ASSESSMENT OF SUSTAINABILITY OF INTEGRATED COASTAL MANAGEMENT PROJECTS: A CBA-DEA APPROACH

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ABSTRACT

Sustainability is a key factor in ensuring coastal and marine resource management. However, achieving as well as assessing the sustainability is not an easy task. Complexities and controversies surrounding its concept hinder practical usefulness of using some methodologies of measuring sustainability. This paper attempts to employ a different approach of assessing the sustainability of coastal and marine resource management through cost- benefit analysis combined with Data Envelopment Analysis (CBA-DEA). In this paper, non-monetary as well as monetary indicators are used to measure the benefits and costs associated with coastal projects. Using Cilacap, Central Java, as a study area, the paper explores the benefit that could be secured from integrated coastal management projects as well as the costs that must be borne by stakeholders.
Keywords: ICM sustainability, CBA-DEA approach, Segara Anakan-Cilacap.

INTRODUCTION

Indonesia's marine and coastal resources play an important role in the economy of Indonesia, particularly, for coastal areas. The contribution of the marine and coastal related activities was estimated to be more than 25% of the Indonesia's Gross Domestic Product (DKP, 2002). The marine and coastal resources provide an important source of income and employment for those living in coastal and rural areas. In addition, one of these resources, the fishery, has been a critical source of affordable animal protein for the majority of coastal inhabitants.

With rapid economic development during the 80s and early 90s, these resources, however, are under tremendous pressures due to several factors which contribute to the unsustainable use of the resources. Excessive extraction of coastal and marine resources was rampant and had led to deterioration of these resources. Unsustainable practice of coral fishing, for example, had destroyed much of the coral reefs in the country. It is estimated that only 20% of Indonesia's coral reefs are in good condition (Hopley and Suharsono, 2000). In the fishery sector, excessive fishing effort had also led to biological as well as economical over fishing in some parts of the coastal areas. Study by Fauzi and Anna (2002), for example, have shown that the fishery resources in the north coast of Java had depreciated as much as Rp 20 billion per year, which is equivalent with the forgone benefits had the resource been managed in sustainable manner.

Efforts by the government of Indonesia to manage its coastal and marine resources in a sustainable manner were limited due to the lack of financial resources and lack of institutional capacity both at national and regional levels. The recent establishment of a national ministry concerned with the management and the development of marine and coastal resources, and the implementation of several coastal and marine resource projects supported by foreign donors alone, are not enough to capture the breadth and complexity of marine and costal resources problems. Even though, investments in coastal management projects have reached more than US $ 400 million, few of these projects sustain once the funding ceases (Sofa, 2000). With regard to marine and coastal management, therefore, there are two questions of sustainability that must be addressed. One is dealing with the sustainability of marine and coastal resources and, two, with regard to the sustainability of the marine and coastal project.

Assessment of sustainability of the ICM projects will undoubtedly encompass many dimension of the sustainability. These include ecological sustainability, socio-economic sustainability, community sustainability and institutional sustainability (Charles, 1994). Given this complexity, it is difficult to assess the whole range of sustainability of the ICM project without reducing its curse of dimensionality. Toman et al (1998), for example, noted that the difficulty of measuring the relationship between sustainability and economic well-being is still being a substantial debate among economists. In particular, whether one should use monetary or non-monetary indicators to measure the sustainability, and whether sustainability assessment should include the physical and spatial scale over which sustainability is assessed. Toman (1998) and Pezzey and Toman (2002) also noted that the notion of sustainability and its assessment embodies deep conceptual ambiguities, which can not be solved easily due to serious theoretical disagreement about the interaction of human with their environment.

Due to these complexities of assessing the sustainability of both resources and the projects, in this paper, the assessment of the sustainability will be embedded into economics of sustainability. That is, both sustainability of the resources and the project will be captured by the benefits and costs associated with marine and coastal management using both non-monetary indicators and monetary indicators. Therefore, if the ICM project is assumed to be sustainable, it will be embodied in its performance indicators. To do this analysis, a different kind of cost-benefits analysis will be employed.

COST-BENEFITS ANALYSIS: AN OVERVIEW OF CONVENTIONAL WISDOM.

Since its birth in the early 1960s, cost benefit analysis, or CBA for short, has been widely used to assess the feasibility of a project. It is used as a practical way of assessing the usefulness of projects, both public and private. Several terminologies are used to describe this technique. These include cost-effectiveness analysis, benefit-cost analysis, systems analysis, or merely analysis. Regardless the terminology that one uses, the CBA is basically refer to the process of assessing the objectives and alternative means of achieving them using theory, data, and models (Womer et al, 2002).

During early 1970s, with the rise of environment movement, the use of conventional cost-benefits analysis, however, was in serious doubt since the technique was not adequate to capture the stream of benefits and costs associated with the flows of goods and services produced by natural resources. By the time Lancaster (1967) published a seminal paper on the new economic theory, the cost benefit analysis had a new nuance, in which the non-price attribute of goods and services can now be incorporated into CBA. The term of economic valuation was then widely used to represent this new technique.

Despite the fact that CBA is a widely popular tool for assessing the benefits and costs associated with projects, it is also subject to some criticisms. Dorfman (1996), for example, noted that one of the shortcomings in CBA is it tends to reduce all comparison into single unit namely dollar term. Therefore, it may loose some crucial information contained in other measurements. CBA also conceals the degree of accuracy in its analysis. Furthermore, Farrow and Toman (1998) noted that estimates of CBA are "too imprecise and incomplete to be useful" as well as it neglects equity and efficiency concerns. They further argued that there are practical as well as methodological limitations to what the cost benefits analysis can do. Other criticisms also arise with respect to the use of discounting in CBA. In this regard, controversies arise both in terms of determining the appropriate discount rate and applying the method to situation where benefits and costs arise across generations (Farrow and Toman, 1998).

Due to these limitations, some variants of CBA such as Cost-Effective Analysis, Extended Cost Benefit Analysis and Economic Impact Analysis are now developed. The use mathematical programming techniques through Data Envelopment Analysis (DEA) combined with CBA is also becoming popular. Womer et al, (2002), for example, have used DEA in their Cost-Benefit Analysis of inter-state project in Memphis, Tenesse, while Kirkley and Squires have used DEA technique to measure the change in fishing capacity in coastal area of the United States. The use of CBA with DEA approach, therefore, can at least, remedy the deficiency of conventional CBA in terms of lack of efficiency analysis. Färe et al, (1995) use DEA analysis to asses the externalities and property right issues which are frequently arise in economics activities. Other applications of DEA in public sectors are voluminous (see Emrouznejad and Thanassoulis, 1996 for detail). In fact, in a relatively short period of time, DEA has become a powerful quantitative, analytical tool for measuring and evaluating performance (Cooper et al., 2002). This paper will attempt to use the DEA technique in line with CBA similar to Womer et al (2002), and to a greater extent with Färe et al., (1995) to assess the impact of ICM projects conducted in Indonesia.

DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis, or DEA for short, is a non parametric technique developed by Charnes, Cooper and Rhodes (1978). DEA is a novel approach to measure relative efficiency where there are multiple inputs and outputs available. It is based on a value free method because it is based on data available without taking into account judgment or preference from decision makers (Korhonen et al.,1998). Using DEA one can perform a comparative analysis of alternative policies and projects each in relation to the complete set of alternatives. These alternative policies, also known as Decision Making Units (DMU), are represented into associated inputs and outputs related to the activities. DMU is simply regarded as an entity responsible for converting inputs into outputs and whose performances are to be evaluated (Cooper et al 2002). In the original sense, DEA is used to measure the relative efficiency performance of these decision making units. In terms of cost benefit analysis, costs are analogous to inputs and benefits are analogous to outputs.

The structure of DEA is written as follows. Let there are n DMUs to be evaluated, and let DMU_j to be evaluated be designated as DMU_o, where o ranges over 1,2,...n, then DEA basically solves the optimal values of input weights (v_i) (i=1,...,m) and output weights (u_r) (r=1,...,s) as variables. The formulation is written as:

$$\max \theta = \frac{u_1 y_{1o} + u_2 y_{2o} + \ldots + u_s y_{so}}{v_1 x_{1o} + v_2 x_{2o} + \ldots + v_m x_{mo}} = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}}$$

subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \text{ for } j = 1\ldots n \qquad (1.1)$$

$$v_i \geq 0 \text{ for } i = 1\ldots m, \quad u_r \geq 0 \text{ for } r = 1..s$$

Equation (1.1) states that the efficiency of target unit will be maximized subject to the ratio of weighted output over weighted input is less than 1. The weighted variation and are calculated optimally by means mathematical programming. One thing to note, however,that DEA formulation, which is described in equation (1.1) is in the form of fractional equation. Hence, to be able to be analyzed by linear programming, the formulation should be transformed into a linear form as described by the following equation:

$$\max \theta = \mu_1 y_{1o} + \mu_2 y_{2o} + \ldots + \mu_s y_{so}$$

subject to.

$$\nu_1 x_{1o} + \nu_2 x_{2o} + \ldots + \nu_m x_{mo} = 1$$

$$\mu_1 y_{1j} + \mu_2 y_{2j} + \ldots + \mu_s y_{sj} \leq \nu_1 x_{1j} + \nu_2 x_{2j} + \ldots + \nu_m x_{mj}$$

$$(j = 1, \ldots, n)$$

$$\nu_1, \nu_2, \ldots, \nu_m \geq 0$$

$$\mu_1, \mu_2, \ldots, \mu_s \geq 0 \qquad (1.2)$$

Equation (1.2) seeks solutions for maximizing efficiency of a target unit o subject to efficiency of other unit must be less than 1. The weighted variables m and n are solved numerically using linear programming as to maximize the efficiency target as large as possible.

Since DEA uses linear programming technique to solve for optimal weighted variables, it is sometimes more convenience to usedual approach to solve the same problem. This is due to the fact that linear programming allows us to use either primal or dual to find optimal solutions. Rewriting equation (1.2) in matrix form as:

$$\begin{aligned} &\max \; uy_o \\ &\text{subject to.} \quad vx_o = 1 \\ &\qquad -vX + uY \le 0 \\ &\qquad v \ge 0,\ u \ge 0 \end{aligned} \qquad (1.3)$$

Where u and v are vectors of weights variables, and are vectors of input and output, respectively.

The primal-dual correspondence of DEA can then be described in the following table:

Table 1. Primal-Dual Correspondence of DEA

Primal variable	Primal Constraint	Dual Variable	Dual Constraint
$v \ge 0$	$vx_o = 1$	θ	$\theta x_o - X\lambda \ge 0$
$u \ge 0$	$-vX + uY \le 0$	$\lambda \ge 0$	$Y\lambda \ge y_o$

Where $\lambda = (\lambda_1, \ldots, \lambda_n)^T$ is non negative vector (transposed):

Using dual variables defined above, the dual problem of DEA can be written as the following:

$$\begin{aligned} &\min \; \theta \\ &\text{subject to } \theta x_o - X\lambda \ge 0 \\ &Y\lambda \ge y_0 \\ &\lambda \ge 0 \end{aligned} \qquad (1.4)$$

or equivalently can be written as:

$$\begin{aligned} &\max \; \omega = es^- + es^+ \\ &\text{subject to} \quad s^- = \theta^* x_0 - X\lambda \\ &\qquad s^+ = Y\lambda - y_o \\ &\qquad \lambda \ge 0,\ s^- \ge 0,\ s^+ \ge 0 \end{aligned} \qquad (1.5)$$

where $e = (1,\ldots)$ is a vector of ones, s^- and s^+ are vectors of slack variables, and θ^* is the optimal objective value.

Modified DEA

All DEA formulations described above are dealing with the technical aspect or nonmonetary measurement of efficiency. In order to capture the monetary aspect of efficiency so that it can be used in cost benefits analysis, some variants of DEA models were developed. One of these models is additive model due to Cooper, Park and Pastor (1999). Given monetary unit of prices and costs, the additive model of DEA-CBA can be written as:

$$\begin{aligned} &\max \sum_{r=1}^{s} p_r s_r^+ + \sum_{i=1}^{m} c_i s_i^- \\ &\text{subject to} \quad y_{ro} = \sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ \quad r = 1,\ldots,s \\ &\qquad x_{io} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- \quad i = 1,\ldots,m \\ &\qquad 0 \le \lambda_j, s_r^+, s_i^- \quad \forall i, j, r \end{aligned} \qquad (1.6)$$

Defining

$$\begin{aligned} s_r^+ &= y_r - y_{ro} \\ s_i^- &= x_{io} - x_i \end{aligned} \qquad (1.7)$$

As slack variables, the objective equation (1.6) can then be modified as:

$$\begin{aligned} &\max \left(\sum_{r=1}^{s} p_r y_r - \sum_{i=1}^{m} c_i x_i \right) - \left(\sum_{r=1}^{s} p_r y_{ro} - \sum_{i=1}^{m} c_i x_{io} \right) \\ &s.t \quad y_{ro} = \sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ \quad r = 1,\ldots,s \\ &\qquad x_{io} = \sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- \quad i = 1,\ldots,m \\ &\qquad 0 \le \lambda_j, s_r^+, s_i^- \quad \forall i, j, r \end{aligned} \qquad (1.8)$$

Equation (1.8) is familiar to the economist. It simply represents the difference between benefits and costs associated with different DMUs. In absent of unit price data, equation (1.8) can be used as a Cost-Efficiency Analysis of CBA. It can now be seen that DEA can not only deals with technical aspect of efficiency, but also the economic aspect of efficiency as well. Therefore, the DEA has potential to overcome the shortcomings of the traditional cost benefit analysis. In fact, as Womer et al (2002) argued that there is strong believe to use DEA formulation as method for cost-benefit analysis.

DESCRIPTION OF STUDY AREA

Cilacap is a coastal area located in the southern coast of Central Java. It is in the border between West and Central Java. Cilacap was chosen for the study since this area is one of areas under Indonesia's Integrated Coastal Management projects. The government of Indonesia, through the interior ministry along with other agencies has allocated budget to develop an integrated management plan for sustainable use of coastal resources in this area. In particular, a 51 700 ha of Segara Anakan (a lagoon located in coastal area of Cilacap), is the main concern for the project since the ecosystem of marine estuarine and upland is strongly interrelated. In addition, the 24,000 ha of mangrove forest located in the estuarine is considered as the largest single stand mangrove remaining in Java. The interaction of mangrove forest ecosystem with that of lagoon make the lagoon enriched with resources such as shrimp and fin fish. Given this unique ecosystem and high value of shrimp and fish, it is not surprising that fisheries activities play an important role in local economy, especially for people residing in the Segara Anakan area.

In 2001, the economic value for fisheries was estimated to be more than US$ 8 million (Dudley, 2002), while aquaculture (brackish water pond) contributed to more than Rp 20 billion or equivalent to US$ 2 million (Cilacap Fisheries Agency, 2002). With the largest standing forest in Java, mangrove forest has also been subject to economic activity for Segara Anakan residents, it is estimated that firewood industry from mangrove forest has generated to more than Rp 87 million (or equivalent to US $ 10000 annually). Some parts of Segara Anakan (more than fifty percent of the area) were allocated for agriculture. An estimated of five ton of rice production per Ha, which is equivalent to 750,000 t of rice, has been produced worth of Rp. 225 billion or equivalent US $ 2.2 million.

Since mid 1980s, Segara Anakan was chosen for the ASEAN-USAID CRMP project. Through the CRMP Project funded by USAID, the government of Indonesia via the Ministry Home Affairs attempted to address those issues described. With huge amounts of fund allocated for the project, backed up by regional state budged (APBD), the project was implemented in three phases. The first four year project (1986-1990) was aimed to develop and implement coastal resources and their environment through an integrated and sustainable approach. The activities of this project included (ASEAN/US CRMP, 1992):

- Analyzing, documenting and disseminating information on trends in coastal resources development
- Increasing awareness of the importance of CRM policies and identifying, and where possible, strengthening existing management capabilities
- Providing technical solutions to coastal resource-use conflicts
- Promoting institutional arrangements that bring multisectoral planning to coastal resources development.

Several issues are identified with respect to coastal management in Segara Anakan. These include resource exploitation, declining environmental quality and institutional problems. Reports from various sources indicate that there was tremendous decline in mangrove forest area. It is estimated that as much as 1,454 ha of mangrove forest has been converted to various uses, such as fish pond, farm land and agriculture. In terms of fishery resources, there is strong evidence that catch per unit effort both from lagoon and offshore areas are declining. This declining in catch, to a large extent was attribute to deforestation of mangrove in the area. With regard to declining of environmental quality, pollution and sedimentation problems are the most common threat for Segara Anakan area. Upland activities along Citanduy river basin area has resulted in accelerating the sedimentation process in the lagoon. Consequently this will affect the primary fisheries production as well as threat to other rare and endangered species.

In terms of institutional concern, the major problem identified by ASEAN/US CRMP report was lack of coordination and communication among government agencies. In addition, there seems significant overlapping function and authority with regard to the management of Segara Anakan. The report also identified that there are disputes over land ownership in the area. This is due to unclear property rights. For example, local residence claimed their right to occupy the area based on "hukum adat" or customary law, while several agencies such as Perhutani claimed their right based on formal laws.

In addition to the project above, through a loan from Asian Development Bank (ADB), the Segara Anakan Conservation and Development Project (SACDP) was initiated in 1997. The project which will be terminated in 2002 was aimed to develop and to conserve the lagoon ecosystem so that it will yield social and economic benefits both for current and future generations. The project has three components viz:

- Component A dealing with water resource management and sedimentation under auspices of the department of public works
- Component B dealing with community development
- Component C dealing with capacity building

One thing is clear from the project however, the economics impact to the society is hard to be materialized. Even though a socio economic study conducted by a team from Sudirman University on the benefits of SACDP indicated that the majority of people in Segara Anakan area answered positively on the perception of the project, the team admitted that it was quite difficult how such benefits were realized (Dirjen Bangda dan UNDIP, 1998). The report indicated that the project was benefited only in terms of increasing people mobility (the village road in better condition) and sanitation, but none was said the economic benefits derived from improving resource condition.

As one can see from the report mentioned above, continuing declining catch from fisheries which can be translated into declining income per capita of the fishermen, has been persisted in the area. A study by Duewel (1994), for example, revealed that average monthly fishing income of Segara Anakan resident was about Rp 159,708. This level of income is 73% lower than that of 5-10 years ago. If this level of income was translated into income per capita, the level would even be lower than the poverty threshold set out by the government. Even though income from fishing is subject to several factors affecting fishing activities, it can be assumed that activities generated by the project will either directly or indirectly affect the coastal economic activity in the Segara Anakan area. Other indicators that can be used to measure the impact of the project are how efficient the economic sectors perform before and after the project were implemented. Hence, contrary to the traditional Benefit-Cost Analysis, this paper will attempt to measure the impact of the project not only through the measurement of monetary units, but also through physical units such as productivity of economic sectors in the coastal area.

DEA OF THE ICM PROJECT IN CILACAP

For the purpose of the analysis, the coastal economic activities in Segara Anakan area disaggregated into three major components, which are fisheries, aquaculture and forestry. Since not all sectors data are available, the analysis is limited to the fishery activity in the lagoon area. The forestry activity, represented by mangrove exploration, was embedded into fishery of the lagoon. In the first part, analysis is based on productivity which is measured in terms of the ratio of inputs to outputs. To some extent this technique is inline with the traditional DEA approach. In this study, however, we modified the traditional approach by incorporating time period as DMUs. Thus, while traditional DEA is static in nature, this modified DEA could be seen as "dynamic" in a sense that it allows trajectory of DMUs to be evaluated. This type of technique has been used by Dinc and Haynes (1999). Our approach, therefore follows theirs. The objective of this stage is to measure the economic efficiency of the sector affected by project activities. The reason is clear, if the project is beneficial for people residing in the area, it should be reflected in the improvement of their productivity. Improvement in productivity could be triggered either by improvement in resource condition or improvement in their production process. This effect is embedded in ratio of input and output used in the production process. In the second part of the analysis each output from sectors is converted into monetary units. This in fact represents the economic value generated by sectors which can be assumed as the benefits accrued to the sectors. The input component of the second stage is the unit cost associated with alternative use of coastal resources such as the cost of conversion, cost of fishing, and the cost of mangrove forest extraction. A modified DEA technique is used in this second stage. The result from the first and the second stage are then compared to assess the benefit and cost of the ICM Project in the area.

DEA OF SEGARA ANAKAN FISHERIES

To assess the benefit of the ICM project in terms of non-monetary unit, the fishery of Segara Anakan was chosen as a unit analysis. A time series of analysis of catch and effort were analyzed. The data were derived from various sources. Due to disagreement in the magnitude of the data, especially after period of 1988, some extrapolations were then used. The results of the extrapolations were re-verified with various reports for consistency. The first stage of the CBA-DEA analysis was employed to assess the productivity of fishery in Segara Anakan using shrimp and fin fish productions as output units while the total number of trip exerted to the fishery was used as unit input. Results of the CBA-DEA analysis of stage one are depicted in the following Tables and Figures (Tabel 2).

As we can see from Table 2 and Figure 1, higher efficiency scores were achieved in the later period of 1990s while lower efficiency scores occurred in early periods (1970s and 1980s) as well as early 2000. This indicates, that in general, the Coastal Management Projects, in particular to that of Segara Anakan were benefited in terms of fishing productivity in relatively short term periods (1987, 1990 and 1994). These benefits, however, were not secured sustainably since at the following periods (1995 onwards) the productivity of fishery of Segara Anakan in term of productivity were declining.

Table 2. DEA Scores for Non Monetary Unit

No.	DMU	Score	Rank	Reference set (lambda)			
1	1976	0.559984	15	1987	0.794754	1990	3.70E-02
2	1977	0.857695	4	1987	0.788979	1990	4.26E-02
3	1978	0.524573	17	1987	0.785139	1990	0.046266
4	1979	0.237831	22	1987	0.779985	1990	5.12E-02
5	1980	0.145942	25	1987	0.889899	1990	0.065697
6	1981	0.173076	24	1987	0.89055	1990	6.51E-02
7	1982	0.181874	23	1987	0.899606	1990	5.64E-02
8	1983	0.292613	20	1987	0.898885	1990	5.71E-02
9	1984	0.277235	21	1987	0.979167		
10	1985	0.352418	19	1987	0.92438	1990	5.26E-02
11	1986	0.481419	18	1987	0.943416	1990	0.054321
12	1987	1	1	1987	1		
13	1988	0.653846	12	1990	0.437736	1994	0.522264
14	1989	0.604799	14	1990	0.142938	1994	0.817062
15	1990	1	1	1990	1		
16	1991	0.737852	11	1994	1		
17	1992	0.821545	8	1994	1		
18	1993	0.84347	5	1994	1		
19	1994	1	1	1994	1		
20	1995	0.842571	6	1990	0.374479	1994	0.625521
21	1996	0.790597	9	1990	0.226294	1994	0.773706
22	1997	0.823452	7	1990	0.350491	1994	0.649509
23	1998	0.738224	10	1990	0.427828	1994	0.532172
24	1999	0.624278	13	1990	0.544653	1994	0.415347
25	2000	0.551255	16	1990	0.346512	1994	0.613488

Figure 2 describes the trajectory of efficiency of non monetary unit during period of observation. As can be seen from Figure 1, upward movement in efficiency occurred during 1980s to mid 1990s, with a fluctuation in between. After period of 1994, however, there is a declining trend in efficiency scores which indicate that there is declining of non-monetary benefits derived from Segara Anakan fisheries

The following table describes the potential improvement of non-monetary benefits for the fishery in Segara Anakan. As we can see from the table, there is little room for improvement in productivity or increasing secured benefits of the lagoon, after mid 1990s. This indicates that achieving sustainable production after this period is relatively difficult. This result is in line with various reports of Segara Anakan fishery which

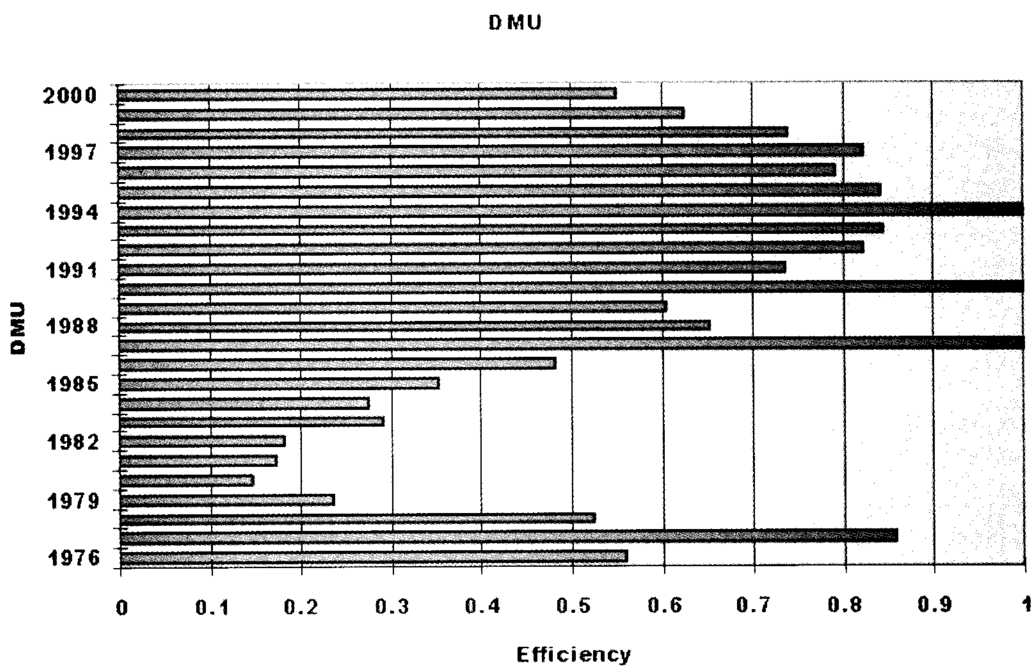

Figure 1 Bar Chart of DMU Scores

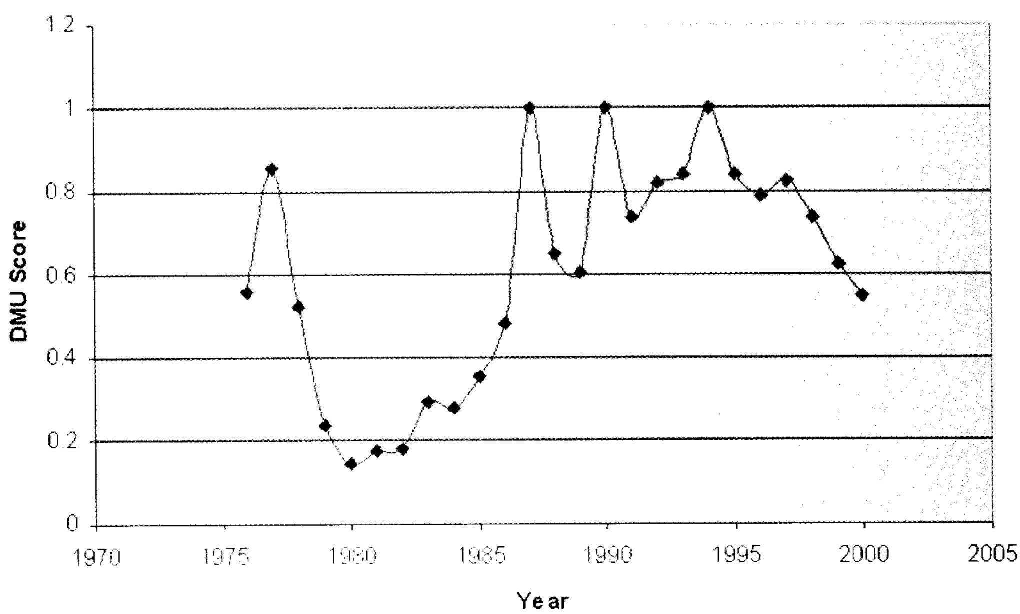

Figure 2. Trajectory of DMU score for non-monetary benefit

Table 3. Projection of Potential Improvement of Non-Monetary Benefits

No.	DMU I/O	Score Data	Projection	Difference	%
1	1976	0.559984			
	Effort	200	200	0	0.00%
	SP	432	771.4508	339.4508	78.58%
	FP	232	414.2977	182.2977	78.58%
2	1977	0.857695			
	Effort	200	200	0	0.00%
	SP	661	770.6699	109.6699	16.59%
	FP	356	415.0658	59.06581	16.59%
3	1978	0.524573			
	Effort	200	200	0	0.00%
	SP	404	770.1509	366.1509	90.63%
	FP	218	415.5765	197.5765	90.63%
4	1979	0.237831			
	Effort	200	200	0	0.00%
	SP	183	769.454	586.454	320.47%
	FP	99	416.262	317.262	320.47%
5	1980	0.145942			
	Effort	230	230	0	0.00%
	SP	129	883.9143	754.9143	585.20%
	FP	70	479.6434	409.6434	585.20%
6	1981	0.173076			
	Effort	230	230	0	0.00%
	SP	153	884.0024	731.0024	477.78%
	FP	83	479.5568	396.5568	477.78%
7	1982	0.181874			
	Effort	230	230	0	0.00%
	SP	161	885.2268	724.2268	449.83%
	FP	87	478.3524	391.3524	449.83%
8	1983	0.292613			
	Effort	230	230	0	0.00%
	SP	259	885.1293	626.1293	241.75%
	FP	140	478.4483	338.4483	241.75%
9	1984	0.277235			
	Effort	235	235	0	0.00%
	SP	253	912.5833	659.5833	260.70%
	FP	127	480.7708	353.7708	278.56%
10	1985	0.352418			
	Effort	235	235	0	0.00%
	SP	319	905.1762	586.1762	183.75%
	FP	172	488.0574	316.0574	183.75%
11	1986	0.481419			
	Effort	240	240	0	0.00%
	SP	445	924.3498	479.3498	107.72%
	FP	240	498.5257	258.5257	107.72%
12	1987	1			
	Effort	240	240	0	0.00%
	SP	932	932	0	0.00%
	FP	491	491	0	0.00%
13	1988	0.653846			
	Effort	240	240	0	0.00%
	SP	340	520.0001	180.0001	52.94%
	FP	510	780.0002	270.0002	52.94%

continued ....

No.	DMU I/O	Score Data	Projection	Difference	%
14	1989	0.604799			
	Effort	240	240	0	0.00%
	SP	220	363.757	143.757	65.34%
	FP	525	868.0565	343.0565	65.34%
15	1990	1			
	Effort	250	250	0	0.00%
	SP	830	830	0	0.00%
	FP	650	650	0	0.00%
16	1991	0.737852			
	Effort	250	250	0	0.00%
	SP	130	300	170	130.77%
	FP	700	948.7	248.7	35.53%
17	1992	0.821545			
	Effort	250	250	0	0.00%
	SP	146	300	154	105.48%
	FP	779.4	948.7	169.3	21.72%
18	1993	0.84347			
	Effort	250	250	0	0.00%
	SP	141	300	159	112.77%
	FP	800.2	948.7	148.5	18.56%
19	1994	1			
	Effort	250	250	0	0.00%
	SP	300	300	0	0.00%
	FP	948.7	948.7	0	0.00%
20	1995	0.842571			
	Effort	250	250	0	0.00%
	SP	420	498.4741	78.47407	18.68%
	FP	705.1	836.843	131.743	18.68%
21	1996	0.790597			
	Effort	250	250	0	0.00%
	SP	332	419.9357	87.9357	26.49%
	FP	696.6	881.106	184.506	26.49%
22	1997	0.823452			
	Effort	250	250	0	0.00%
	SP	400	485.7602	85.7602	21.44%
	FP	695	844.0084	149.0084	21.44%
23	1998	0.738224			
	Effort	240	240	0	0.00%
	SP	380	514.7487	134.7487	35.46%
	FP	578	782.9599	204.9599	35.46%
24	1999	0.624278			
	Effort	240	240	0	0.00%
	SP	360	576.6661	216.6661	60.19%
	FP	467	748.0641	281.0641	60.19%
25	2000	0.551255			
	Effort	240	240	0	0.00%
	SP	260	471.6511	211.6511	81.40%
	FP	445	807.249	362.249	81.40%

indicate a declining trend of the fishing production in the area. For example, report from Roesmidi (1998) said that there was tremendous decline in the fishery production (shrimp and fin fish) from 1992 till 1996 for about 300%.

MONETARY MEASUREMENT

As mentioned above, the importance of Segara Anakan ecosystem lies not only in its ecological function but also in its economic benefits that could be derived from the ecosystem. It is also acknowledge that from economic interest, the most common argument for the management concern of the Segara Anakan is the link between mangrove forest surrounding the area and the fishery resources in the lagoon. Recent figures indicate that the economic benefits that could be derived from the area are quite significant to the economy of the regency of Cilacap. The following Table describes the potential benefits that could be secured had the Segara Anakan managed sustainably.

It is worth noting, however, that the economic benefits derived above should be interpreted with caution. The economic benefits secured could be higher or even lower than the figures above due to the following reasons. First, the benefits do not include the non-use values of the resources derived from Segara Anakan, since no appropriate economic valuation had been applied for the area so far. Second, as acknowledged by Dudley (2002), the value is only an approximation (rough estimates) since no data available for detail calculation. For example, one has to estimate demand function for the goods and services derived from Segara Anakan to include the benefits secured by consumers as a whole. To do this analysis, however, it requires a complete panel data, which is not easily available. Third, the benefits must be weighted against resource degradation which has been occurring in the Segara Anakan area. This would require a complete resource accounting which, perhaps, was not the priority of the CRMP in the area during the period of the project.

To secure the benefits from coastal resource projects such as Segara Anakan, however, is not a cost. The local as well as national government has spent substantial amounts to ensure better imple-

Table 4 Potential economic benefits of Segara Anakan

Type of Benefit	Benefit /ha (US$)	Total benefit of the area (US$)	Other benefit
Fishery[a]: • From lagoon • From mangrove	 $1,996 $1,376	 $2.8 million $5.5 million	$150,000[c]
Mangrove[b]: • Direct use	$107.78	$907,020	

Note:
a. Derived from Dudley (2002)
b. from Anonymous (1992) and Miftah (2002). This value includes the use of mangrove for woodchips and logs. The value was adjusted to the current currency conversion.
c. This benefit is attributed to the tax levied by the local government from the fishery

Table 5 Costs component of Segara Anakan Management

Cost component	Cost/ha (US$)[a]	Total cost (US$)
Mangrove rehabilitation	$436	$66,490
Mangrove preservation	$40.5	$28,350
Seedling	$67.32	$13,632
Dredging	$18,684	$9.8 million[b]
Other cost[c]	Na	$66,746

Note: a) Source BPKSA (2002) adjusted by current conversion rate
b) This is not yearly cost, rather the cost of over period of dredging (approximately 3 years)
c) Administrative costs which include management cost and operational cost of management office of Segara Anakan

mentation of CRMP in Segara Anakan. At a micro level, it would require substantial management and rehabilitation costs to achieve a healthy Segara Anakan, so that the potential economic benefits described above could be sustained. The following are the costs associated with such a concern.

As can be seen from Table 3 and Table 4, direct comparison reveals that there is potential surplus from Segara Anakan. If we take dredging cost of approximately US$ 3.2 million per year, then the total benefits secured from Segara Anakan exceed the total costs allocated for managing the area. A surplus of approximately US$ 4.4 million could be secured. Whether this surplus could be sustained, however, is questionable. One could argue that if the costal management programs, as outlined in Segara Anakan Conservation and Development Project (SACDP), were implemented successfully. These potential surpluses could be sustained.

Another way of looking at how the benefit would be sustained in the future is by analyzing it using cost-effective analysis. This approach basically tries to determine which component of costs that would sensitive to the sustainability of the benefits. To employ this approach, a modified DEA as outlined in the previous section (equation 1.8) was used to assess the cost-efficiency of the Segara Anakan Management Project. Data from Table 3 and 4 were used for the purpose of the analysis. Four alternatives of management costs i.e., controlling sedimentation, mangrove rehabilitation (mangroveG), mangrove preservation (mangroveB), and dredging were chosen as DMUs. All unit costs were normalized to 1, so the unit is US$ thousand. Data from Table 3 were also combined with production of shrimp and finfish from Segara Anakan. The solution for this problem was found using mathematical programming by means of DEA-Solver. After eleven simplex iterations, the results are depicted in the following Tables and Figures.

As can be seen from Table 5 and Figure 3 , cost efficiency scores could be achieved for sediment control and dredging. Translating this into the benefit, the sustainable benefit could be achieved had these two alternatives been given priority in coastal management of Segara Anakan. Results also indicates that even though the link between mangrove and fisheries in lagoon is very important, mangrove preservation has low score of cost efficiency. That is, given the relatively wide area of mangrove, the costs allocated to this program could have been made more efficient to achieve sustainable benefits. Perhaps, it is too simplistic to say that based on this result alone, one could argue that mangrove management at current condition did not achieve the goal of sustainable lagoon management. Given a relatively long period of time for the ecosystem to recover from resource degradation due to mangrove overextraction, the benefits of mangrove programs might take longer period of time to be ma-

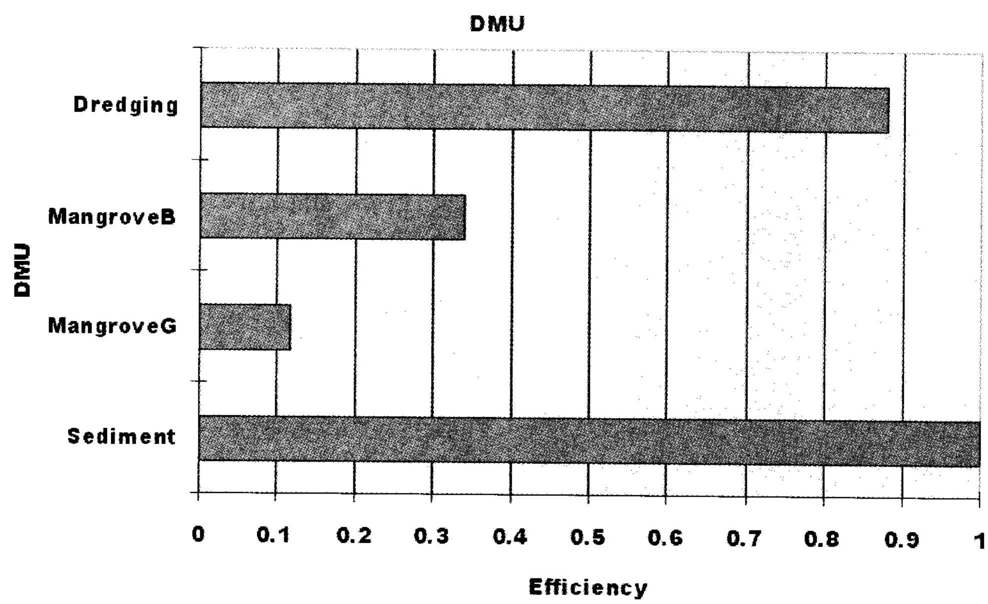

Figure 3 Bar Chart of Cost-Efficiency DEA scores

terialized. The mangrove program could be made more efficient, therefore, yield higher benefits to the lagoon fishery if the unit costs of the program could be reduced. As can be seen from Table 6, there is potential improvement of cost-efficiency if cost per unit of dredging could be reduced as much as 12% while that of mangrove program could be reduced by 66 to 88% of the current level. This could be achieved, for example, by prioritizing the mangrove management program adjacent to lagoon so it reduces the unit cost per ha while at the same time ensuring the short term benefits that could be achieved from the fishery lagoon.

Table 6 DEA Scores for Monetary Unit

No	DMU	Score	Rank	Reference set (lambda)	
1	Sediment	1	1	Sediment	1
2	MangroveG	0.117435	4	Sediment	1.333333
3	MangroveB	0.338217	3	Sediment	1.5
4	Dredging	0.879365	2	Sediment	0.833333

CONCLUSION

Assessing the sustainability of ICM projects in terms of its economic dimension is a indeed difficult and challenging exercise. This paper, however, has illustrated the use of Data Envelopment Analysis as a means of performing such a task. Even though there are limitations that hinder the full scale application of benefit cost analysis of costal projects, the simple approach which is used in this paper has demonstrated the potential usefulness of such an approach in the future when data availability becomes constraints. Contrary to the traditional approach of CBA in which Dorman's argued about its three prominent shortcomings, the DEA model of CBA used in this analysis could serve as an alternative means of assessing the benefits of coastal projects.

In terms of findings from this paper, the general conclusion is that the secured benefits derived from ICM project in the study area could not be said to be sustainable judging from the performance

Table 7 Projection of potential improvement in cost efficiency

No	DMU Score I/O Data	Projection	Difference	%	Unit cost	Cost change
1	Sediment	1				
	Cost 8620.24	8620.24	0	0.00%		
	Area 554	554	0	0.00%	15.56	0
	Prod 600	600	0	0.00%		
2	MangroveG	0.117435				
	Cost 254745	29916	-224829	-88.26%		
	Area 6290	738.6667	-5551.33	-88.26%	40.5	-224829
	Prod 800	800	0	0.00%		
3	MangroveB	0.338217				
	Cost 1236657	418258.9	-818398	-66.18%		
	Area 2457	831	-1626	-66.18%	503.32	-818398
	Prod 900	900	0	0.00%		
4	Dredging	0.879365				
	Cost 9809100	8625780	-1183320	-12.06%		
	Area 525	461.6667	-63.3333	-12.06%	18684	-1183320
	Prod 500	500	0	0.00%		

of non-monetary indicators during 25 years of observation, as well as from monetary indicators. Further limitation of input exerted to the fishery in the area, could, in the future, increase the total benefits of the ecosystem. Similarly, engaging a cost-efficient mechanism for the management of Segara Anakan, would undoubtedly sustain the benefits derived from the ICM project.

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