RURAL WATER SUPPLY PROJECT, NUSATENGGARA TIMUR-INDONESIA

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ABSTRACT

Rainwater collection from roofs has been a common mode for providing drinking water supply to remote rural areas in South East Asian countries, and is quite a viable, acceptable and reliable method of drinking water supply to these rural communities. The paper discusses the components of rainwater collection tank system, water supply requirements, review of the various practices, hydrometeorological analysis, computation of storage requirements for various roof areas and a detailed proposal for the rural water supply for Nusa Tenggara Timur province of Indonesia. Cost estimates for ferrocement tank design and masonry design are also provided.

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INTRODUCTION

The province of Nusa Tenggara Timur (NTT) Indonesia is located between 8°31' S to 11° 1' S latitude and 118° E - 125° E longitude and is spread on Timor, Flores, Sumba groups of islands. The area is divided in 12 regencies and sub-regencies The population of NTT province is Timor-1002828, Flores-1368610 and Sumba-354925. Many inland and coastal areas are dependent on rainwater for domestic purposes This is because either ground water is saline, or it is not available or ground is rocky, therefore, difficult to dig wells and spring/rivers are far from the villages The population of such areas is usually scattered in a range of population varying from 100 to 500 and is economically poor Due to very high cost of construction and operation and maintenance of pumping or gravity water supply system from a far-off spring source or other sources, the rainwater collection system for individual houses or commune are often planned to meet the drinking water requirement for such areas. This paper, therefore, attempts to develop an approach to the design of optimal rainwater collection and storage systems The paper covers and examines the relevant design parameters for the development of optimal solution for NTT.

COMPONENTS OF THE RAINWATER COLLECTION TANK SYSTEM

The system components are · roof surface (of tiles or galvanised mild steel sheets), rainwater gutters (of galvanised mild steel sheets), rainwater drain pipes (of fabricated mild steel sheets or AC or PVC non-pressure pipes or large diameter bamboo pipes), small straining filter, storage tank with overflow, wash-out and outlet pipe with a tap for withdrawal of controlled/restricted daily water requirement as and when required

The rainwater after falling on the roof surface partly evaporates specially during dry periods at low intensity showers, some part may overflow from the rainwater gutters while the remaining would flow down to the storage tank. Not all the water flowing into the storage tank is, however, available for drinking water use, because part of it overflows, part leaks or evaporates from the tank. The remaining quantity left is available for withdrawal through the tap daily for meeting the drinking water needs.

PRESENT DESIGN GUIDE LINES OF THE DEPARTMENT OF HEALTH

The following guide lines issued by the Ministry of Health to all the provincial Departments of Health for the construction of rainwater collection tank systems, are at present being followed :

(i) Per capita daily water requirement : 5 - 10 litres
(ii) Dry spell period - 3 months
(iii) Number of persons per tank - 100 (20 families)
(iv) Capacity of masonry tank 45 m^3 or alternatively ferrocement tanks 10 or 20 m^3 capacity.

(v) Roof area to suit local rainfall - To collect sufficient rainwater for filling the tank, roof and gutter system of three houses is to be utilised to fill a tank of 45 m^3.

(vi) Designs - Following designs are being adopted :

(a) Nominal capacity 45 m^3 :

Masonry tank 5 m x 5 m x 1.75 m deep(43.75 m^3)

(b) Nominal capacity 9 m^3 or 10 m^3 :

Ferrocement tank 3 m in diameter 1.3 m deep (9.10 m^3) or 1.42 m deep (10 m^3).

(vii) Designs are for guide and could be modified to suit the local conditions and availability of local materials.

(viii) The work is not to be contracted but to be constructed with people participation under the supervision of Health Department Staff.

PARAMETERS INFLUENCING STORAGE CAPACITY

Following parameters affecting the storage capacity have been considered while evaluating the design:

(i) rainfall and its distribution
(ii) per capita daily water requirement
(iii) dry spell period in a year
(iv) number of persons per family
(v) nature of roof surface and effective roof area
(vi) run-off losses and evaporation cum leakage losses
(vii) Safety from short spell of no rain in a month preceding or succeeding the dry no rain period in a year.

The attempt here is to delineate the possible combinations of roof area and tank size required to meet a specified per capita daily water demand for a selected probability of failure.

Rainfall and Its Distribution

A study of the rainfall data of the NTT province reveals that the annual rainfall varies from a spatial maximum of 4321 mm at Manggarai agency to a minimum of 481 mm at Sumba Timur with inter annual variations. There is a large variation in the monthly rainfall pattern. Three to four months in a year are generally dry. The available rainfall data for 10 stations varied from 26 years to 9 years of record. Summary of mean annual rainfall and standard deviations of the data available is tabulated (vide table 1).

TABLE - 1

Rainfall Statistics of Various Regencies

Regency	Station	No. of year of data	Mean annual rainfall	Standard deviation
Sumba Timur	Mauhau	26	839.78	245.89
Kupang	Mapoli	18	1717.28	610.21
Sikka	Waioti	9	1242.56	393.80
Flores Timur	Larantuka	9	1402.44	476.33
Ngada	-	11	1800.73	996.14
Manggarai	-	11	3220.55	742.86
Endo	-	9	1726.22	578.71
Alor	-	11	1265.18	350.19
Sumba	-	11	2167.64	536.57
Belu	Atambua	21	1451.62	364.81

Spatial Average and Standard Deviations

Regency	No. of stations	Spatial Mean	Standard Deviation
Kupang	14	1531.43	436.31
Belu	18	1694.06	572.92
TTS	9	1561.11	427.76
TTU	7	1133.00	234.02

Per Capita Daily Water Requirement

Storage capacity is a function of per capita water supply and the variations in precipitation. Higher the per capita supply more is the storage needed, consequently higher is the rainwater storage cost. Therefore, storage for drinking water requirement only has to be provided for designing a rainwater storage system.

Following per capita water requirement have been adopted elsewhere for the design.

West Java	5 lpcd	By rural water supply project West Java OTA 33/5-7
Central & East Java	5-6 lpcd	Program for rainwater collection tank in Madura, East Java by DIAN DESA
Thailand	4 lpcd	" The potentials of Ferrocement and related materials for rural Indonesia" prepared for USAID by Dr. Ricardo Pama and C. Phramratapongsi.

Sikka Regency, Flores-NTT	4 lpcd	Actual field survey by this project in Oct. 1980

The aim should be to provide as high a rate of supply as feasible at a reasonable cost. To determine the quantity of water being actually collected and transmitted by families during summer for meeting their drinking water requirement, a survey was conducted by the project staff in Sikka regency in October 1980. It was found that every family transports about 2 bamboo full of water daily for meeting their drinking water needs. The actual quantity per bamboo was measured and found to be 12 litres. The average number of persons per family was found as 5.5 to 6. Actual per capita water requirement transported, therefore, works out as 4 litres per day.

The paper, therefore, analyses the system storage capacities required for a per capita supply of 4 and 5 lpcd.

Dry Spell Period in a Year

From the rainfall data it is also clear that the dry period in a year varies from 3-8 months.

Number of Persons Per Family

Regency and Subregency wise number of persons per family as per 1980 census is given in Table No. 2.

TABLE NO. 2

Regency Population & Number of Persons per Household

Regency	Population	No. of Households	No. of persons per household
Alor	125,006	24,254	5.15
Belu	180,417	39,241	4.60
Ende	195,047	36,537	5.33
Flores Timur	240,747	43,889	5.48
Kupang	403,013	78,915	5.10
Manggarai	398,774	64,873	6.15
Ngada	121,749	18,042	6.74
Sikka	219,944	35,778	6.15
Sumba Barat	231,959	39,070	5.94
TTS	283,555	60,563	4.68
TTU	159,052	26,205	6.07

Further, the population is rising and hence the number of persons per household is likely to increase in future. For computations of required storage per family, the numbers of persons per family has been taken as six for all regencies.

Nature of Roof and Roof Area

Nature of roof surface : Rural housing in NTT is classified into permanent, semipermanent and temporary. Semipermanent and temporary houses have thatched roof. A large percentage of houses in a desa are usually thatched. Such houses are unsuitable for rainwater collection system. This is because fine organic particles of thatched roof straw are found to flow along with the rainwater, imparting colour, smell, taste and pollution to water, rendering it unfit for storage and subsequent human consumption. Only those houses which have galvanized mild steel sheet roofing or tile roofing are, therefore, considered for the development of rainwater collection systems.

Gross roof area : The housing improvement and resettlement programme of the Government of Indonesia for NTT envisages following four types of houses :

Type	Plinth area mxm	Roof size mxm	Roof area m^2
Type I	6x6	8x8	64
Type II	6x7	8x9	72
Type III	6x8	8x10	80
Type IV	7x8	9x10	90

Due to limited financial resources, most of the houses planned for resettlement are however of type I or type II. All these houses have galvanised corrugated metal roof. The height of the lower edge of the roof varies from 240 to 250 cm above ground level. The roof areas of houses of Puskesmas doctor and employees of Puskesmas are as tabulated below:

	Plinth Area m^2	Roof Area m^2
For Puskesmas Doctor		
Type I	70	103
Type II	70	103
For Sanitarian/midwife	50	84

Effective area : The effective area of the roof draining rainwater to rainwater gutters and then to the tank will depend upon the type of house, the location of the tank, capacity of the gutters and the arrangement of rainwater pipes conveying roof water from gutters to the tank. Any corner bend on the rainwater gutter, reduce its capacity by 25%. The length of the gutters, the effective roof area percapita draining to the filter assuming number of persons per house as six is tabulated below.

Standard House type, plinth area mxm	Storage tank located at side corner				Storage tank located at the back			
	Effective roof area - m^2		Gutter length (m)		Effective roof area m^2		Gutter length (m)	
	Total	Per cap	Total	per cap	Total	per cap.	Total	per cap
Type I, 6x6	32	5	16	2.66	48	8	24	4
Tvpe II, 6x7	36	6	17	2.90	54	9	25	4.16

Verv few heads of families are however fortunate to have a house even of 6mx6m size as being adopted for the resettlement areas. Due to joint family system manv houses have more than one family in one house. A roof area of more than 3 to 4 m^2 percapita contributing flow to the tank is, therefore, hardly likely to be available.

In West Java a roof area of 2.0 sq.m. percapita was adopted for design evaluation. For analysis of storage capacity however, calculations have been worked out with roof area as 2 m^2, 3 m^2, 4 m^2 and 5 m^2 per capita for calculating the rainwater flow to the tank to determine the effect of area on the tank capacity.

Runoff Losses and Evaporation Losses

Runoff and evaporation losses with galvanised metal sheet roofing may be quite small in rainy season, but may be appreciably high during the period of very low rainfall when atmospheric temperature is high. Based on the data of temperature and evaporation, a runoff cum evaporation loss from the roof surface as 15% is adopted for storage design calculations. Storage tank is covered and water proof, not much water stored is therefore likely to be lost from the tank. A leakage cum evaporation loss from the tank surface at 5% is however adopted for design evaluation.

Safety Against Short Spell of No Rainfall Preceding and Succeeding a Long Dry Spell

The analysis of storage required for a selected roof area and supply percapita in a year is based on the monthly rainfalls. However, storage may fall short due to daily variations in the precipitations. This is clear from a detailed analysis based on daily rainfall for Sumba Timur regency, wherein it is computed that the storage required is about 7% more than that computed based on monthly data dry spell. To cover such an eventuality 7% extra storage has been provided on the storage computed on monthly rainfall data. A provision of 10 cm in height of the tank is provided as a dead storage.

STORAGE TANK CAPACITY

Maximum average percapita supply possible : It may be of interest to know as to how much percapita gross storage (including evaporation and leakage quantity from the tank) is feasible if every drop of rainwater (after evaporation losses etc., from the roof) is retained in the tank. This has been analysed and the percapita supply figures have been computed for various regencies. It is clear from this analysis that to provide 4 to 5 lpcd even in drought year, a maximum roof area of 3 to 4 m^2 (more than 2 m^2) is necessary.

Storage Capacity : As the rainfall is concentrated in a period of 4 to 8 months in a year, if attempts to retain every drop of rainwater available is made, balancing storage capacity becomes considerably higher in comparison to the case when storage is provided to meet the maximum no rainfall dry period requirement at a restricted supply of 4 or 5 lpcd. This is because total rainfall is much more than required to provide a continuous supply of 4 or 5 lpcd. This difference will be more noticeable in caseof Kupang than Sumba Timur because average rainfall for Kupang is higher than Sumba Timur, where as dry spell period remains almost same.

Storage for longest dry spell : Maximum dry period of no rainfall in NTT is 7 to 8 months in the area with total annual rainfall of 1500 mm or less. The most critical storage to meet the dry period (no rainfall months), works out to be as follows :

Most critical storage required for the dry period of 8 months :

(i) At 4 lpcd required 4 x 30 x 8 = 960 litres per capita
(ii) At 5 lpcd requires 5 x 30 x 8 = 1200 litres per capita

Thus about 25% more storage is required if one adopts dry period daily per capita supply as 5 lpcd.

The storage calculations have, however, been performed on year to year basis to meet the requirement at 4 and 5 lpcd for a roof area of 2, 3, 4 and 5 m^2 per capita for all the stations using the available data. The storage capacities required have been analysed for different dependability levels. These are given in tables 3, 4 and 5. It is clear from this that about 170 to 847 litres storage capacity per capita is required with a roof area of 4 m^2 to meet water requirement at 4 lpcd with 90 percent dependability.

Storage analysis : Total storage required for all the regencies for 90% dependability is worked out for 4 lpcd and 5 lpcd supply respectively. The storage so computed includes adjustment for daily variations in rainfall (7 percent) and leakage and evaporation from tank (5 percent) and a summary of the same is given below :

Regency	Total storage required (litres) for	
	4 lpcd	5 lpcd
Sumba Timur	948	1207
Flores Timur	932	1040
Kupang	814	1030
Sikka	796	1054
Ngada	784	1349

Belu	651	822
Alor	553	723
Sumba Barat	411	582
Ende	321	458
Manggarai	191	278

Storage capacity per family : Based on the analysis of storage requirements, it is found that some regencies require less storage than others even for higher rate of supply as they have less variations in the monthly rainfall. Hence it is desirable to divide the regencies into two broad categories :

Group I - Sumba Timur, Flores Timur, Kupang Sikka, Ngada, Belu and Alor: These are to be provided with a family storage of 6000 litres. Leaving a dead storage height of 10 cm and maximum height of tank limited to 1.6 m, these regencies are to be provided with a tank 2m x 2m x 1.6m for each household. With this the regencies Belu and Alor will have capacity to supply of 5 lpcd whereas the others will have a capacity of 4 lpcd.

Group II - Sumba Barat, Ende and Manggarai : These are to be provided with a family storage of 3600 litres. Again making provisions for dead storage and size 1.55m x 1.55m x 1.6m has to be provided for each household in these regencies and it will have a capacity to supply at 5 lpcd.

SUGGESTED DESIGN CAPACITY OF STORAGE TANKS

In deciding this the existing practice and the past experience are relevant.

(i) The rainwater collected in the rainwater tanks constructed for communal use soon gets exhausted within 2 - 3 months after the rains, mainly due to uncontrolled draw off by too many people.

(ii) The rain water tanks of 45 m^3 capacity require a large roof area and an elaborate arrangement and long lengths of the rainwater gutters which often is not available, as a result tank is not always full up to the design level.

(iii) The construction of the rain water tank has to be sturdy and water proof to prevent loss of water after collection.

It is, therefore, suggested that the construction of smaller tanks of $5m^3$ for individual household use should be encouraged to provide 4 to 5 lpcd supply throughout the year wherever feasible.

The larger capacity tank 10 m^3 (preferably) and 20 m^3 should be provided at Puskesmas, residences of Puskesmas staff, Gereja, Masjid, Schools, Balai Desa Office, Police Station/Military Office and joint family households provided sufficient roof area is available in preference to a single tank of 45 m^3 capacity. As a thumb rule roughly 4 m^2 roof area should contribute (2m gutter length) flow per cubic meter of water intended to be stored in the

TABLE NO. 3

ABSTRACT OF STORAGE REQUIREMENT FOR DIFFERENT DEPENDABILITY

Regency and station	Dependability	Per capita storage in litres with supply 5 lpcd roof area				supply 4 lpcd roof area			
		$2m^2$	$3m^2$	$4m^2$	$5m^2$	$2m^2$	$3m^2$	$4m^2$	$5m^2$
Regency : Sikka	100%	x	x	1081	1046	876	871	837	818
Station: wioty	88.9%	x	1038	926	870	809	763	896	656
	77.8%	x	952	910	815	616	736	651	549
Regency: Sumba Barat	100%	612	581	525	504	490	428	403	382
	90%	530	546	520	459	457	424	367	309
	80%	340	296	232	175	280	197	140	124
Regency: Belu	100%	854	823	793	765	671	640	612	612
	90%	798	637	734	727	597	589	581	574
	80%	750	742	544	452	554	458	368	368
Regency: Alor	100%	x	840	740	669	x	610	535	485
	90%	967	739	646	588	723	525	493	471
	80%	849	665	510	471	635	523	414	355
Regency: Ende	100%	x	733	629	559	x	519	450	395
	90%	554	460	409	360	401	338	287	238
	80%	529	387	209	155	381	208	124	124
Regency: Manggarai	100%	590	579	569	559	468	457	447	437
	90%	473	329	249	212	321	210	170	150
	80%	375	258	154	113	253	139	90	82
Regency: Ngada	100%	x	x	x	1195	661	563	986	950
	90%	x	x	1205	874	528	418	700	661
	80%	875	776	679	855	499	385	523	502
Regency:Sumba Timur	100%	x	x	1128	1105	x	x	886	861
Station: Mauhau	96%	x	x	1098	1067	x	921	854	843
	92%	x	x	1091	1057	x	884	847	835
	88%	x	1128	1065	985	x	879	846	823
	84%	x	1100	1021	974	x	856	788	771
	80%	x	1049	992	974	x	828	778	750
Regency: Kupong	100%	1166	1138	1111	1084	922	894	867	840
Station: Mapoli	93.3%	1072	998	924	915	877	754	732	732
	86.7%	1061	950	915	902	828	736	722	719
	80%	990	948	910	870	776	734	696	656
Regency: Flores Timur	100%	1087	1062	1060	1057	851	848	846	843
Station : Larantuka	88.9%	994	948	915	915	774	734	732	732
	77.8%	958	915	907	873	732	732	699	689

TABLE NO. 4

STORAGE ANALYSIS FOR 5 lpcd

Conditions	Sikka	Sumba barat	Belu	Sumba Timur	Kupang	Flares Timur	Alor	Ende	Manggarai	Ngada
90% dependable storage from 4 m^2 area in litres	941	520	734	1078	920	929	646	409	249	1205
Adjustment for daily flow variation 7%	66	36	51	75	64	65	45	29	17	84
5% for Evapn. and leakage	47	26	37	54	46	46	32	20	12	60
Total storage per capita in litres	1054	582	822	1207	1030	1040	723	458	278	1349

TABLE NO. 5

STORAGE ANALYSIS FOR 4 lpcd

Conditions	Sikka	Sumba barat	Belu	Sumba Timur	Kupang	Flores Timur	Alor	Ende	Manggarai	Ngada
90% dependable storage for $4m^2$ area in litres	710	367	581	847	727	743	493	287	170	700
Adjustment for daily flow variations 7%	50	26	41	59	51	52	35	20	12	49
5% for evap. and leakage losses	36	18	29	42	36	37	25	14	9	35
Total storage per capita in litres	796	411	651	948	814	832	553	321	191	784

tank. Gutter length draining to the tank to the one side of drainpipe should not exceed 10 - 12 m units.

Keeping in view the above considerations following designs of 5 and 10 m^3 capacity tank has been suggested for individual household and community rain-water tanks in NTT.

Masonry tank :

(i) Size : 1.8 m x 1.8 m x 1.6 m deep or twin unit each 1.8x1.8mx1.6m

(ii) Nominal capacity : 5 m^3 or twin units with 10 m^3 capacity. Actual capacity 5.184 m^3 or twin unit of 10.368 m^3 capacity.

(iii) Foundation : Local stone compacted under the floor with masonry foundation under the walls.

(iv) Walls : Masonry in cement mortar 1 : 3, plastered in cement mortar 1 : 2, 18 mm thick in 2 layers.

(v) Floor : Ferrocement floor with chicken wire net 5 cm-thick in 1 : 2 cement mortar (water cement ratio 0.4).

(vi) Roof : Ferrocement roof slab 6 cm thick with MS reinforcement and 2 layers of chicken wire mesh.

(vii) Filter : Perforated slab with sand and gravel topped with open jointed bricks or big size stones to prevent disturbance of sand underneath.

(viii) Overflow chamber (optional): The tank is sized for failure of one in 10 years. Therefore, in most of the years more rainfall is available at least during the rainy season than 4 to 5 lpcd for which the tank is limited, the rainwater will naturally, overflow to waste.

(ix) As the height of the roof is limited, the tank floor cannot be raised above ground. The tap being almost at the floor level, a pit has to be constructed to place the bucket under the tap. The pit has to be provided accordingly with the open jointed floor so that spilled out or rainwater may soak into the ground, if it cannot be drained. If topography permit a drain should be provided to drain the waste water. Site should be dressed and sloped away from the tank to prevent rainwater finding way to the foundation of the tank.

(x) A water level inspection pipe is to be provided with a cap.

(xi) For entry into the tank, manhole for large capacity tank is to be provided.

Ferrocement tank : The design of ferrocement concrete tank is circular in shape with domical or flat roof. The details are :

	As per West Java Domical roof	As per project	Alternative design flat roof
Nominal capacity	5 m^3	10 m^3	10 m^3
Size	2 m dia	2. 9 m dia	2 94 m dia
Water depth	1. 6 m	1. 6 m	1 6 m
Capacity actual	5. 02 m^3	10 m^3	10. 86 m^3

The structural design reinforcement is based on the designs developed by the West Java rural water supply project. The alternative design of ferrocement tank is based on the structural Engineering Research Institute, Madras, India and International Ferrocement Centre, Bangkok. Other design features are similar to those mentioned earlier under masonry tank. A comparative cost estimate is provided in Appendix A.

CONCLUSION

Based on the detailed studies the following conclusions are drawn :

(i) Per capita daily water supply of 4 to 6 litres during the dry spell is feasible for NTT province with reasonable storage.

(ii) The dry spell period in NTT varies from 3 to 8 months (6 months being quite common) in a year. The criteria of 3 months dry spell for sizing of storage is therefore not applicable. A detailed analysis of storage required is advisable with rainfall data preferably of long duration.

(iii) At present storage tank 45 m^3 is provided to meet the requirement of 100 persons (20 families). This criteria which is practice now is very large. Such a large system is obviously not feasible due to :

(a) Non-availability of roof area of about 300-400 m^2
(b) Elaborate arrangement of rainwater gutters required to convey rainwater to the storage tank.

The capacity of the tank is too big to fill under the NTT rural housing and rainfall conditions.

(iv) As per the analysis 1 m^3 capacity requires a roof area of 4 m^2. The 45 m^3 capacity tank will therefore require a roof area of 180 m^2. Normally more than 50 m^2 roof area per family of 5 persons may not be available. Thus roof area more than 3 houses will be required to fill the tank of this capacity. The rural houses in NTT are very much scattered and distance between houses is several meters in most cases. Even in case of schools and gereja's it may be difficult to collect roof water from a roof area greater than 40 sq. m. without having to make elaborate arrangement for the support of rainwater gutters.

(v) A smaller tank of 5 m^3 for individual household and 10 m^3 (preferably) and 20 m^3 should be provided at public places and joint households wherever feasible.

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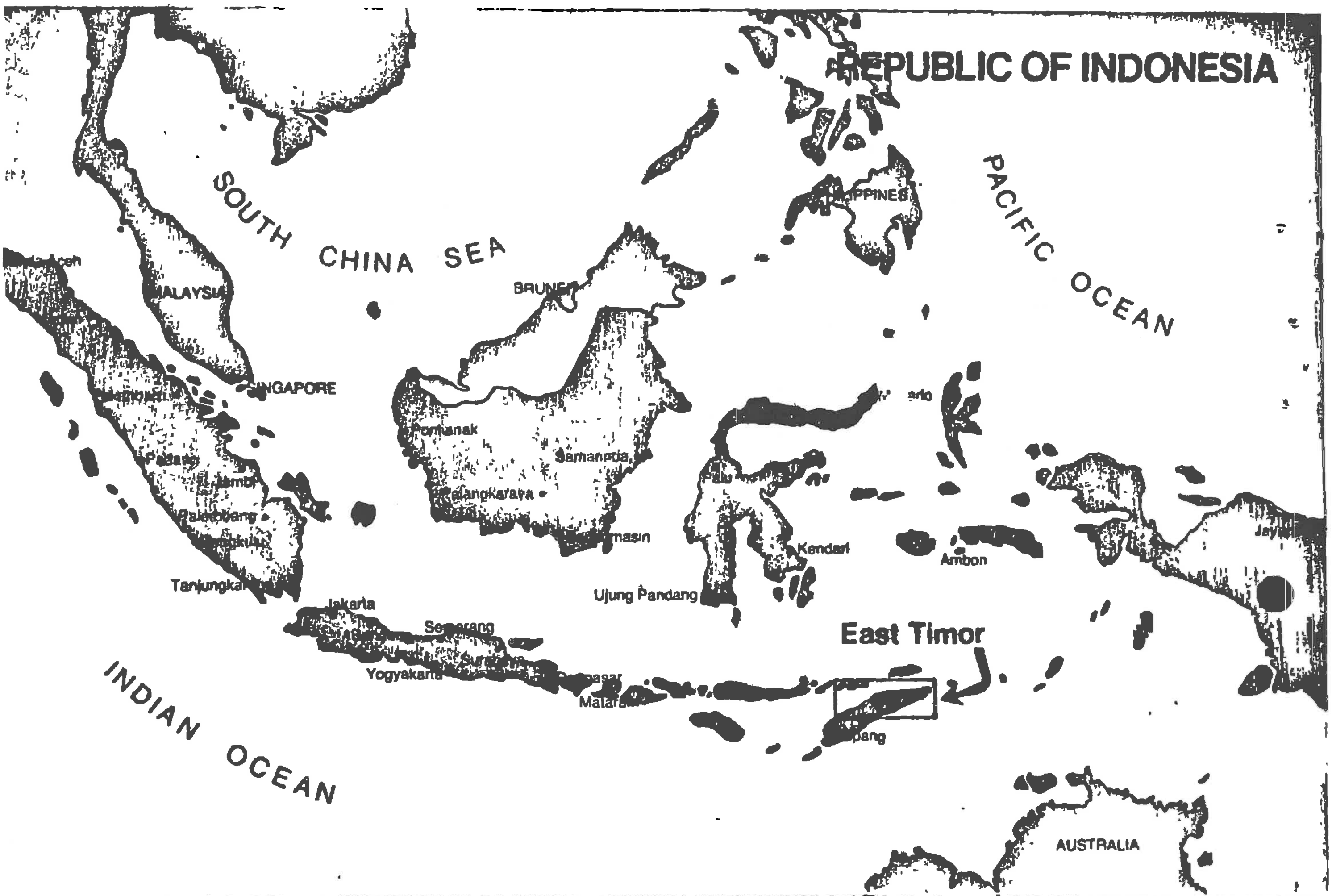
APPENDIX - A

COMPARATIVE COST ESTIMATES OF 10 M^3 CAPACITY TANKS OF DIFFERENT DESIGNS

Item	Unit rate	Ferrocement Tank Design: As per West Java Project, 2.9møx1.6m, Design No. 5		Design by the Project, 2.94møx1.6m, Design No. 6		Design as per SRI Madras India, 2.4møx2.3m, Design No. 3		Design as per F.C.R.I. Bangkok, 2.2møx2.63m, Design No. 4		Masonry Design: Design by the Project, 1.8mx1.8mx2, Design No. 7	
		Quan.	Amount	Quant.	Amount	Quant.	Amount	Quant.	Amount	Quant.	Amount
1	2	3	4	5	6	7	8	9	10	11	12
1. Cement	3000/bag	18	54,000	18	54,000	18	54,000	14	42,000	38	114,000
2. Clean sand	4500/m^3	1.4	6,000	1.8	6,300	1.0	4,500	0.9	4,050	4	18,000
3. Galvanised rod	1000	74.0	74,000	120	120,000	152	152,000	95	95,000	45	45,000
4. Binding wire	1200/kg	2 kg	2,400	2.5 kg	3,000	2.5	3,000	2.5	3,000	1/2 kg	600
5. Chicken wire net	1000/m^2	50	50,000	-	-	-	-	-	-	24	24,000
6. Steel wire mesh 10x10m of 20SWG	1000/m^2	-	-	150	150,000	160	160,000	160	160,000	-	-
7. Water tap	5000	1	5,000	1	5,000	1	5,000	1	5,000	1	5,000
8. G.I. outlet pipe	1500	1,3/4"	1,500	1,1/2"	1,000	1,1/2"	1,000	1,1/2"	1,000	1,1/2"	1,000
9. Drain out pipe	1500	1,1 1/2	1,500	1,1"	1,000	1,1"	1,000	1,1"	1,000	1,1"	1,000
10. Galvanized overflow pipe		1,1 1/2	2,000	1,3"	5,000	1,3"	5,000	1,3"	5,000	1,3"	5,000
11. Water depth measurement pipe	5000	1	5,000	-	-	-	-	-	-	1	5,000
12. Filter plate of RCC		1	3,000	1	3,000	1	3,000	1	3,000	1	3,000
13. Filter sand			300		300		300		300		300
14. Filter gravel			400		400		400		400		400
15. Coconut husk for filter			200		200		200		200		200
16. Brick or large stone for filter			200		100		180		180		200

1	2	3	4	5	6	7	8	9	10	11	12
17. Gutter of galvanised Iron sheet 20 cmø with F.I. stays		10m	10,000	10m	10,000	10m	10,000	10m	10,000	10m	10,000
18. Rainwater pipe of sheet iron		1/2m	1,000	1/2m	1,000	1/2m	1,000	1/2m	1,000	1/2m	1,000
19. Water proof epoxy paint		4	10,000	4	10,000	4	10,000	4	10,000	4	10,000
20. Mosquito net			200		200		200		200		200
21. Nails			500		500		500		500		500
22. Planks	Local		Local		Local		Local		Local		Local
23. Bamboo	Local		Local		Local		Local		Local		Local
24. Brick or stone for wall	-	-	-	-	-	-	-	-	-	$3750m^3$	Local
25. Plywood for shuttering 1.2x2.4m	3750/sheet		5,250		5,250		5,250		5,250		-
26. Total			232,450		376,250		416,530		347,080		240,400
Reason for variation in cost		Dome roof comparative less reinforcement		Flat roof more reinforcement		Flat roof More reinforcement as per structural institute		Dome roof More reinforcement		Brick work RC roof excluding cost of brick or stones	
Overhead charges Labour 30% incentive			69,735	112,875		124,959			104,124		72,120
transport material etc.			302,185	489,125		541,489			451,204		306,900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Ambon
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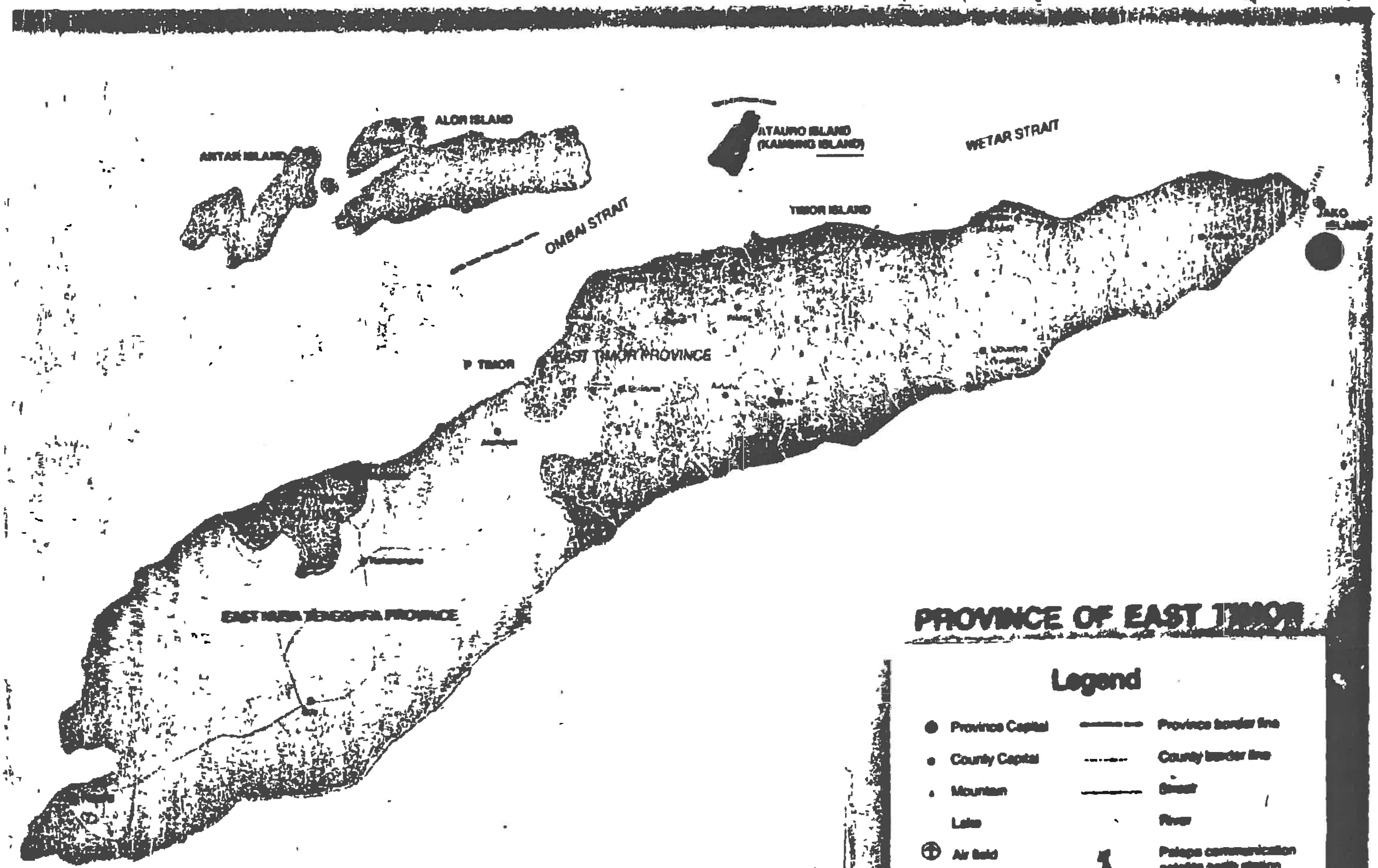
ALOR ISLAND
ATAURO ISLAND
(KAMBING ISLAND)
WETAR STRAIT
OMBAI STRAIT
TIMOR ISLAND
JAKO ISLAND
P. TIMOR
EAST TIMOR PROVINCE
EAST NUSA TENGGARA PROVINCE
PROVINCE OF EAST TIMOR
Legend
Province Capital
Province border line
County Capital
County border line
Mountain
Lake
River
Air field
Harbour
Palapa communication satellite earth station