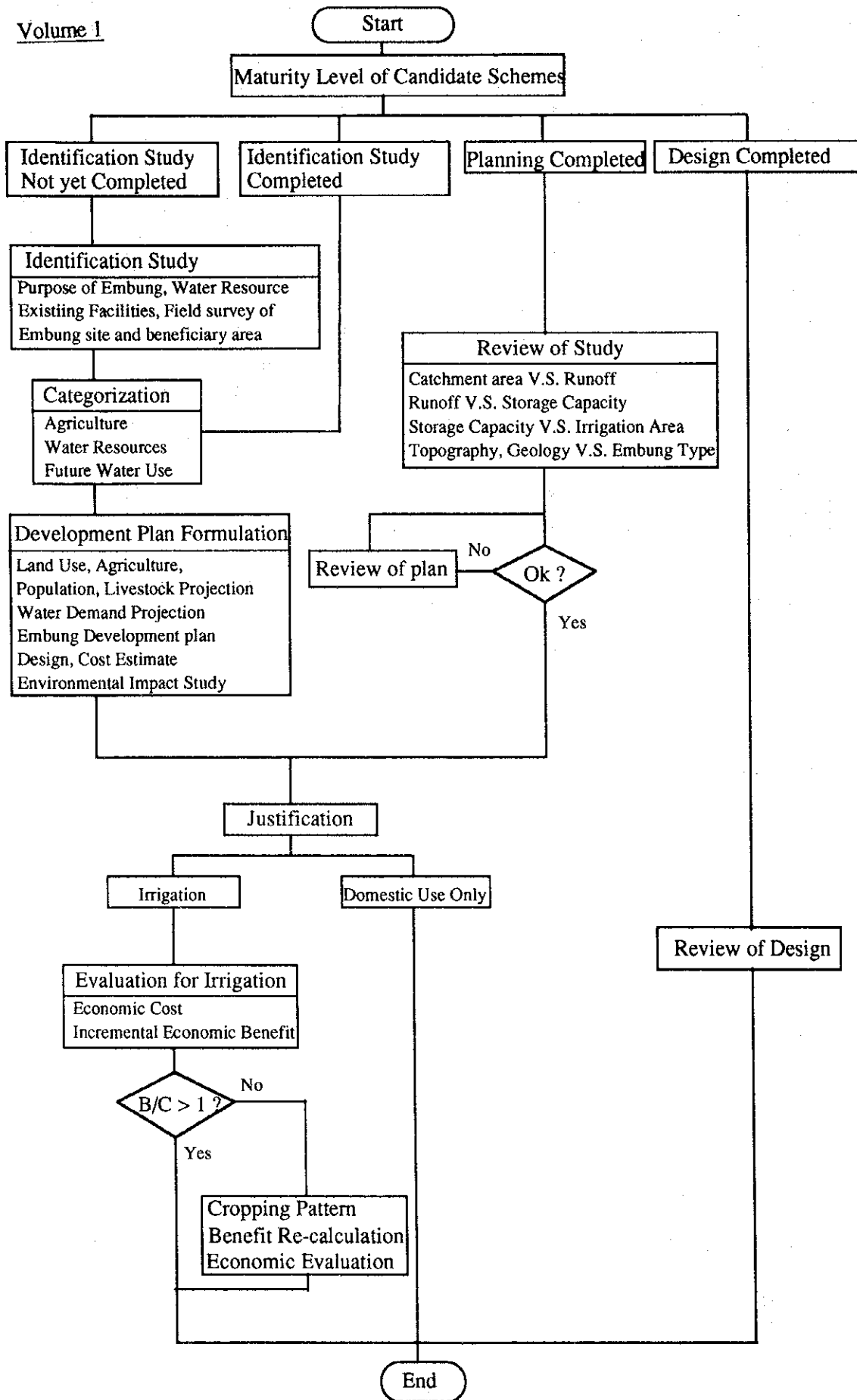
**Sumbawa Island**

Item	Unit	Tiu Tui	Penyempeng	Ncoha II	Ntonggu II
Design discharge	lit/s	350	900	160	200
Irrigation inlet box	Nos.	1	1	1	1
Canal to be constructed	km	1.2	8.2	3.0	5.4
Canal to be rehabilitated	km	3.5	1.1	1.2	-
Type of canal		Masonry Trapezoidal	Masonry Trapezoidal	Masonry Trapezoidal	Masonry Trapezoidal
Irrigation diversion box	Nos.	22	82	29	54
Livestock division box	Nos.	5	-	-	14

**NTT Province**

Item	Unit	Fatukmetang	Mataiyang
Design discharge	lit/s	70	400
Irrigation inlet box	Nos.	1	1
Canal to be constructed	km	2.2	11.0
Canal to be rehabilitated	km	-	-
Type of canal		Concrete Flume	Masonry Trapezoidal
Irrigation diversion box	Nos.	22	110
Livestock division box	Nos.	-	-





**Figure S-10 Basic Flow of Guideline for Investigation and Planning**





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