AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

AARES 53rd Annual Conference

Cairns International Hotel, Northern Queensland, Australia

10-13th February 2009

Management of Water Reservoirs (Embungs) in West Timor, Indonesia*

Authors:

Deepa Pradhan, Tiho Ancev, Ross Drynan and Michael Harris

Agricultural and Resource Economics Group
The University of Sydney
NSW, Australia

***The generous funding of this research work by the ACIAR Project**

SMAR/2007/219 is gratefully acknowledged.

Abstract

Communal water storage reservoirs (embungs) that serve many villages in West Timor, Indonesia, by providing water during the prolonged annual dry season are experiencing severe sedimentation problems. Sedimentation of reservoirs progressively reduces their water storage capacity and the benefits to community. This paper investigates four alternative strategies for managing the sedimentation of a typical village embung: (1) current management (a "no management" situation), (2) soil conservation in the embung catchment, (3) periodic sediment removal and (4) both soil conservation and sediment removal. Without periodic sediment removal, an embung has a finite life dependent on the rate of sedimentation. The results indicate that periodic cleaning is clearly worthwhile. Strategy (4) gives the highest NPV. Strategy (3) was not as good, though towards the upper end of the range of reasonable discount rates, it was almost as good as strategy 4. No management is the worst strategy.

Keywords: management, reservoir, sediment, water use, West Timor

1. Introduction

Demand for water and water related services have increased throughout the world as a result of growing population and rising food demand. Availability of the water resource is affected to a large extent by the climatic conditions in a given area. Stochastic distribution of rainfall is the most important determinant of fluctuations in water availability: water shortages during dry periods of the year, and excess water availability during wet seasons. Management of this variability in water availability is a crucial factor for agricultural production in tropical areas. This is even more

important in developing countries that experience significant demographic change and have a large proportion of the population suffering from poverty or near poverty conditions in many rural areas.

Various management approaches have been used to deal with inadequate distribution of water availability over time. One of the possibilities is to use small reservoirs, which is particularly suitable in poor regions of developing countries (Liebe et al., 2005). Storage of water in these reservoirs can alter the effects of uneven distribution of water availability by collecting the excess water during the wet season which can then be used to grow crops and support livestock during the dry season.

Unfortunately, these small reservoirs often suffer from sedimentation, which has been identified as a serious problem facing many water projects in less developed countries (Andrus, 1986). It is estimated that around 0.5 per cent to 1 per cent of global water storage space on average is lost annually as a result of sedimentation (White, 2001). Sedimentation of reservoirs is a naturally occurring process due to erosion of soil around the reservoir area, and the degree of its severity depends on the topography, soil type, and intensity of rainfall in the area. However, the rate of sedimentation can be accelerated by human activities such as agriculture, livestock rearing, deforestation and other activities. The accumulation of sediment in water reservoirs compromises the benefits obtained from these structures over time by reducing their water storage capacity and shortening its economic life. Several possibilities exist to alleviate this problem. These include: minimising the rate of sedimentation by improving the management of the catchment area and reducing soil erosion, and periodic clean-up of the sediment from the reservoir (Kapadia et al., 2002).

From an economics perspective, reservoirs can be treated as assets that provide services across a period of time. Since the deposition of sediment reduces the available storage volume, it reduces the flow of benefits that can be derived from reservoir services overtime. Therefore, sedimentation can be viewed as asset depreciation (Hansen and Hellerstein, 2007). The present study uses the principle of capital asset depreciation to analyse the effect of sedimentation on the benefits derived from water reservoirs through a case study of water reservoirs in West Timor, Indonesia, and to evaluate several alternative possibilities to alleviate this problem.

A number of embungs (local name for water reservoirs that are similar to farm dams in Australia) were constructed in West Timor largely through international donor funding to capture intense runoff during the wet season. The stored water is then used in the dry season for livestock water consumption — which was the original intention of the AusAID funded project to build embungs — but also for sanitary purposes in the households, as well as for watering of some crops, typically vegetables and nurseries. These communal embungs are currently being used and managed at the village level. However, in the past 10-15 years these embungs have lost significant amount of water storage capacity due to intensive sedimentation. The field evidence suggests that some of the embungs are filled up to 80 per cent with sediment and most have lost more than 50 per cent of the water storage capacity. Such large loss of the storage capacity limits the ability of the water users to make great use of water and realise economic benefits from embungs. The villagers are using the embungs but they are not taking any action to address the sedimentation problem. Conceptually, from an economics perspective, this represents pure consumption of the asset that has been given to these communities by the donor agencies without taking into account the depreciation of this asset and without making any provision for such

depreciation. If this process of asset consumption without management continues, the communities will use up the asset and after some time the asset will stop producing benefits.

In order to maintain long-term viability of using these assets, the villagers could adopt various management approaches towards addressing the sedimentation problem. One of the focal points of this study is to determine the suitable sediment management strategy to address the sedimentation problem in the embungs of West Timor. The study evaluates the performance of alternative sediment management strategies including soil conservation and/or sediment removal. It contrasts this to the current practice of no management and tests the economic performance of each of the considered strategies based on several key parameters, such as discount rate, and the effectiveness of sediment management strategies. The strategies evaluated are: no management (*laise-faire*); soil conservation to minimise erosion; periodic sediment removal (dredging); and a combination of both soil conservation and periodic sediment removal.[1]

Previous studies have carried out economic analyses of some conservation practices such as contour farming and strip farming (Kapadia et al., 2002). Kawashima (2007) examined the economic efficiency of alternative methods for periodic sediment removal (dredging, flushing). Discount rates are noted to be an important factor contributing towards determination of profit maximising sediment management strategy (Kapadia et al., 2002 and Kawashima, 2007). Liu et al. (2001) recommended various sediment removal methods depending on sedimentation rate. They recommend dredging as a suitable sediment removal method for small and

[1] Dredging is the method of removing sediment from the reservoir by using buckets to dig and lift the sediment to the surface with minimal water entrainment (Malano et al., 2005).

medium reservoirs (Liu et al., 2001). In a recent article Hansen and Hellerstein (2007) postulated an analytical framework for examining the sedimentation of reservoirs as a capital asset replacement problem (Perrin, 1972), and empirically considered several management scenarios for a reservoir in the US. The current article builds on these studies and provides an application of the capital asset replacement view of the sedimentation problem in the context of one of the least developed regions of Indonesia. The article also makes a contribution by explicitly examining the role of alternative discount rates, and the effectiveness of the soil conservation methods, for the optimal management approach to the sedimentation problem.

2. Study Area

West Timor is a part of the island of Timor and forms part of the East Nusa Tenggara (NTT) province, in Indonesia. The land area of West Timor is 15,850 km² and its capital is Kupang. The West Timor region constitutes of 32 per cent of the total NTT area and is inhabited by around 38 per cent of the total population of NTT (Suharyo et al., 2007). West Timor had population of 1,953,965 inhabitants in 2005.

Climate

West Timor has a semi arid climate with longer dry season lasting from March to November, and a rainy season lasting for 2-4 months, usually starting around November-December and ending in March-April. The average annual rainfall varies between 500 mm – 2,000 mm. Since, West Timor suffers from long dry season lasting up to eight or more months, such dry spell has been considered as the main reason for various problems such as forest fires, water shortage, community health degradation, all resulting in hunger and malnutrition (Pasaribu, 2007). At a household level, water

shortages in the long dry season affect the activities such as agriculture, livestock raising, and other everyday activities (washing, cooking, bathing).

Agriculture

The crop production systems in West Timor are mostly carried out at the subsistence level where the main objective of the farmers is to fulfil the food requirement for the family (Benu, 2003). The long term dry season has influenced farmers to retain their traditional agricultural production system of growing the subsistence crops i.e. rice/maize in the wet season and crops requiring less water such as mungbean and soybean in the dry season. In addition to this traditional cropping, vegetable production is gaining popularity among the farming community. Vegetables are one of the more promising agricultural enterprises in Indonesia, as there seems to be substantial unmet domestic demand for vegetables.

Vegetable production in Indonesia fulfils only 13 per cent of the local consumption demand (Arsanti and Boehme, 2007). As reported in Arsanti and Boehme (2007), the producer's price for vegetables such as tomato, onion, cabbage, potatoes, cucumbers, carrots and other vegetables have increased substantially over the 10-15 years. The demand for fruit and vegetables in Indonesia is growing fast because of rapid economic development and high income elasticities of demand. Consumption of vegetables is expected to grow from 4.6 per cent in 1988 to 8.9 per cent in 2010 (Darmawan and Pasandaran, 2000). In addition to this, horticultural farmers are usually able to earn higher incomes compared to subsistence crop producers. Therefore, increasing horticultural production can have a great impact on commercialization of rural economy via creation of off-farm jobs related to marketing and processing (Weinberger and Lumpkin, 2005).

In the NTT province, of which West Timor is a part about 50,000 tons of vegetables from 11,000 hectares of land are produced per annum and the average yield is 4.5 t/ ha (White, 2007). The main vegetables grown in NTT and their average yields (t/ha) and production in 2005 are presented in Table 1.

Table 1: Production of Vegetables, NTT- 2005

No.	Vegetable	Production (Tons)	Yield (Tons/ha)
1	Red Kidney Bean	8,380	3.2
2	Chinese Cabbage	5,064	6.6
3	Pumpkin	4,585	7.5
4	Shallot	3,837	4.5
5	Aubergine	3,422	6.9

Source: (White, 2007)

Some of the market price data gathered in the field indicate prices of 7,000 IDR per kilogram of tomato, 3,000 IDR per head of cabbage, 1,000 IDR per bunch of five long beans, 6,000 IDR per kilogram of beans.[2]

Livestock production systems in West Timor are quite traditional, dependent on pasture capacity and do not make use of many inputs. The overgrazing of pastures is widespread leading to significant pasture degradation (Benu, 2003). As a result of pasture degradation and lack of supplementary forage coupled with water scarcity, the growth rate of livestock (cattle) in NTT as a whole is quite low with an average growth of around 70 kilogram per year (Benu, 2003). In general the community in West Timor raises one to three heads of cattle per household (Suharyo et al., 2007).

3. Analytical Framework

Let the benefits from an embung be a function of water available for use in time *"t"*, *AW(t)* be a function of the total volume of sediment present in the embung at time *"t"*, *SED(t)*, which in turn is a function of the average sedimentation rate *(SR)*.[3] Let

[2] Exchange rate: 1 US Dollar =11,000 IDR (Indonesian Rupiah) and 1 AU Dollar=7435 IDR

"T" represent the expected service period of embung. The value of benefits from embung services depreciates over time with any increase in sediment accumulation which leads to reduction in *AW(t)*. The maximum volume of water that is available for use is *AW(0)* when the embung has no sediment at all i.e. when *SED(t)=0*. *AW(t)* is calculated as the initial water holding capacity of embung less *SED(t)*: $AW(t) = AW(0) - SED(t)$. The accumulated sediment reduces *AW(t)* every year and here it is assumed that once the quantity of available water is reduced as a result of continuous sediment accumulation every year , it does not increase unless sediment removal is done, so $\partial AW(t) / \partial t \leq 0$. Therefore *AW(t)* decreases as time *"t"* approaches *"T"* when no management activities are implied. The models used for estimation of benefits from four alternative sediment management strategies are presented as follows

3.1. Benefits without any Management (*Laise-faire*)

Let the average rate of sedimentation of the embung without any sediment management strategies applied be SR_N. In a reservoir with no management, the total expected economic benefit in net present value terms (B_N) is as follows:

$$B_N(t) = \int_0^T f\,(AW_N(t))\, e^{-rt}\, dt \qquad [1]$$

where, *r* is the discount rate, $AW_N(t)$ is the water available for use in time *"t"* in absence of embung management, and the subscript *"N"* indicates absence of soil conservation.

[3] In general along with the total sediment in the embung, *AW(t)* should be a function of evaporative losses too, but this study does not take into account the effect of evaporation in calculation of benefits from embung water. Since the amount of water lost by evaporation is also affected by the time when water is used and also the calculation of such losses is a complex process, evaporative effect has not been included in this study for simplicity. If we assume that all water is used up in the beginning then there will be no evaporative losses. Besides, evaporative effect does not have any significant contribution to the sedimentation rate, expected service period of embung and also do not contribute on the performance level of the proposed sediment management strategies.

3.2. Benefits with Soil Conservation

When the catchment management strategies are implemented, the sedimentation rate decreases due to decrease in the rate of soil erosion. Let SR_s be the average sedimentation rate when soil conservation is adopted, so that on average $SR_s < SR_N$. This implies that the expected service period of embung extends from T years to T' years, where $T'>T$.

There are costs associated with the soil conservation strategies. Let the costs be denoted by $CM_s(t)$. Let B_S be the present value of the total benefits that could be obtained under soil conservation strategy.

$$B_S(t) = \int_0^{T'} [(f\ (AWs(t))\ e^{-rt} - (CMs(t))\ e^{-rt}]dt \qquad [2]$$

where, $AW_S(t)$ is the available water at time *"t"* under soil conservation strategy. The subscript *"S"* represents presence of soil conservation.

3.3. Benefits with Sediment Removal (Dredging)

Dredging is sediment removal undertaken to recover the lost water storage space. Since no soil conservation is practiced under this strategy, the sedimentation rate is the same as in the no management case i.e. SR_N, and if sediment removal is not undertaken the embung would fill up in *"T"* years. Let CR be the cost of dredging and B_D be the present value of embung benefits with dredging at year (D):

$$B_D(t) = \sum_{p=1}^{\infty} \int_0^{D_p} [f\ (AW_N(t_p))\ e^{-rt} - CR(D_p)e^{-rt}]dt \quad . \qquad [3]$$

Dredging occurs when the sediment level in the embung reaches 30 per cent as proposed by Hansen and Hellerstein (2007). Under this strategy, the expected service period of an embung is infinite, as removal of sediment replaces the lost storage space

of the embung and provides more space for water storage and use in repeated cycles. Here, it is assumed that the flow of cost and benefits will be the same in perpetuity, i.e. the stored water will be used for the same purpose and in the same amount between the consecutive dredging periods, and the sedimentation rates in the years of first cycle exactly repeats every cycle and also that the relative benefits, costs and prices remain constant along time. Here the subscript *"p"* is an index for the service period between two dredging events and "*D"* is the year of dredging under the strategy without soil conservation.

3.4. Benefits with Soil Conservation and Sediment Removal (Dredging) Combined

The previous sections dealt with the benefits that could be obtained from sediment removal (dredging) and soil conservation activities separately. This section looks at the benefits when both soil conservation and sediment removal are applied. Under this scenario, the sedimentation rate (SR_S) can be assumed to be the same as that for the scenario under soil conservation strategy. Since both soil conservation and sediment removal actions are incorporated into this strategy, the costs incurred are the sum of the costs for the two actions, CR and $CM_S(t)$. The net present value of embung benefits under this strategy is given by:

$$B_{DS}(t) = \sum_{p=1}^{\infty} \int_0^{D'p} [(f\ (AWs(t_p))\ e^{-rt} - \{CR(D'_p) + CMs(t_p)\}e^{-rt}]dt` \qquad [4]$$

where, *"p"* is an index for the service period between two dredging events and *D'* is the year of dredging when soil conservation activities are applied.

4. Methods

Net Present Value (NPV) approach is used in the current study to compare the expected benefits obtainable from the four alternative sediment management strategies.

1) Current management *(Laise-faire)*: This describes the present situation where the users are using the asset until the benefits turn zero at the end of the service period without applying any management activity. Therefore, there are no costs under this strategy.
2) Soil conservation: This strategy involves different activities to reduce the rate of sedimentation thereby extending the expected service life of embung. The main activities that have been considered in this study are planting trees around the catchment to reduce sediment runoff, and maintenance of fences to prevent entrance of livestock in the area. This strategy involves management cost in the form of cost for planting trees, and the opportunity cost of labor and land occupied in soil conservation activities.
3) Periodic sediment removal (Dredging): This involves removing the accumulated sediment from embung to restore the lost storage capacity when the total sediment accumulation reaches 30 per cent of the original embung capacity. Under this strategy the benefits obtained from embung service keeps on repeating from one cycle to another.
4) Combination of strategy (2) and (3) i.e. both soil conservation and periodic sediment removal.

4.1. Benefits

In order to determine the change in the reservoir benefits over time, three main types of water uses are taken into consideration: benefits from domestic water supply, benefits from using water for livestock raising, and benefits from irrigation of vegetables. These three uses of water have been prioritised in the above order in this study. That means the water supply for domestic use has a priority over all other uses, and water for livestock has priority over irrigating vegetable crops.

The benefits from using embung water for each activity starts to decline with decrease in the water available for a particular activity. Since irrigation has the lowest priority, benefits derived from irrigation would start to decline first, followed by decline in benefits from livestock, and then benefits from domestic use of water. Calculations of benefits using embung water for these activities are described below.

4.1.1 Benefits from Domestic Use

The basis used for calculation of benefits from water supply for domestic use from the embungs is the opportunity cost of time spent in collecting water for domestic use from embung as compared to the alternative source of water which may be a nearby spring or creek. The cost of time is estimated with reference to the wage rate of unskilled labor in the study area. The benefits from domestic water use starts to decline when the available water is less than the total quantity of water required for domestic use. The list of variables for the estimation of embung benefits from domestic water use are provided in Appendix 1.

4.1.2 Benefits of Using Water for Livestock

The benefits from livestock rearing are assumed to be the profit that is earned from the sale of that livestock. Such assumption has been made because if the embung

water is not available then the households would not be able to raise that livestock. The variables used for estimation of benefits from using embung water for livestock rearing are tabulated in Appendix 2.

Available water for livestock per year would be equal to the total water requirement until the difference between total available water and water required for domestic use is greater than or equal to the total water required for livestock. The benefits from livestock will start to decline as the water available for livestock declines below the requirement level, as less water means household can support less livestock with available embung water.

4.1.3 Benefits Using Water for Irrigating Vegetable Crops

The amount of water available for irrigation is the residual amount left after the domestic and livestock water needs have been fulfilled. This implies that sedimentation of embungs mostly affect the irrigation benefits compared to benefits from other uses. Benefits from irrigating high value vegetable crops using the water stored in embung is estimated as follows:

$$B_I = VAP * I_y / I_A \quad , \qquad [5]$$

where, I_y is total quantity of water available for irrigation per year (litre/year), I_A is the water required to irrigate a hectare of vegetable crop land, I_y/I_A is the size of land (ha) that can be irrigated with I_y amount of water, VAP is the value of average product of irrigated land (IDR/ha) and:

$$I_y = AW - H_y - L_y \qquad [6]$$

where, H_y is the total quantity of water required for domestic use per year (litre/year), L_y is the total quantity of water required for livestock per year (litre/year), AW is the total embung water available for use (litre/year).

4.2. Present Value of Benefits and Present Value of Asset

Total benefits from the use of water stored in an embung is given as the summation of benefits from domestic water use*(B_H)*, livestock raising *(B_L)*and irrigating vegetable crops *(B_I)*. The value of the land at time *(T)* on which the embung stands i.e. the salvage value of embung land also affects the value of an embung as an asset because the alternative use of land is in agricultural production. Let the salvage value of land be represented by *LV*. The total value of the flow of benefits from the embung service can be estimated by the following equation:

$$VB(t) = \int_0^T B_H(t) + B_L(t) + B_I(t) + LV(T) \qquad [7]$$

In equation (7), *LV*= 0 for strategy (3) and strategy (4) as the embung service cycle is repeated for infinite time period, so the land is not available for other uses at any point in time. The Net Present Value of net benefits can be estimated as

$$NB(t) = \int_0^T (VB - CM_s - CR)e^{-rt}dt\,, \qquad [8]$$

where T is replaced by T' in strategy involving soil conservation. CM_s is the cost of soil conservation and *CR* is the cost of dredging. The NPV of total embung benefits was derived using Microsoft Excel.

5. Data

The major sources of data for this study include the primary data collected from the study area through semi-structured interviews and farmer surveys conducted within the framework of a related ACIAR project.[4] Some data were acquired from the existing literature on related studies in Indonesia and other countries.

[4] ACIAR: Australian Centre for International Agricultural Research

5.1. Sedimentation Rate

Dimension of the representative embung taken into account for this study is 80m x 40m x 15m as of one of the embung in an area named Tupan in West Timor. The average sedimentation rate was estimated to be 4 per cent per annum of the total embung capacity i.e. (1,920 m^3/Year). This was obtained from the primary data on original capacity, current capacity and the establishment year of embung from the study area. Since no catchment management strategies have been currently implemented, this sedimentation rate is taken as the mean sedimentation rate for embungs without any management.

When the soil conservation strategies are implemented, it is assumed that the sedimentation rate is reduced by 40 per cent of the mean sedimentation rate without any management i.e. 2.4 per cent (1,152 m^3/Year). There is no reliable data available to indicate the effect of soil conservation on sedimentation rate in West Timor. One of the studies conducted in the United States by Claassen et al. (2001) reports a reduction in the sedimentation rate by 40 per cent after soil conservation activities are applied. Therefore, this figure of reduction in sedimentation rate by 40 per cent is acquired from Claassen et al. (2001). The expected sediment accumulation each year for the period of the embung service was simulated using random number (uniform distribution) tool in Microsoft Excel using a standard deviation of 50 per cent on either side of the average sedimentation rates.

5.2. Data for Calculation of Benefits from Domestic Water Use

In order to estimate the expected benefits from using embung water for domestic use, the water use per person per day was assumed to be 40 litres. Gleick and IWRA (1996) recommends 50 litres per person per day as a standard for meeting four basic domestic needs (drinking, sanitation, bathing and cooking), independent of climate,

technology, and culture. But since, it is time consuming for the villagers to get water from a source outside the home and the household members also consists of children who probably require less water, the assumption of water required per person per day is 40 litres in this study.

The average family size is 5 members per household as obtained from the survey of 76 households in West Timor. The quantity of water that a person can collect per visit is assumed to be 30 litres. The data on time spent in getting water from near by reservoirs and springs were obtained from the villagers through semi-structured interviews. The time spent can vary with the distance of household location with respect to the water tank (containing embung water) and springs. In the present study, it is assumed that the water tank is at 50 metre distance and the spring at 1 kilometre distance from household. The number of households served by the embung is 55 (average calculated on the basis of the survey of eight villages within the study area).

The time saved in hauling water due to the existence of an improved water service can be utilised for many other productive uses like agricultural labor or other wage earning employment. Whittington et al. (1990) have noted that the American Development Bank assumes that time savings should be valued at 50 per cent of the market wage rate for unskilled labor in the local economy. However, they themselves recommend that the value of time might be near- or even above-the market wage rate for unskilled labor in relation to a study conducted in Kenya on value of time spent in collecting water. In the present context, the time savings is valued at 50 per cent of the unskilled labor wage rate. Since most of the time the household member collecting water is a woman or a child (not generally working fulltime anywhere else) their

opportunity cost of labor in time spent for collecting water is assumed to be half of the cost than that of the cited value.

In order to estimate the opportunity cost of time spent in collecting water, the average wage rate is calculated using the data for minimum regional wage/month i.e. 650,000 IDR/Month i.e. US$ 59/Month (Patung, 2008) and average working hours per week of 44 hours as acquired from BPS (NTT) website.[5]

5.3. Data for Calculation of Benefits from Livestock Raising

In this calculation the livestock component includes only cattle; other livestock is not included in the estimation for simplicity. As obtained from the primary data, the average number of cattle per household is 2-3 (used 3 cattle heads per household in the calculation). Cattle are sold when they reach live weight of 250 kilogram and the market price of cattle is 13,000 IDR per kilogram (US$ 1.18 per kilogram) (Source: Semi-structured interview).

The minimum water requirement per head of cattle per day as recommended by NRCS (2007) is 12 gallons which is equivalent to 45 litres per day.[6] On the other hand, according to research conducted in research station at BPTP (NTT), the daily water requirement for cattle weighing 250 kilogram is 25 litres per day in dry season and 15 litres per day in wet season.[7] In the present study the minimum water requirement per day per cattle is taken to be 25 litres since the local beef cattle in West Timor consumes less water as they are relatively smaller in size than the American breed. Only the water requirement for the dry season is taken into consideration in this study.

---

[5]BPS :Badan Pusat Statistik (Central Bureau of Statistics – Indonesia)
[6]NRCS : Natural Resource Conservation Service
[7]BPTP : Balai Pengkajian Teknologi Pertanian (Assessment Institute for Agricultural Technology)

Profit per cattle head is taken as 14 per cent of the gross revenue. The profit percentage is calculated on the basis of the profit data for beef cattle fattening as reported in Perdana (2003) for Java, Indonesia under different scale of livestock farming.

5.4. Data for Calculation of Benefits from Irrigation

The amount of water left for irrigation after fulfilling the requirements for domestic use and livestock raising limits the size of land that can be irrigated. The quantity of water required to irrigate per hectare of land for vegetable production as given by Bryan and Marvanek (2004) is 4.5 Megalitres (ML). The farm size that can be irrigated using the available embung water for irrigation can be calculated by dividing the quantity available by 4.5 Megalitres (ML).

As reported in EASRD (2005), the marginal productivity of irrigated land (VAP) in Indonesia towards the end of 1990s was US$ 3,000 (in 1993 US dollars) per hectare.[8] Adjusting that value with the GDP deflator gives marginal productivity (VAP) of irrigated land to be around US$ 4,000 (in 2008 US dollars) per hectare as calculated by GDP Deflator Inflation Calculator given on the website of National Aeronautics and Space Administration (NASA) . Since, NTT has less fertile land and suffers very harsh weather conditions; the above value of VAP is thought to be higher for West Timor. Therefore in the present study the VAP is assumed to be 50 per cent of the cited value i.e. US$ 2,000 per hectare.

5.5. Other Data

The salvage value of land is 8 million IDR (US$ 727) per hectare (Source: Semi-structured interview). For calculating the costs of fence maintenance, the opportunity

[8] EASRD: East Asia Social and Rural Development unit (World Bank)

cost of 14 hours per month has been assumed. The area of catchment is assumed to be three times the area covered by the embung. The cost of planting trees in the catchment is obtained from primary source in West Timor as 32 million IDR (US$ 2,909) per hectare. The catchment area inside the fence is assumed to be equal to the area covered by embung.

Cost of dredging is 160 million IDR (US$ 14,545) as obtained from semi-structured interview. The optimal time of dredging is considered to be when the embung gets 30 per cent filled with sediment. NPV calculation for strategy (3) and (4) takes into account that the dredging is done at that point of time. Since dredging is assumed to be done at 30 per cent sediment; the cost of dredging is taken as 40 per cent of the total cost considering the presence of economies of scale effect in the cost of dredging from Hansen and Hellerstein (2007).

It was assumed that dredging removes all the sediment leaving the embung with its original capacity. The rate of discount taken into account for calculation of present values is 12 per cent per annum. In the analysis, it is assumed that the embung gets filled to its available capacity every year and all of the water collected in a particular year is used up in the same year.

6. Results and Discussion

6.1. General Results

Using the values for different types of water requirements as described in the data section, the total water requirement per year for domestic use was estimated to be 4 Megalitres (ML) per annum and for livestock around 1 Megalitre (ML) per annum. Then, the volume of water that is available for irrigation is around 43 Megalitres (ML) i.e. at the maximum capacity of the embung (when embung has no sediments) which is enough to irrigate vegetable crops in 10 ha of land in a village.

The value of the benefits for a village from using embung water for domestic use, livestock raising and irrigating vegetables crops at full embung capacity are as tabulated in Table 2.

Table 2: Estimated Benefits from Embung Water Use

Activity	**Benefits (US Dollars)**
Domestic water use	11,205
Livestock raising	6,825
Irrigation	20,000

According to the values in Table 2 regarding the benefits from embung service, the capitalised value of the embung would be US$ 316,916 using the capitalisation formula for assets i.e. $\frac{\sum_{t=0}^{T} ExpectedAnnualBenefits}{r}$. The calculated value would be equivalent to around US$ 5800 per household.

The reported results on benefits were estimated using various parameters as described in the data section. Best efforts were put to collect data that is most close to the reality; nevertheless some uncertainty might still prevail.

6.2 Evaluation of Alternative Sediment Management Strategies

The expected life of an embung with no soil conservation was estimated to be 25 years (for strategy 1); and when soil conservation activities are applied the expected life of embung was found to be 42 years (for strategy 2). This shows that soil conservation activities can significantly extend the expected service life (by 68%). The expected life of embung under the two strategies that includes sediment removal (dredging) i.e. strategy (3) and strategy (4) goes up to infinity as the periodic dredging recovers the lost space due to sediment accumulation. As described in data section, when sediment removal (dredging) is done at the stage when sediment level reaches 30 per cent of the original embung capacity, strategy (3) and (4) reaches that stage at

every 8 and 14 years interval respectively. Therefore, these are the dredging interval for strategy (3) and strategy (4) respectively.

The estimated NPV for strategy (4) at the discount rate of 12 per cent i.e. 291 thousand dollars, was the highest value of NPVs among all strategies compared, followed by strategy (3), with NPV of 290 thousand dollars (Table 3). Therefore, strategy (4) is the best option under the general assumptions made and data used for this study as described in data section.

Table 3: NPVs of Benefits from Alternative Sediment Management Strategies

Strategies	**NPVs of benefits (1,000 US Dollars)**
1. No management	251
2. Soil conservation	276
3. Dredging	290
4. Both soil conservation and dredging	291

6.3 Sensitivity Tests

Sensitivity tests were done for change in NPVs with change in discount rate and variation in the effect of soil conservation due to reduction in sedimentation rate in order to test, if the estimated results vary with change in these parameters and whether those changes significantly contribute to change in decision about the most appropriate sediment management strategy. Sensitivity tests for effects due to change in costs of soil conservation (in strategies 2 and 4) were also done but are not reported in this paper because the cost of soil conservation are small compared to the benefits realised from embungs, and the results did not change greatly even when the costs were dramatically changed.

Varying Discount Rates

Tests of NPV under different discounting rates were done in order to determine the possible effects of varying discount rates on the NPVs of different strategies. NPVs for these strategies under different interest rates are presented in Figure 1 below.

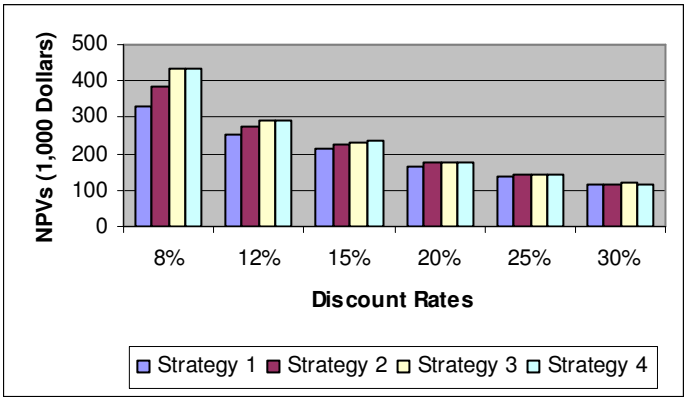

Figure 1: NPVs under Varying Discounting Rates

At low discount rate (8%), there was significant difference between the NPVs of benefits from no management strategy (i.e. strategy 1) and other alternative management strategies. Strategies involving sediment management gave much higher benefits at low discount rate. With increase in discount rate the gap between NPVs from the alternative sediment management strategies narrowed down. At 30 per cent discount rate, the difference between the highest NPV (from strategy 3) and lowest NPV (from strategy 1) was 3,000 dollars. While at the low discount rate (8%), the difference was 106 thousand dollars with strategy (4) giving highest and strategy (1) the lowest NPV. Therefore, it shows that the difference between NPVs of alternative sediment management strategies becomes quite insignificant at higher discount rates. Hence, it indicates that if the discounts rates are too high, people would be better off doing nothing rather than spending their time and money for management costs. Such conditions are quite likely to occur in West Timor's case because the individual discount rates of farmers can be much higher than the documented value of 12 per cent per annum as used in this study.

Varying Sedimentation Rates

Sensitivity testing was done to check the results of varying effects of soil conservation activities. That means the tests were done to get the results for the conditions when

the soil conservation activities decreased the sedimentation rate by varying amounts. Tests were done for reduction in sedimentation rate by 20 per cent, 40 per cent, 60 per cent, and 80 per cent of the original rate (Table 4).

Table 4: Sensitivity Test for Varying Effects of Soil Conservation on Sedimentation Rate

Strategy	NPVs (1,000 US Dollars) for reduction in sedimentation rate due to soil conservation by 20%	40%	60%	80%
2	265	276	289	301
4	289	291	295	302
Difference in NPV between strategy (2) and (4) (1,000 US Dollars)	*24*	*15*	*6*	*1*
Expected Life (years)				
2	30	42	58	111
4	∞	∞	∞	∞
Dredging interval for strategy (4) (years)	10	14	19	38

Strategy (4) gave the highest NPV for all of the cases (Table 4). However, with the increase in the positive effect of soil conservation the difference in NPV between these two strategies decreased and the difference was quite insignificant when the reduction in the sedimentation rate was greater. Hence, if the soil conservation activities can be applied to the level where the sedimentation rate is decreased by higher percentages, then the strategy which does not involve sediment removal is profitable.

7. Conclusion and Recommendation

Expected benefits from embung service for three main water uses were estimated in the study. Calculation of the value of embung as an asset (US$ 316,916) on the basis of the benefits estimated provides significant evidence about the importance of embungs for the communities in West Timor. This knowledge can provide an

incentive for the communities to acknowledge the value of embungs, and to carry out the sediment management options for sustaining the embungs as valuable assets.

The choice of best strategy for management of sediments in the embungs in West Timor depends on various factors. Based on the current assumption of the value of variables used in the study, strategy with both soil conservation and sediment removal (strategy 4) was found to be the best followed by strategy (3) which gave a slightly lower NPV compared to strategy (4), and strategy with no management (strategy 1) was the worst in terms of NPV estimates. However, the sensitivity tests on the varying effect of soil conservation strategy in reducing sedimentation rate showed that the strategy with soil conservation only i.e. strategy 2 (without sediment removal) is the better option provided that the soil conservation activities applied are very effective in reducing the sedimentation rate, as the difference between NPVs for strategy (2) and strategy (4) declines with the increase in effectiveness of soil conservation. Nevertheless, increasing the positive effect of soil conservation might require greater expenditures on soil conservation activities. Therefore, further analysis is required regarding the relationship between cost level and performance of soil conservation activities.

The study also showed that higher the discount rate, sediment management strategies become less desirable as the difference between NPVs of benefits from management strategies and no management gets closer. This confirms the similar results reported in Kawashima (2007) and Kapadia et al. (2002). Therefore, discount rates play important role in the embung user's choice between sediment management and no management strategies. Hence, it is recommended that a more detailed study to find out the actual individual interest rate should be conducted with a more comprehensive study in future in order to estimate more accurate results.

References:

Andrus, C. (1986). "The Economics of Erosion Control in a Subtropical Watershed: Comment". Land Economics **62**(3): 329-330.

Arsanti, I. W. and Boehme, M. (2007). "Vegetable Farming System in Upland Areas of Indonesia: Economic Externalities." Indonesia Agricultural Journal.

Benu, F. L. (2003). "Farm Productivity and Farmers Welfare in West Timor, Indonesia". Curtin University of Technology. **PhD Thesis**.

BPSNTT. "Statistics of Nusa Tenggara Timur." from

http://www.bps.go.id/~ntt/wage/wg02.htm

Bryan, B. and Marvanek, S. (2004). "Quantifying and Valuing Land Use Change for Integrated Catchment Management Evaluation in the Murray-Darling Basin 1996/97-2000/01". CSIRO Land and Water.

Claassen, R., Hansen, L., Peters, M., Breneman, V., Cattaneo, A., Feather, P., Gadsby, D., Hellerstein, D., Hopkins, J., Johnston, P., Morehart, M. and Smith, M. (2001). "Agri-Environmental Policy at the Crossroads: Guideposts on a Changing Landscape". Agricultural Economics Report 794.

Darmawan, D. A. and. Pasandaran, E. (2000). Dynamics of Vegetable Production,Distribution, and Consumption in Asia. Indonesia. M. Ali, Asian Vegetable Research and Development Center, AVRDC Publication No. 00-498

EASRD (2005). "Public Private Partnerships for Agriculture in Eastern Indonesia: A Comparative study of the Beef Cattle and Cocoa Industries". Technical Note Prepared for World Bank.

Gleick, P. H. and IWRA. M. (1996). "Basic Water Requirement for Human Activities: Meeting Basic Needs". Water International **21**: 83-92.

Hansen, L. and Hellerstein, D. (2007). "The Value of the Reservoir Services Gained With Soil Conservation". Land Economics **83**(3): 285-301.

Kapadia, M., Shah, F. and Warner, G. (2002). "Sedimentation of Reservoirs: Prevention vs. Cleanup". American Agricultural Economics Association Annual Meeting. Long Beach, CA.

Kawashima, S. (2007). "Conserving Reservoir Water Storage: An Economic Appraisal". Water Resources Research **43**(WO5417).

Liebe, J., Gieson, N. van de. and Andreini, M. (2005). "Estimation of Small Reservoir Storage Capacities in a Semi-arid Environment." Physics and Chemistry of Earth **30**: 448-454.

Liu, J., Liu, B. and Ashida, K. (2001). "Reservoir Sedimentation Management in Asia".

Malano, H. M., George, B.A. and Davidson, B. (2005). "Asset Management Modelling Framework for Irrigation and Drainage Systems: Principles and Case Study Application". Irrigation and Drainage Systems **19**: 107-127.

NRCS (2007). "Livestock Watering". NRCS NJ Data Sheet.

Pasaribu, S. M. (2007). "Revitalizing Institutions to Enhance Climate Forecast Application in East Nusa Tenggara Province, Indonesia." Analisis Kebijakan Pertanian. **5**(3): 239-253.

Patung (2008). "Business and Economy". Indonesia Matters.

http://www.indonesiamatters.com/1509/minimum-wage/

Perdana, T. (2003). "Competitiveness and Comparative Advantage of Beef Cattle Fattening in Bandung Regency". Bandung, Padjadjaran University.

Perrin, R. K. (1972). "Asset Replacement Principles". American Agricultural Economics **54**(1): 60-67.

Suharyo, W. I., Toyaman, N., Poesoro, A., Sulaksono, B., Usman, S. and Febriany, V. (2007). "Improving the Business Climate in NTT: The Case of Agriculture Trade in West Timor". K. Weatherley (ed). Jakarta, The SMERU Research Institute.

Weinberger, K. and. Lumpkin, T.A. (2005). "Horticulture for Poverty Alleviation-The Unfunded Revolution." The World Vegetable Centre, AVRDC Publication No. 05-613. Working Paper 15.20.

White, R. (2001). "Evacuation of Sediments from Reservoir". London, Thomas Telford.

White, B. (2007). "Vegetable Value Chains in Eastern Indonesia–A Focus on Chilli". SADI-ACIAR.

Whittington, D., Mu, X. and Roche, R. (1990). "Calculating the Value of Time Spent Collecting Water: Some Estimates for Ukunda, Kenya". World Development **18**(2): 269-280.

Http://www.nusa-tenggara.com/east/html/general.html

Appendixes

Appendix 1: Variables for calculation of embung benefits from domestic water use

Time required to get water from reservoir (embung)	X (hours)
Time required to get water from spring/ creek	Y (hours)
Number of HH using embung	HH
Average household size	M (number of people)
Quantity of water required/person/day	P litres
Quantity required per day/HH	$H_d = P*M$ litres
Total quantity required per year/HH	$H_y = H_d*365$
Quantity that can be collected per visit	Q litres
Thus, no. of visits required per day	$N = H_d/Q$ times
Unskilled Labor Wage rate/hour	$\$L$
Value of the time for collecting water/year from reservoir (embung)	$V_E=(X*L)*N*365$
Value of the time for collecting water/year from spring/creek	$V_C=(Y*L)*N*365$
Benefit of embung service/year/HH	$V_C - V_E$
Benefit/Year/Embung	$B_H = (V_C - V_E)*HH$

Appendix 2: Variables for calculation of embung benefits from livestock raising

Number of HH using embung	HH
Number of cattle head/ Household	C
Total livestock served by embung	$A = C*HH$ (number of cattle heads)
Quantity of water required/cattle/day	L_d (litres)
Total Water required / year (1 year= 7 months)	$L_y = L_d*A*30*7$ (litres)
Weight of livestock when ready to sell	$Wt.$ (kilogram)
Price per kilogram	P (IDR)
Net Profit/ livestock	Y (IDR)
Total Benefit/ year/embung	$B_L=Y*A$