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Socio-economic and ecological impacts of coral reef management in Indonesia

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Abstract

The destruction of coral reefs occurring within the last decades has attracted a great attention of Government of Indonesia by implementing a programme called coral reef rehabilitation and management programme (COREMAP). This paper is intended to assess the impacts of the programme on the welfare of local people and on the ecological condition of the coral reef. The research findings indicate that the programme does not appear to be able to increase the households' welfare substantially as well as to improve the ecological condition of coral reef so far. However, since the implementation of the programme a reduction of detrimental tendencies can be observed as a result of (1) the participation of the local people in law enforcement activities and (2) the development of environmentally sound additional sources of livelihood.

Introduction

Indonesia, an archipelagos nation composed of 17,508 islands, has the world's second longest coastline, stretching over 81,000 km (Jameson et al., 1995). The marine area amounting 75% of the total Indonesian territory encompasses about 3.1 million km² and about 75,000 km² of the area are covered by coral reefs. Coral reefs in Indonesia are extensive and represent the most significant reef resources in Southeast Asia. They are of critical importance as a centre of marine biodiversity in there exist 75 genera and 350 known species of stony coral (COREMAP, 1998). In good condition, the sustainable harvest of coral fisheries is averagely 20mt km² yr⁻¹ (Soekarno et al., 1995). As a fish-habitat, tourism-attraction, and natural protection function the value of Indonesian coral reef is USD 70,000 km² yr⁻¹ so that the total value of the Indonesian reefs is about USD 4.2 billion (Republika, 22-12-1999).

However, the condition of coral reefs in most part of Indonesia is very apprehensive due to a substantial deterioration and destruction occurring within the last few decades. From 324 observation stations consisting of 129 stations in the western part and 195 in the eastern part of Indonesia show that only 6.48% of Indonesian coral reefs are in excellent condition while most of them (70%) are in fair and poor condition (Suharsono, 1995). This condition is caused mostly by man-made induces (anthropogenic) including dredging stone and sand for construction industry and coral mining for lime production

or rock extraction; destructive fishing practices such as poisoning, blast fishing, muro-ami, spear fishing; coral collection; and side effect from tourism including anchor throwing, coral trapping during diving trip, (Jameson et al., 1995; Cesar, 1996). In addition, other induces as a result of human activities include sedimentation, industrial and household sewage, thermal pollution, hydrocarbon, pesticide, radio active substances, and eutrophication which is caused by fertilized agricultural land and by the discharge of domestic sewage and industrial effluents (Mc Manus, 1995).

The situation becomes worse due to the absence of an appropriate management, poor enforcement capacity, ineffectiveness of awareness program, lack of defined user rights over coastal area, overlapping institutional mandates, lack of sound environment alternative of livelihood, and other external potentials.

Understanding the situation, with support from several international donors Government of Indonesia has established a project called 'Coral Reef Rehabilitation and Management Programme (COREMAP)'. The implication of the program on the socio-economic condition of local people as well as the ecological condition of coral reef has not been much known. This study, therefore, is intended to investigate and analyse the impact of the project on the household welfare of local people and the ecological condition of coral reef in the project site.

Methodology

This study was carried out in Gili Air Lombok Indonesia and the fieldwork took place in 1999. The unit analysis of the study is household, which is defined as a group of people living within one compound who usually share in common of household food and whose present, or temporarily absent, working members contribute to the income of the household (BPS, 1993). Data used in the analysis were collected using structured questionnaire and in-depth interview techniques. The respondents of the study included participants and non-participants living in the island where the programme was being implemented. The non-respondents were used as a control group which was intended to undertake the problems of counterfactual outcome. The number of respondents was 106 household comprising 29 participants and 77 non-participants.

The data was analysed using cross-tabulation (with chi-square test) and Heckman Model. Cross-tabulation analysis combined with chi-square tests was used to describe the *bivariate* relationship between program intervention and household welfare indicators as response variable. The level of significant relationship used in the analysis is 90% ($\alpha \leq 0.10$). Cross-tabulation accompanied with chi-square can only measure the strength relationship among variables but does not measure to what extent programme affect household welfare. In addition, the analysis does not control for the influence of other variables characterizing the households. Therefore, the Heckman model, an econometric model, is employed in order to be able to assess specific impact of programme after controlling for the effect of other variables (Zaini, 2000; Zaman, 2000).

General model of Heckman two-stage procedure could be formulated as follows:

$$\text{Household welfare (Y)} = f(\text{Xi, PARTICIP}) \quad (\text{Equation i})$$

$$\text{Predicted Probability of Participation (P}^*) = f(\text{Xi}) \quad (\text{Equation ii})$$

$$\text{Household welfare (Y)} = f(\text{Xi, P}^*) \quad (\text{Equation iii})$$

Equation (i) states that household welfare (Y) relies on participation in the programme, a set of variables (Xi), and random error term (E). Equation (ii) states that probability of participation in the programme relies on a set of variables (Xi) and random error term (E). Equation (iii) states that household welfare depends on the predicted probability of participation (P^*) (from equation ii), a set of variables (Xi), and random error term (E)

Meanwhile, the ecological condition of coral reef is measured through the trend of living coral cover during 1996-1999. The methods of data collection include transect permanent and manta tow (rapid assessment method)

Socio-economic Impacts of the Programme

Bivariate Analysis

It is very important to examine the relationship between participation in COREMAP program with household welfare, which supposedly reveals the level of association between those variables. In this analysis the welfare of household will be represented by two variables including level of income and per capita income. Income as an indicator of household welfare is a very significant indicator of the project achievement. One of the program goals is of course to increase the income level of household participant in order that the households can live properly and acceptably in their community.

Level of income assessed in this section points to the income earned by household and it has been calculated by summing all household members revenue during one year (July 1998-June 1999). By using five categories of income (quintiles) it is obvious that according to the result of chi-square estimate and level of significant test shown in table 1 there is a significant statistical relationship between participation in the program and level of household income in 92% level of significant. Although the different between participants and non-participants in term of income level is statistically significant it is imperative to verify if the income level of participants is caused by their participation in the COREMAP program. Therefore, the multivariate analysis will be employed in the next section to make sure the cause of the level of household income.

Table 1 Participation in COREMAP Program by Level of Income (%)

Participation in COREMAP	Household Income Level					Total
	Lowest	Low	Moderate	High	Highest	
Participants	31.0	13.8	6.9	27.6	20.7	100
Non-Participants	15.6	20.8	27.2	16.9	19.5	100
Total	19.8	18.9	21.7	19.8	19.8	100
Chi-Square	8.348					
Sig. (2-sided)	0.080					

Source: Author own survey 1999.

The association assessment of per capita income with participation in COREMAP programs is intended to detect the incident of poverty among participants and non-participants. The poverty level is measured by comparing the annual household income divided by the household size resulting income per capita per year with the poverty line. Poverty line refers to the level of well being which makes it possible for a person or household to live acceptably in a given community (BPS, 1999). In this respect, according to Sayogyo, the poverty line has been set at the value money, which is equal to the price of 320 kg rice per capita per year. It means that a person who earn more than those value is categorized as not poor (Dyson, L: 1995). The price of 320 kg of rice was Rp 512,000,- in 1999 in which the price of 1 kg rice in that time was Rp 1,600,-.

Therefore, the poor households are those whose income are equal or below to the value of the poverty line.

In contrary with income level, the participation in the COREMAP program has no considerable statistical relationship with per capita income indicated by the low value of chi-square estimate and the low level of significant. According to table 2, both participants and non-participants mostly have per capita incomes above the poverty line and also the incident of poverty occurs amongst both parties (participants and non-participants).

Table 2 Participation in COREMAP Program by Per Capita Income (%)

Participation in COREMAP	Per Capita Income		Total
	Below Poverty Line	Above Poverty Line	
Participants	10.3	89.7	100
Non-Participants	15.6	84.4	100
Total	14.2	85.8	100
Chi-Square			0.476
Sig. (2-sided)			0.490

Source: Author's own survey 1999.

Determinants of Household Participation in COREMAP Program

The regression analysis has indicated several variables as significant determinants of participation in the program based on estimated coefficient and significant level. Table 4 shows that among three variables represented the demographic aspects of household - household size, age and origin of household heads - only household size is a significant determinant of household participation in the program. The larger the household size, the more likely it is to participate in the program. If the household size increases by 10%, then the probability of the household to involve in the program increases by 3.9%.

The other two variables – origin and age of household heads – are not significant determinants of the household participation in the program at 10% of standard error, but it is significant at 13% especially for origin of household heads. There is a tendency that the household heads born in the island are more likely to take part in the program than those born in outside the island.

The area of house floor is a significant determinant of household participation in the program. The larger area of house floor that household has, the less likely it is to participate in the program. Area of house floor is a clear indication of the household prosperity although almost all of the houses construction in the island is similar i.e. stilt house. The larger area of house floor it has, the higher level of household welfare is. It is understandable since one of the program aims is to help poor household to improve their welfare, therefore, the better-off households are less likely to involve in the program.

By using variable SERVICE (service as main occupation of household head) as benchmark, the multivariate analysis shows that main occupation of household head is not a significant determinant of household participation in the program. However, there is an indication that households engaged in agriculture activities are less likely to take part in COREMAP program than those engaged in fishery and service activities.

Tabel 3 Descriptive statistics of variables used in the analysis (n = 106)

Name of Variable	Definition	Mean	Standard deviation
INCOME	Total annual income of household	4800283.02	2878835.15
POOR	Household probability of not being poor, 1 = not poor; 0 = poor	0.8585	0.3502
PARTICIP	Household participation in COREMAP Programme, 1 = participates; 0 = no	0.2736	0.4479
PPARTICIP	Predicted value of PARTICIP	0.27358	0.28013
<i>Demographic Aspects</i>			
AGE	Age of household head	38.11	11.84
HSIZE	Size of Household	4.51	1.67
ORIGIN	Household head place of birth, 1 = in the island; 0 = outside the island	0.7642	0.4265
<i>Economic Aspects</i>			
HFLOOR	Area of house floor	30.02	17.99
FISHERY	Fishery as main occupation of household head, 1 = yes; 0 = no	0.3396	0.4758
AGRICULT	Agriculture as main occupation of household head, 1 = yes; 0 = no	0.1132	0.3184
SERVICES	Service as main occupation of household head, 1 = yes; 0 = no	0.5472	0.5001
<i>Social Aspects</i>			
NOEDU	Household head has had no education and not finished Elementary School, 1 = yes; 0 = no	0.5189	0.5020
SDEDU	Household head has finished Elementary School, 1 = yes; 0 = no	0.3868	0.4893
SMEDU	Household head has finished Secondary School, 1 = yes; 0 = no	0.0943	0.2937
SACTIVE	Number of Social Activity participated by household in the island	0.7358	1.0806
MOBILITY	Household head has left the island during the last three months, 1 = yes; 0 = no	0.5283	0.5016

Educational attainment of household heads is a significant determination of household participation in the COREMAP program until 88% of significant level. Using NOEDU as benchmark the results of multivariate analysis indicate that household heads who have finished elementary school or above are more likely to participate in the program than those who have had no education and not finished elementary school. The higher level of education attained by household head is, the more likely is he to involve in the program. It indicates that the willingness of educated person to take part in the program is higher than uneducated one.

Other evidences resulted from the analysis prove that social capital and mobility of households head are significant determinants of participation in the COREMAP program. It indicates that household with higher level of participation in social activity held in the island is more likely to participate in the program than those with lower level of participation in social activities. Likewise, household heads that leaved the island during the last three months are more likely to take part in the program than those lived in the island at the same time. It is clear that the program is more interesting for well-educated and mobile households than uneducated and immobile households.

Based on the analysis findings it is interesting to note that the better-off households are less likely to participate in the COREMAP program. In other sides, the household participants of the program have a tendency to be greater in term of educational

attainment, better social capital, wider slight, and more chances to involve in fishery and service activities. This indicates that the selection bias problem occurs in this respect since the aims of the program are to empower local people in order to be able to improve their life standard and their environment as well.

Table 4 Probability of Participation in COREMAP Program

Variables	Coefficient	Stand. Error	Significant
AGE	0.023	0.035	0.510
HSIZE	0.388	0.191	0.042
ORIGIN	1.405	0.934	0.132
HFLOOR	-0.048	0.026	0.070
FISHERY	0.802	0.704	0.255
AGRICULT	-2.093	1.340	0.118
SDEDU	1.208	0.771	0.117
SMEDU	2.506	1.295	0.053
SACTIVE	1.493	0.466	0.001
MOBILITY	1.436	4.874	0.027
Constant	-6.613	2.606	0.011

Notes: Dependent variable is PARTICIP (participation of household in the program). Number of observation: 106. Chi-square = 25.724. Significant = 0.012.

Impact of COREMAP Program on Household Income

According to the result of chi-square estimate and level of significant test discussed in previous section there is a significant relationship between household income and participation in the COREMAP program. However, it doesn't mean that the participants have higher income than non-participants although about 48% of participants have high and higher level of income while approximately 36% of non-participants have similar level of income. This result tells us solely that there is a different between participants and non-participants in term of income level based on the quintiles of household income. Besides, the result of cross-tabulation analysis explains the association between two variables without any interference from other variables. Therefore, the Heckman model will verify variables affecting the household income simultaneously by using regression technique.

The result of the analysis using participation in the program as a dummy variable (PARTICIP) gives the impression that participation in the COREMAP program has influenced household income with high level of significant until 99%. However, the result is overvalued comparing to the result of second analyses using predicted probability of participation (PPARTICIP) in which participation in the program has no significant effect on household income. Moreover, the both regression coefficients of variable PARTICIP and PPARTICIP are negative indicating that the participation of households in the program can reduce their household income. It indicates that the program has not been successful in improving the life quality of participants since it has no impact on the household income of participants whether the regression coefficient is positive or negative.

The influence of socio-economic aspect of household on household income will be analysed based on the result of regression analysis using PPARTICIP as independent variable. The demographic aspects, which have effect on household income, are only household size, while neither age nor origin of household head are significant

determinants of household income. The bigger the household size, the higher the household income.

Table 5 COREMAP Program and Household Income
(Predicted Probability of Participation as an Independent Variable)

Variables	Coefficient	Standard. Coefficient	Signif.
AGE	-24914.11	-0.102	0.383
HSIZE	488602.08	0.284	0.020
ORIGIN	239299.08	0.035	0.757
HFLOOR	50947.79	0.318	0.049
FISHERY	377905.29	0.062	0.518
AGRICULT	1093266.70	0.121	0.274
SDEDU	-675447.30	-0.115	0.323
SMEDU	1178328.40	0.120	0.367
SACTIVE	572876.14	0.215	0.435
MOBILITY	213925.84	0.037	0.765
PPARTICIP	-1473955.00	-0.143	0.632
Constant	1599469.4		0.383

Notes: Dependent variable is INCOME (Household Income). Number of observation: 106.
R-squared = 0.581 and adjusted R-squared = 0.338.

Table 6 COREMAP Program and Household Income (Participation as an Independent Variable)

Variables	Coefficient	Standard. Coeff.	Signif.
AGE	-24480.70	-0.101	0.361
HSIZE	522650.66	0.304	0.001
ORIGIN	339414.77	0.050	0.590
HFLOOR	46929.04	0.293	0.016
FISHERY	414881.26	0.069	0.437
AGRICULT	990076.57	0.109	0.250
SDEDU	-590914.80	-0.100	0.295
SMEDU	1387214.90	0.142	0.151
SACTIVE	739052.54	0.277	0.029
MOBILITY	338221.22	0.059	0.499
PARTICIP	-2251623.00	-0.350	0.001
Constant	1442522.40		0.376

Notes: Dependent variable is INCOME (Household Income). Number of observation: 106. R-squared = 0.644 and adjusted R-squared = 0.415.

Area of house floor is the only significant determinant of household income among the three considered economic aspects. Households with wider area of house floor have high household income. It means that area of house floor is one of the household wealth indicators in which the bigger the house floor, the wealthier is the household. Household cannot afford a big house if his income is not high enough. House is considered generally a symbol of economic and social status in most Indonesian communities. Besides, some of them use also their house as a workplace so that they require a big house.

By using PPARTICIP as independent variable all three variables indicating social aspects are not significant determinants of household income. The social capitals owned by households do not play any significant role in generating the households' income.

Impact of COREMAP Program on Household Poverty

The relationship between participation in the program and per capita income as discussed in the previous section is not statistically significant indicated by the value of

chi-square and level of significant test. Therefore, households participating in the COREMAP program have no probability to alleviate their poverty. After controlling for other variables, the result of regression analysis using either PARTICIP or PPARTICIP as independent variable still shows that participation in the program has no impact on the per capita income of household. It means that involving in the program cannot actually grant household to leave of poverty since the probability of not being poor is not determined by the participation of household in the program.

After controlling for selection bias problems (see table 7), the probability of not being poor is affected solely by household size at 10% of error level. Household with more members has bigger probability of dropping into the poor category. A 10% increase in household size reduces the probability of not being poor by 4.7%. In this situation, the household members are burden of household instead of providers of household necessities.

Table 7 Determinants of Probability of Not being Poor (Predicted Probability of Participation as an Independent Variable)

Variables	Coefficient	Stand. Error	Significant
AGE	-0.051	0.034	0.126
HSIZE	-0.470	0.285	0.099
ORIGIN	-1.031	0.940	0.273
HFLOOR	0.529	1.258	0.674
FISHERY	0.626	0.832	0.452
AGRICULT	2.060	1.385	0.137
SDEDU	-0.973	0.903	0.281
SMEDU	5.661	28.910	0.845
SACTIVE	-0.116	1.130	0.918
MOBILITY	-0.792	0.965	0.411
PPARTICIP	3.593	4.384	0.412
Constant	5.256	2.462	0.033

Notes: Dependent variable is POOR (Household probability of not being poor). Number of observation: 106. Chi-square = 14.303. Significant = 0.282.

Table 8 Determinants of Probability of Not being Poor (Participation as an Independent Variable)

Variables	Coefficient	Stand. Error	Signif.
AGE	-0.048	0.033	0.141
HSIZE	-0.292	0.184	0.112
ORIGIN	-0.589	0.780	0.450
HFLOOR	0.023	0.034	0.495
FISHERY	0.925	0.750	0.217
AGRICULT	1.676	1.301	0.198
SDEDU	-0.542	0.743	0.466
SMEDU	6.700	28.914	0.817
SACTIVE	0.783	0.679	0.249
MOBILITY	-0.137	0.659	0.836
PARTICIP	-0.306	0.962	0.751
Constant	4.215	2.057	0.040

Notes: Dependent variable is POOR (Household probability of not being poor). Number of observation: 106. Chi-square = 13.695. Significant = 0.321.

By using 15% of standard error, the probability of not being poor is determined also by the age and the main employment of household heads. The older the household heads, the greater the probability of being poor. The increase of the age of household head by 10 years reduces the probability of not being poor by 0,51%. Similarly, using service as benchmark, households engage in agriculture activities have larger probability of not being poor than those engage in other activities including fishery and services activities.

The increase of 1% engagement in agriculture increases the probability of not being poor by 2.06%.

Ecological Impact of the Programme

The assessment of ecological condition of coral reef as an impact of COREMAP program is difficult to undertake due to several reasons. *First*, the COREMAP program does not deal directly with the ecological aspect of coral reef. The program is intended to both stop any destructive activities carried out by local people as well as outsider and prevent coral reef from any pressure. *Second*, the recovery process of destroyed reef is a long-term process (Galvez, 1989; Cesar, 1996), meanwhile the program started in 1996 (preparation stage). Therefore, it is not easy to assess the extent to which the COREMAP program affects the recovery process. *Finally*, the destruction of coral reef is not only caused by human activities but also natural events. No one can overcome the last cause since it is beyond the authority of humankind.

However, the trend of living coral cover during 1995-1999 can be used to assess the ecological condition of coral reef. Suharsono (1995), for example, has researched the ecological condition of coral reef in Indonesia including Lombok using rapid assessment method (RAM) in 1995. From 24 research stations in Lombok it was found that only 8.3% were excellent condition, 16.7% were good, 16.7% were bad, and 58.3% were very bad. Especially in Gili Islands, from 8 research stations he found that 25% were categorized as excellent, 25% were good, 12.5% were bad, and 37.5% were very bad. Suharsono (1995) noted also that coral cover on the offshore islands and patch reef ranged from less than 10% in areas devastated by blast fishing to more than 80% in relatively undisturbed areas. Quantitative estimates of coral cover in Gili Trawangan, for instance, ranged from 20-30% for the eastern slope to 60-80% for the western slope. Similarly, on Gili Meno, the northern slope supported 60-80% cover of living coral whereas the eastern slope had less than 30%. (Suharsono, et al. 1995).

Suharsono et al (1995) found also approximately 148 species of hard coral, from 54 genera and 15 families in Gili Islands. Coral communities around the islands are more diverse than those of the mainland fringing reefs, primary in response to a greater array of habitat types and oceanographic conditions. They recorded over 110 species of hard corals from the northern and the southern parts of Gili Islands representing all major coral growth forms.

Table 9 Percentage of Live coral cover in Gili Air 1999

Form Growth	Percentage of Live coral cover in Various Depth			
	South Gili Air		North Gili Air	
	3 meter	10 meter	3 meter	10 meter
Acropora	0	0	0.23	0
Non Acropora	5.63	0	3.05	7.41
Algae	24.09	0	43.05	45.91
Other Fauna	4.53	0	31.74	42.42
A biotic	65.75	100	21.93	4.27
Fish	167	0	376	516

Source: Author own survey (1999).

By applying line transect method in 2 observation stations in Gili Air and 3 observation stations in Gili Trawangan, author found that the live coral cover in north of Gili Air was better than those in south of Gili Air in both 3 m and 10 m of depth even there was

no live coral cover in 10 depth found in south of Gili Air (see table 9). Soft coral included in other fauna dominated the growth form of live coral cover in the area. Meanwhile, the live coral cover in three different sites of Gili Trawangan varied from about 2% to 78% (see table 10). Hard coral (non acropora) was a predominance growth form of live coral cover in the area.

Table 10 Percentage of Live coral cover in Gili Trawangan 1999

Station	Percentage of Live coral cover in Various Depth		
	3 meter	10 meter	
	Transect I	Transect I	Transect II
Snorkel Area	1.92	2.17	2.84
In front of Casuarinas Tree	31.68	6.40	3.11
In front of Nusa Tiga Hotel	- ^{*)}	77.57	45.60

Source: Author own survey (1999).

^{*)} No information

Compare to the result of the previous investigation, the ecological condition of coral reef in the island is worse mostly due to the increase of seawater temperature influenced by El Nino phenomenon occurred in 1998. Nevertheless, some important remarks as an implication of COREMAP program can be drawn here. The activities created by project have apparently attracted much attention and participation of local people because those activities can satisfy their needs. The development of alternative sources for livelihood that concerns in the willingness of local community as well as the availability of local resources has resulted a high level of participation from local people. The introduction of sound environmentally alternative of livelihood sources can reduce the threats of coral reef ecosystem since people tend to lessen their destructive activities in fulfilling their needs.

In addition, the integration of the local community and the implementation of community-based management have resulted in many cases in the contribution of ideas from local people to create local institution relating to coastal resources. Several diving centres have also decided to establish a police station in the island as well as to finance every day patrol of water police to protect the coral reef ecosystem from destructive activities. Since then, the destructive activities taking part in the island and its vicinity conducted either by local people or outsiders have been remarkably decreasing. Several cases of illegal fish catching practices have been prosecuted so far.

Conclusion

The statistical analyses employing in this study prove that the COREMAP program has no significant impact on the households' income level as well as the probability of household not to be poor. It indicates that the program has not been able to generate the households' income and to help households to move out from poverty as well so far. In addition, the ecological condition of coral reef has been worse in recent years mostly due to the El Niño phenomenon occurring in 1998 leading to a reduction of the living coral cover. However, the program has been apparently successful in achieving the participation and integration of the local community in many activities particularly. As a result, there is a decreasing tendency toward the destructive fishing technique employed by local people as well as outsiders in the island. Moreover, the experiences derived from the implementation of the program are valuable lessons concerning the early processes of building consensus and commitment to protect the coral reef resources.

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