14th WEDC Conference

Water and urban services in Asia and the Pacific

Kuala Lumpur 1988

Rural water supply – W Timor Indonesia

Euan R Nichol

INTRODUCTION

Background

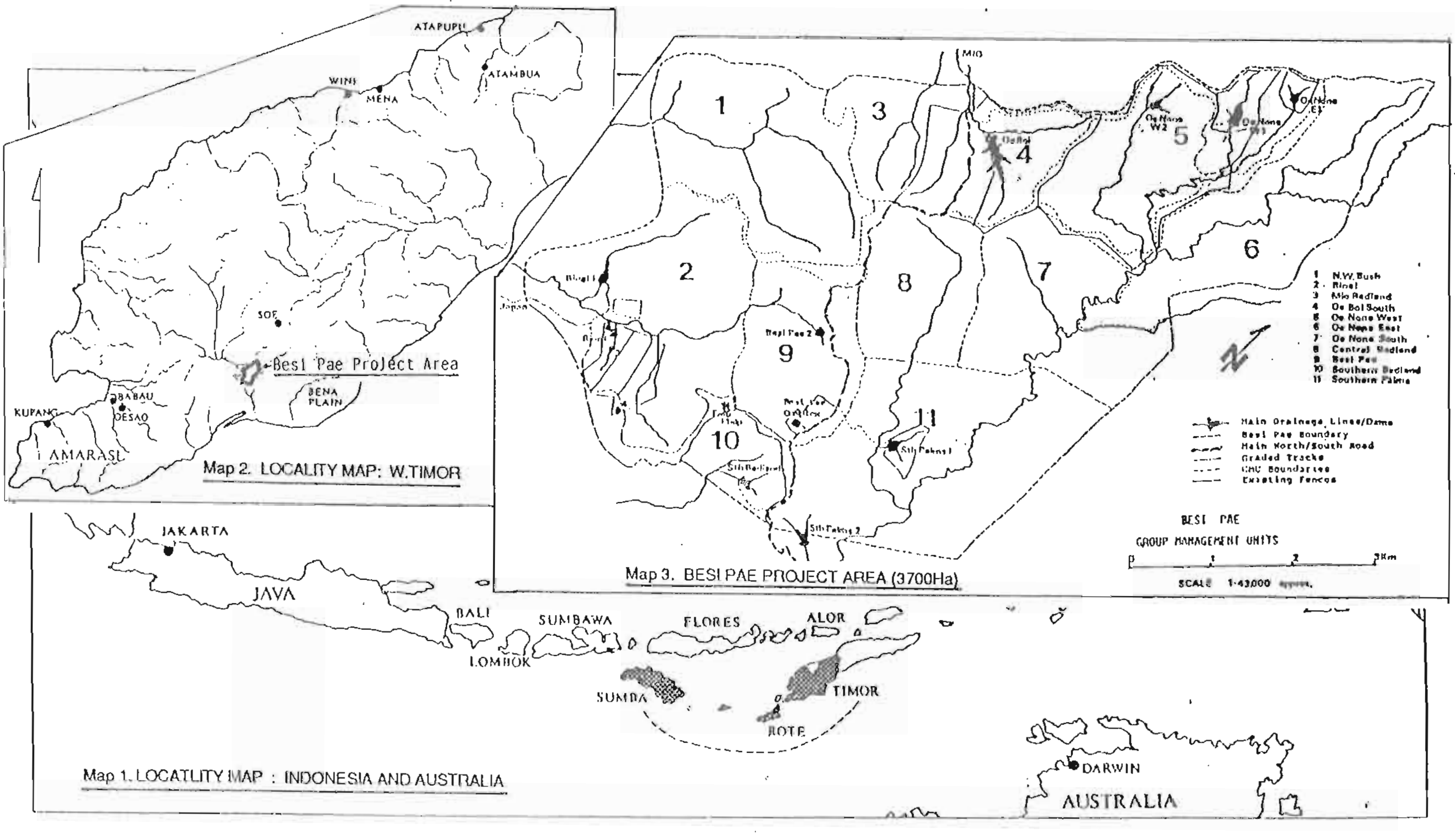
West Timor is part of the major island in the Indonesian outer arc province of Nusa Tengara Timur (Map 1). Due to factors such as adverse climatic conditions, poor soils, severe soil erosion, shifting agriculture, extensive cattle grazing, a high population density and a lack of water, it has one of the lowest per capita incomes in Indonesia.

For the village people living at a subsistence level, a highly variable wet season and a long dry bring epidemic disease and hunger. It is at this time that people and animals may have to share limited polluted water sources. Thus the key to improving health and living standards is the supply and maintenance of adequate unpolluted water sources.

In 1982 the Australian Development Assistance Bureau (ADAB) and the Indonesian Government working through an agricultural consulting company and the livestock department respectively, started a two-year pilot project. They sought to formulate an appropriate dry land farming model/s, that could be replicated in other areas of the province in order to arrest the increase of rural poverty and the decline of the ecosystem.
The pilot project was an attempt to try various known techniques and determine the most appropriate for this area, with a view to use in subsequent expanded phases.
This paper deals primarily with the water resource development.

Geography

Timor and the other outer arc islands, unlike most of the other islands of Indonesia are non volcanic in origin, being of recent raised marine sediments (5×10^6 years old). With the highest point at over 2400 m the area is generally very rugged and diverse.
The geomorphic processes are still very active so much of the steep hillside is highly disected and unstable.
The geology is complex.
Below an upper raised coral crust and a limestone marl series lies a massive, both in depth and area, montmorillonitic clay series (Bobonaro).



Map 2. LOCALITY MAP: W.TIMOR

Map 3. BESI PAE PROJECT AREA (3700Ha)

Map 1. LOCATLITY MAP : INDONESIA AND AUSTRALIA

Climate

The climate is affected by Timor's proximity to Australia. Typically a low, highly variable rainfall falls between December and March with a long hot dry season and high evaporation over the rest of the year. Rainfall comes with the western monsoon thus the western side of the island tends to receive the most rain. However, the mountainous topography produces a range of variable micro climates.

Hydrologically, the rainfall on the raised coral and limestone marl areas produces perennial springs of high quantity and quality, but these areas are relatively small. Semi arid conditions prevail when a long dry season occurs on land systems of the Bobonaro clay series.
Lack of drinking water for livestock and man during the dry season prevents utilisation of the grasslands and concentrates overgrazing and environmental deterioration around permanent waters.

THE BESI PAE PROJECT

The project site

Approx. 3700 ha of land was selected near the village (Desa) of Mio (Map 2 & 3). The area was sparsely populated, with under utilized grassland. It lacked permanent water and had a variety of topographical features including flat plains, limestone capped ridges, undulating grasslands and highly dissected valleys.
A project centre consisting of dormitories, living quarters, training centre, meteorology station, workshop and storage area was established on the main district road 96 km and 3 hours drive from Kupang the provincial capital (Map 2).
The original project design called for the land to be divided into Group Management Units (GMU). Each unit would have a small dam, a fenced foodcrop area and an upgraded animal grazing area to settle a group of families. The topographical catchment became the logical division of Group Management Units.

Water resource development

Catchment filled storages with earth banks of less than 10 m height are an accepted method of providing stock and domestic water supplies in rural Australia. It is estimated that about US$30 million is spent each year in rural Australia on small dam construction (1). Thus the use of these proven techniques as applied to the Timorese environment was the first approach to water conservation in the Pilot Project Area.

Dam construction is a relatively new concept in Timor. Small dams called check dams have been built to a common design of a full height concrete core and steep hand or machine placed batters of the local material. Spillways are formed with unreinforced concrete floors and masonry sides. Despite the fact that their performances have only been fair with high rates of bank seepage and spillway failures the idea of building dams with earth alone was met with a high degree of incredulity.

Dam location and siting

Many factors affect the dam siting decision process.
The catchment area yield must be sufficient to fill the storage for a given return period, in this case, each year. On the other hand, large flood flows - a function of the catchment size - present difficulties in spillway design, construction and maintenance. The skill is to try to match catchment yield to storage volume.
The storage/excavation ratio is the economic function of the dam. The steeper the drainage line gradient the smaller the stored volume relative to each volume of placed embankment material. The aim is to maximise this function.
Dam surface area, in this particular situation, needs to be minimised for a given stored volume as the evaporation losses (approx 2 metres) are high. Thus the dams need to be deep (greater than 6 m) with a minimum area of shallow water at the maximum capacity.
Other topographic features may provide a site which can minimise earthworks costs. A suitable area for safe disposal of flood flows back to the drainage line also needs to be identified.
Insitu materials at sites need to be identified for their ability both to provide a stable impervious bank and to retain water within the storage without excessive seepage loss. Seepage tests were undertaken at some sites.
The location of storages near to the users is an obvious desirable factor. Women in the Timorese society are the water carriers and for some in the project area this meant daily treks of over 20km. Usually the above criteria; i.e. topography, materials and suitable catchments controlled site selection. However by piping water and water tank construction, the time and effort in water carrying was substantially reduced.

Dam design and construction

Thirteen (13) dams of varying type and size were constructed during this pilot phase. (Table 1.) General Cross sectional design of the banks is shown. (Diagram 1.)

Table 1

NO.	IN ORDER OF CONSTRUCTION	EARTHWORKS (CuM)	STORAGE CAPACITY (Ml)	MAX WATER HEIGHT (M)	STORAGE EXCAVATIONS RATIO	UNIT COST EARTHWORKS ($A/CuM)	CATCHMENT AREA (Ha)
1	Binel 1	5080	17.5	6.0	3.4	2.42	86.0
2	Binel 2	685	1.0	2.4	1.5	3.98	2.0
3	Binel 3	3460	6.3	5.2	1.8	1.96	8.0
4	Besl Pae 1	3200	5.0	5.2	1.6	1.27	6.0
5	Oe Boi	9300	60.0	7.5	6.5	1.47	70.0
6	Binel 4	1950	4.4	3.6	2.3	1.72	2.5
7	Besl Pae 2	5000	8.8	8.0	1.8	1.15	4.0
8	Oe Noni W1	10450	28.8	7.8	2.8	1.98	28.0
9	Oe Noni E1	7250	9.6	7.3	1.3	2.13	8.0
10	Oe Noni W2	3640	14.6	6.4	4.0	2.54	10.0
11	South Palms	4400	12.1	6.3	2.8	2.22	15.0
12	South Badlands	5300	9.2	6.2	1.7	1.60	10.0
13	Maiskolen (South Palm 2)	13100	16.3	5.7	1.2	2.04	22.0

The equipment used was a Komatsu D65E bull dozer, a small 4 tonne vibrating pad foot roller, a 4000 litre water tank with spray bar on a trailer towed by a tractor or on the back of a 4WD truck.
The construction methods used were certainly not low technology, but were conventional and conservative bearing in mind that these earth dams had to work. The methods could be replicated by suitable trained personnel from either the Public Works Department or private contractors.

1. Site cleared, top soil stripped and stockpiled for recovering bank.
2. Cut off to bank excavated and backfilled with selected clays.
3. 50 mm diameter galvanised steel outlet pipe with rubber cutoffs (anti seep collars) from truck wheel inner tubes. Cut into fill, laid back filled and hand compacted.
4. Bank material pushed up, spread evenly 150mm layers, moisture added and rolled to maximum density.
5. Near top of bank, trickle pipe laid through bank 1.2 m below FSL. A concrete block inlet structure was later constructed.
6. Spillway/s cut to discharge to best available disposal area.
7. Topsoil brought back to cover bank.
8. Bank and spillway planted down to appropriate running grasses.

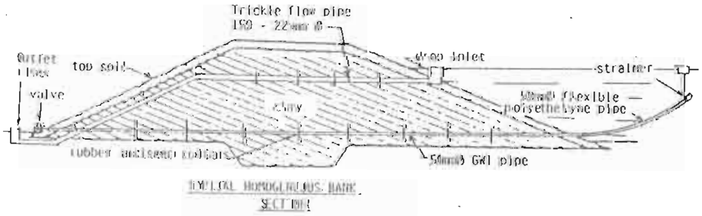


Diagram 1

Catchment performance

Each storage was surveyed on completion and meter depth gauge boards levelled into position.
The storage volume was calculated allowing a storage volume to stage (water depth) relationship to be established.
Rain gauges were placed on each dam or in a central position if there were several dams close together.
Daily rainfall and water depths are read by the local community appointed and project trained Jaga Air (water watchman). To this data is added daily readings from the Met Station at the project buildings of Pan A evaporation figures, and more recently Pluviometer rainfall intensity data.

Over a long time period a fair assessment of catchment yield performance in terms of runoff megalitre (Ml)/area(ha) will be obtained allowing compilation and confirmation of local values of the parameters for the United States Department of Agriculture Soil Conservation Service Daily Rainfall Runoff Model. (USDA Model) (2). Initial results indicate catchment yields ranging from 0.5 Ml/ha/yr to 1.3 Ml/ha/yr with average 0.1 Ml/ha/yr.

Dam performance

The ability of the storage to hold water during the dry season can be assessed by accounting for all losses from the storage. Evaporation losses are obtained from pan figures mm/day. Abstraction volumes are metered or guestimated from population and stock usage, leaving only the seepage losses unaccounted in the total loss/day from daily dam height readings. Early dams built on limestone based country have shown high losses while those on the Bobonaro clay land systems have performed well.

Given the highly variable nature of the rainfall in West Timor the on going performance of the pilot dams, should provide a good data base for the future dam design.

It was recognised from the outset that provision of large bodies of still water could exaserbate the existing critical Malaria problem. Two species of surface feeding fish (Ikan Tilapia and Ikan Mas) were introduced to the larger storages. Subsequent negative water sampling for mosquito lavae and no increase of incidence of the disease would indicate that the dams have not added to the scourge of this island.

Water Usage

Water is reticulated from the storages through handlaid black polyethelyne piping to covered concrete water tanks. Separate tanks were constructed for human and animal use.

The water level in all tanks was float controlled with the floats being well protected from user manipulation. Pipe sizes were designed to minimize losses should a pipe breakage occur. This, however, has brought problems with supply, as increasing demands have lead to villagers tampering with the pipe system. A redesign using a break storage tank and a larger diameter delivery pipe has eased this situation.
The peoples tank was usually located near or within a fenced communal garden area. Water was still carried from the tanks to the home in the traditional manner by the women of the village but the distance/time was reduced. Time and water was now available for cultivation of dry season vegetables by the village women. Although initially these were sold as cash crops to the passing traffic, succeeding seasons have shown a much greater incorporation of this produce into the villagers diet. At some of the peoples tanks washing cubicles were constructed. Using carried water (to limit consumption) the villagers could regularly wash during the dry season (something not previously possible) with the residue running on to the vegetable gardens.
The animal tanks were sited separately on well drained flat areas.

Conclusion

Small earth dams (Dam Tannah) of conventional design and construction could be built and performed satisfactorally in the Timorese environment.
Dam siting was critical. However with the establishment of a land system map of the project area (and later over much of West Timor) key areas with desirable features have been identified. Thus less experienced personnel can rapidly hone in on possible sites that need to meet population and animal criteria.
Spillways and spillway returns perceived at the beginning as potential problem areas have performed well except in the extreme condition - when they are really needed. A one in 20 years return storm (est) Feb. 86 left some of the spillway returns in need of major repair. Some recent research in the U.K. on alternative (to reinforced mass concrete) more natural solutions may provide directions for solving this ongoing problem.

This project has moved into an expanded 2nd phase at two other locations in West Timor. Further Indonesian Government Institutions are involved with an ever increasing local community involvement in the planning, construction and maintenance of the dams, food crops and pastures.

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