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Analysis of Social, Economy , Ethics Influence on the Use of Fishing Technology and Sustainability of Demersal Fish Resources in the Madura Strait: Ecosystem Approach With Partial Least Square

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ABSTRACT

This research was conducted in the Madura Strait in 2011. The purpose of this study is to analyse the influence of social, economy, ethical and fishing technology in the sustainability of biological and demersal fish resources in the Madura Strait. Ecosystem-based research approach to the social domain, economics, and ethics, technology, biology and fishery resources was then analysed using Partial Least Square with smartPLS software. Environmental knowledge, education level, status of the conflict, the income of fishermen, subsidies, habitat mitigation, co-management affect the use of unenvironment friendly technologies and result in biological and demersal fish resources sustainability of the Madura strait.
KEYWORDS: demersal, fish resources, sustainability, Madura Strait

INTRODUCTION

The uutilization of fish resources in the Madura Strait is an open access and causes the catch of fish tend to decrease each year. The management of fish resources in the conventional approach with reference to the Maximum Sustainable Yield (MSY) turned to have caused uncertainty and the resources still undergo overfishing [1][2]. Furthermore, as fishing activities also involve the attitude of fishermen, then the management is not solely focused on the population dynamics of fish alone, instead, it involves the integration of both [3][4][5]. Infact, the management of fisheries has even multi-disciplinary characteristics that relate to social issues, economics, ethics and technology [6]. Subsequently Charles [7][8] proposes a new approach to fisheries management called the fishery system approach, which is an element of ecosystem approach. Several studies have been conducted with a multi-disciplinary approach and believed to be able to produce better management of fish resources [9]. However, those studies have not explained the cause and effect in the multi-disciplinary domain. Therefore, the purpose of this study is to analyse the influence of social, economy and ethics on the use of fishing technology and the sustainability of biological and demersal fish resources in the Madura Strait.

MATERIALS AND METHODS

This research was conducted in the Madura Strait in 2011. This research used an explanatory research, analysed with the Partial Least Square (PLS). This analysis can explain causality between variables through hypothesis testing using a quantitative approach. The meaning of causality is a causal relationship between the two or more variable [10].

The flow of operations research with PLS

Partial Least Square is a powerful method of analysis. PLS (Partial Least Square) can also be used to confirm theories. Compared with covariance based Structural Equation Model (SEM), represented by the software LISREL, EQS, or AMOS, component-based PLS is able to avoid two major problems faced by the covariance-based SEM (CBSEM), is inadmissible solutions and factor indeterminacy [11].Besides, Wold [12] explains that in order to avoid the indeterminacy problem and provide an exact definition of component scores, PLS provides a general model that includes canonical correlation techniques, redundancy analysis, multiple regression, multivariate analysis of variance (MANOVA) and principle component analysis. The application of resampling methods, allowing freely-distributed data, does not require the assumption of normal distribution, and does not require a large sample (recommended minimum of 30 samples) [13].

The usefulness of PLS is to obtain a powerful structural model for prediction purposes. The estimation of parameters in the PLS includes three terms, i.e 1) Weight estimate, used to calculate the latent variable data, 2) path estimate that connects between the latent variables and estimation loading of latent variable with the indicator, 3) Means and location parameter (the regression constant, intercept) for the indicator and latent variables.

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To obtain all estimates, PLS uses the iterative process of three stages and each stage of iteration yields as an estimate. The first stage generates weight estimate, the second stage results an estimate for the inner and outer model, and the third stage generates estimates of means and locations (constants). The diagram of PLS analysis steps can be seen in Figure 1.

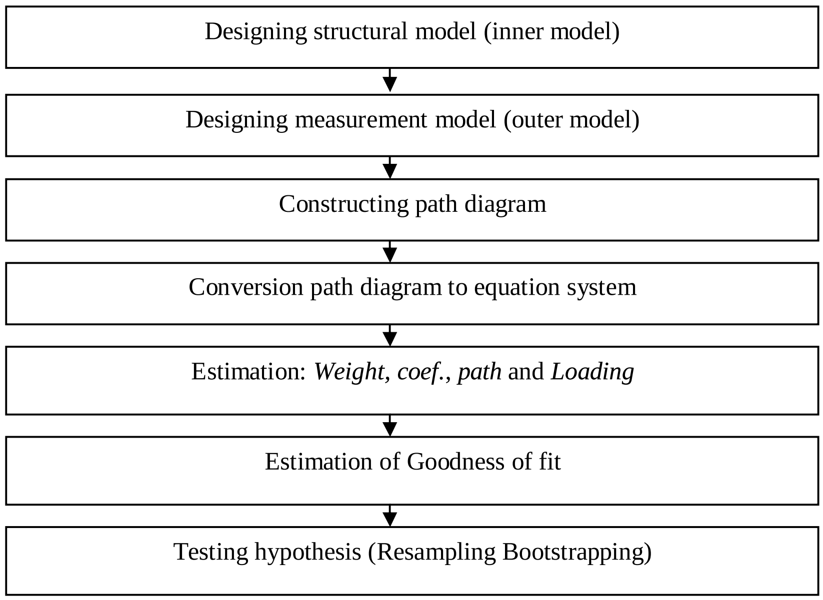

Figure 1. The flow of operational analysis of PLS

Conversion of path diagram into equation system

(1) Outer of model is the specification of the relationship between latent variable with the indicator, also called outer relations or measurement model, is to define how each block of indicators is related to its latent variable. A block with a reflexive indicator can be written with the following equation:

X = ξ + ε Λ × × .... (1)

Y = Λy л + εy .... (2)

where x and y are the indicators or manifest variables to exogenous and endogenous latent variables ξ and Л. While Λ × and Λy are loading matrix portraying regression coefficient is simple regression connecting latent variables with the indicator. Residuals as measured by ε× and εy can be interpreted as measurement error or noise. A block with formative indicators of the equation can be written as follows:

ξ = x + δς Лς .... (3)

Лл y = л + δл .... (4)

where ξ, л, x, y are similar to those used in the equation above. Л is the coefficient of x and Лy, regression of the latent variables and block indicators. δ× and δy are residual from the regression.

(2) Inner model is the specification of relationships among latent variables (structural model), it is also called the inner relation, describing the relationships among latent variables based on subtansive theoretical research. Without losing its generality, it is assumed that the latent variables and indicators or manifest variables of scaled zero means and unit variance is equal to one, so that the location parameter (constant parameter) can be removed from the model [13]. Inner models are sometimes also called the inner relations, structural model, and substantive theory, describing the relationships among latent variables based on substantive theory. The formula of the model equations can be written below:

л = βo βлl + + + ς Γξ .... (5)

where describing the endogenous vector (dependent) of latent variables, ξ is the exogenous vector of latent variables, and ς is the residual vector variables (unexplained variance). Therefore, PLS is designed to recursive model. The relationships among latent variables, each of the dependent latent variable л, or often called causal chain system of latent variables [11] can be specified as follows:

лj = Σi βji лi + + ΣI yjb ξb ςj .... (6)

where is path coefficients βji linking the latent predictors of endogenous and exogenous variables (ξ and л) a long range indices i and b, ςj is the inner residual variable [11].

Further design of the inner model, the outer model and the construction of the path diagram is shown in Figure 2 below.

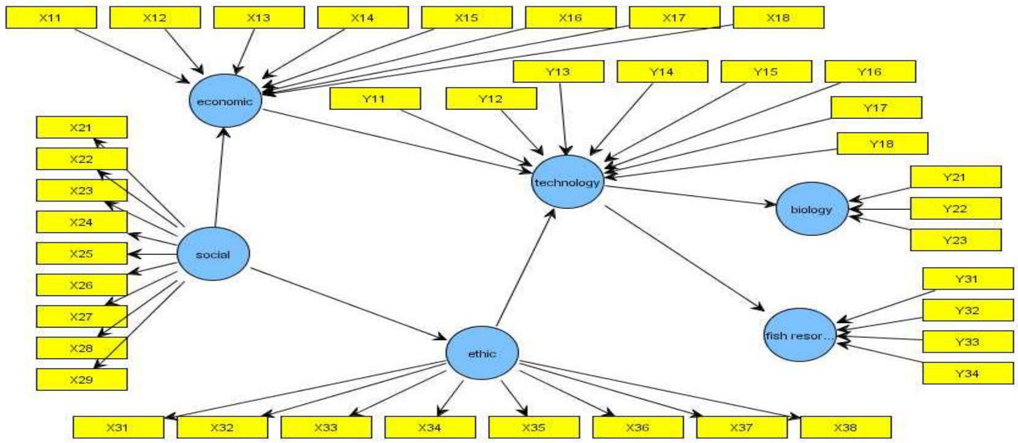

Figure 2. Conceptual framework of research of the basic design of the structural model (inner model), the measurement model (outer model) and the design of the study pathway diagram.

The inner and outer model is used as the design of this research study, in which the inner domain model consists of social, economic, ethical, technological, biological and fishery resources and the outer model consists of indicators that make or domain reflects the inner model. In the present study it was designed that the indicators referring to Rapfish indicators [14] are modified, as follows: For the latent domain of ecology, the indicators were: the status of exploitation (Y31), catcth per unit effort (CPUE) trend (Y32), changes in fishing areas (Y33), changes in species composition (Y34). For fish biology domain, the indicators were: the size of fish (Y21), by-catch (Y22), fish caught before gonad mature (Y23). For fishing technology domains, indicators were: fishing gear activity (Y11), gear selectivity (Y12), fish agregate devices (Y13), vessel size (Y14), fishing capacity (Y15), the number of vessel (Y16), gear side impact (Y17), trip length (Y18). For the economy domain, the indicator was: fishermen income (X11), local economy impact (X12), licensing (X13), fish catch quotas (X 14), alternative livelihood (X15), employment (X16), marketing distribution (X17), subsidies (X18). For the social domain, the indicator was: Dissemination of fisheries (X21), the increase in fishing communities (X22), the number of fishery households (X23), environmental knowledge (x24), educational level (X25), conflict status (X26), the effect of fishing to the policy (X27), the percentage of fishermen income of (x28), kin participation (X29). For the domain of ethics, the indicators were: geographical proximity (X31), the entry of fishermen in the fishery (X32), co-management (X33), environmental influences (X34), ecosystem mitigation (X35), habitat mitigation (x36), illegal fishing (X37) , fish discarded (X38). Primary data were taken from 160 respondents in the Madura Strait, consisting of fishermen, community leaders, fisheries agencies and researchers. The data were then analysed using Partial Least Square (PLS) with the help of SmartPLS software.

RESULTS AND DISCUSSION

Inner model of the test results after bootstrappings

The domain which influences the economy, social, ethics in technology, the biological and fish resources can be seen in Figure 3 and Table 1 below.

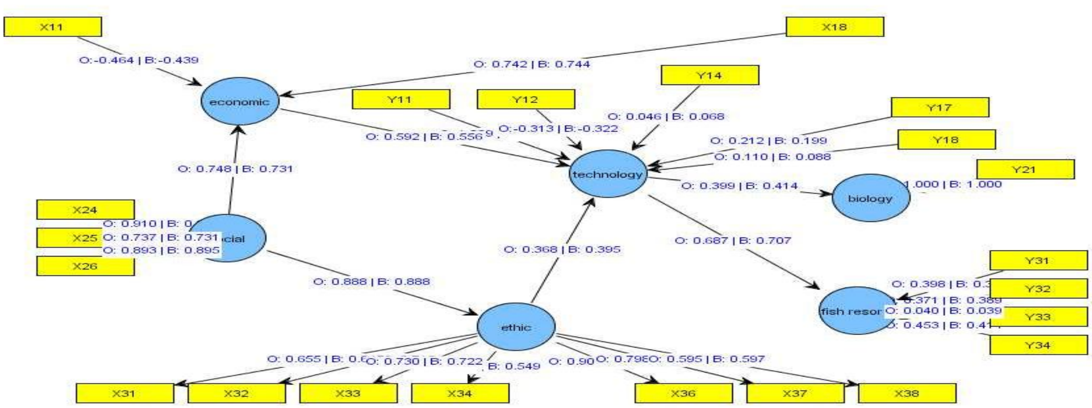

Figure 3. Inner-outer model after bootstrappings

Table 1. Estimate, Standard deviation and T-Statistic

	original sample estimate	*mean of subsamples*	*Standard deviation*	*T-Statistic*
Social->Economy	0,748	0,736	0,128	5,857
Social-> Ethic	0,888	0,889	0,018	50,165
Economy->Technology	0,592	0,555	0,108	5,511
Ethic ->Technology	0,368	0,400	0,071	5,170
Technology-> Biology	0,399	0,409	0,085	4,706
Technology -> Fish Resources	0,687	0,709	0,041	16,654

Table 1 shows that the social domain which has significant effect on the economy is acceptable, where the value of T-Statistics > T-Table (1.96). The significant effect on social ethics is acceptable, where the value of T-Statistics > T-Table (1.96). The economy and ethics significant effects on the use of fishing technology are acceptable, where the value of T-Statistics> T-table value (1.96). The fishing technology which has significant effect on of fish biology is acceptable. Tstatistics > Ttable (1.96). Fishing technology significant effect on demersal fisheries resources in the Madura Strait is acceptable,where T-Statistics> T-Table (1.96).

The results test of outer model of social domain after bootstrappings

The results of the model calculations with outer loadings in the social domain and ethics after bootstrappings can be seen in Table 2 and Table 3.

Table 2. The results of outer loadings (Mean, STDEV, T-Values) for the indicators in the social domain after bootstrappings

Social indicators	*Original Sample Estimate*	*Mean Of Subsamples*	*Standard Deviation*	*T-Statistic*
Environtment knowledge (X24)	0,910	0,910	0,017	53,023
Education level (X25)	0,737	0,738	0,054	13,534
Conflict status (X26)	0,893	0,893	0,015	58,838

Table 2 shows that, the social domain for demersal fisheries of the Madura Strait is reflected and has a significant effect on indicators of environmental knowledge, level education and conflict status. Most fishermen (71%) do not understand how to manage the fish resources, since they have not been provided with information relate to the management training. At the average, the education of the fisherman is finished elementary school of 40.62% and lower secondary school of 26.88%. This educational level is below the average level of education of coastal communities in general. Conflicts often occur (1) on the basis of the different districts with the same fishing gear and different fishing gear, (2) on the basis of different fishing gear, (3) in one district with a different fishing gear, (4) violation fishing pathway, (5) the possibility of differences in local rules that apply to every regency in the Madura Strait and (6) illegal fishing practices.

The results of testing the model outer domain of ethics after bootstrappings

The results of outer loadings (Mean, STDEV, T-Values) for the indicator in the domain of ethics after bootstrappings can be seen in the table below.

Table 3. The results of outer loadings (Mean, STDEV, T-Values) for the indicator in the domain of ethics after bootstrappings

Ethics indicators	*Original Sample Estimate*	*Mean Of Subsamples*	*Standard Deviation*	*T-Statistic*
geographical proximity (X31)	0,655	0,654	0,071	9,201
Fishermen entry (X32)	0,712	0,713	0,056	12,755
Just management/Fishermen involement in comanagement (X33)	0,730	0,726	0,047	15,533
environmental influences (X34)	0,542	0,544	0,066	8,223
Habitat mitigation (X36)	0,904	0,907	0,018	50,770
Illegal fishing (X37)	0,798	0,798	0,044	18,032
Fish discard (X38)	0,595	0,605	0,052	11,525

Table 3 shows the domain of ethics for demersal fisheries of the Madura Strait is reflected a significant effect on indicators of geographical proximity, the influx of fishermen in the fishery, the involvement of fishermen in the process of co-management, environmental impact in coastal areas, mitigation of habitat, illegal fishing and fish discard. When asked about the participation of fishermen in fisheries management, they never managed fisheries. Besides, the government did not involve them, even they did not want to know with all management problems that the fishermen faced on account of additional work. Therefore they are indifferent to the preservation of fisheries resources. Dahuri & Duton assert that coastal communities are, in fact, lack of knowledge related to coastal and ocean management issues [15].

The management of demersal fisheries based on co-management in the Madura Strait is still not optimal. The fishing management is instructive on the part of the government. Fisherman institutions are currently deemed by most fishermen as less representative. Co-management is an attempt to overcome the mistrust, fragmentation and inefficiency of fisheries by providing a forum for action by the partners in the regulatory negotiation, conflict management, information sharing, and dialogue and communication [16]. The results of research in Muluk can be used as an alternative to local knowledge-based resource management in which local leaders or chiefs have the power and autonomy to determine the period of closure and removal of the next location will be closed to exploitation [17]. Co-management make users feel that they have the resources for better and more responsible utilization of long-term goals [18].

Classic problems for households of fishermen in Madura Strait when faced with management efforts and establishment of marine protected areas is the lack of availability of jobs for them as a substitute job which is not environmentally friendly fishing as they do. When the Madura Straits will be manage for the potential sustainable demersal fish resources, the first essential factor consideration is that the affected fishermen must first look for alternative jobs. This is in line with the opinion of Cheung and Sumaila , when doing research in the South China Sea as a case study, they maintain the implementation of conservation plans can be hindered by the reduced number of jobs related to alternative livelihoods [19]. Settlement of the issue of alternative livelihoods appears to be a priority to improve the management of fish resources and their conservation plans [20][21]. Furthermore, marine protected area can improve , maintain the fish resources and to protect marine biodiversity especially marine capture fisheries in Indonesia. Sasi Laut Regulation as a teritorial user right of local fisheries shows highly obedience by local users[22].

The test results of fish resources as outer domain model after bootstrappings

While the results of the calculation model with outer weights for indicators of fish resources domain can be seen in the table below.

Table 4. Outer weights (Mean, STDEV, T-Values) domain indicators of fish resources after bootstrappings

Fish resources indicators	*Original Sample Estimate*	*Mean Of Subsamples*	*Standard Deviation*	*T-Statistic*
Exploitation status(Y31)	0,398	0,384	0,120	3,309
CPUE trend (Y32)	0,371	0,383	0,145	2,563
Species composition changes (Y34)	0,453	0,438	0,153	2,957

From Table 4, it can be seen that an indicator of exploitation status, decline in fishery resources (CPUE trend) and changes in species composition have a significant effect on the fish resource domain. The condition of demersal fish resources in Madura Strait has suffered from overfishing pressure. The results of estimation of threadfin bream, one of the demersal fish in Madura Strait, by using Schaefer approach has shown overfishing [23]. Similarly, CPUE shows a downward trend. Catch per unit effort (CPUE) of pony fish in 1998 of 18.9 and in 2008 decreased to 4.95 (down of 74%), CPUE threadfin bream decreased of 19%, lizzard fish declined of 57%, goatfish of 55% and croacker of 69% [24]. Changes in species composition of demersal fisheries have occured in the Madura Strait. Fishermen said there are existing symptoms of percentage change in species composition of catches by fishing gear for demersal fisheries, where several species were not visible and very rare species found in landing site (such as grouper).

The results of biological testing of outer domain model after bootstrappings

The results of calculation of outer weights (Mean, STDEV, T-Values) of indicators of biological domain after bootstrappings can be seen in the table below.

Table 5. Outer weights (Mean, STDEV, T-Values) of indicators of biological domain after bootstrappings

Biology indicators	*Original Sample Estimate*	*Mean Of Subsamples*	*Standard Deviation*	*T-Statistic*
Fish size (Y21)	1,000	1,000	0,000	

From Table 5, it can be seen that the indicators have a significant decrease in fish size on the biological domain. Biological condition of demersal fish caught has effect on the sustainability of fish resources. The amount of the value of Lc (length at first capture) <Lm (length at first maturity) can be one sign that the demersal fishery in the Strait of Madura began to experience excessive and lead to growth overfishing, resulting increase in smaller size of fish caught.

The test results outer model of technology domain after bootstrappings

The calculation results of outer weights (Mean, STDEV, T-Values) indicator after bootstrappings technology domain can be seen in the table below.

Table 6. Outer weights (Mean, STDEV, T-Values) technology domain indicator after bootstrappings

Technology indicators	*Original Sample Estimate*	*Mean Of Subsamples*	*Standard Deviation*	*T-Statistic*
Gear activity (Y11)	0,944	0,931	0,025	38,191
Gear selectivity (Y32)	0,631	0,620	0,068	9,330
Fishing vessel size (Y14)	0,527	0,514	0,081	6,503
Gear side effect (Y17)	0,537	0,538	0,079	6,819
Trip length (Y18)	0,277	0,268	0,133	2,446

The indicators of active fishing gear, selectivity devices, the size of the vessel, the side effects and the long trip means a significant effect on the technology domain (Table 6). From the analysis, it is known that the danish seine operated actively have negative impact on biological condition of demersal fish resources in the Madura Strait. Active fishing gear, fishing gear selectivity, the increase in fleet capacity, side effects and the long trip means a top priority that needs to be resolved in planning sustainable management of demersal fish resources in Madura Strait. Active fishing gear does not only catch fish with a non-selective mode but also has a negative impact on the trail and the destruction of reefs. This issue is similar to that occurring in the Gulf of Thailand, where the introduction of more active fishing gear and not selective like Trawl with a soft loan assistance in 1960 has led to the decline in catches of very large and resulted in a fishery household economy [25][26].

The test results outer domain model economy after bootstrappings

The analysis outer weights (Mean, STDEV, T-Values) indicator of economic domain after bootstrappings can be seen in the table below.

Table 7. Outer weights (Mean, STDEV, T-Values) indicator of the economic domain after bootstrappings

Economy indicators	*Original Sample Estimate*	*Mean Of Subsamples*	*Standard Deviation*	*T-Statistic*
Fishermen income (X11)	-0,464	-0,457	0,111	4,202
Subsidies (X18)	0,742	0,726	0,124	5,999

The indicator of average incomes of fishermen and subsidies have a significant effect on the economic domain (Table 7). In this study, the average income of fishermen has a significant negative effect on the fishing technology used. The higher the income of fishermen is the more environmentally unfriendly fishing gear used.The economic behaviour is certainly very harmful to the sustainability of demersal fish resources in the Madura Strait especially with the lack of regulation allowing the number of catches landed. The issue of subsidies to fishing also be a trigger factor in the use of environmentally unfriendly technologies and ultimately have a negative influence on demersal fish resources in the Madura Strait. Help procuring a boat, fishing gear and fishing tool has resulted in negative impact to the demersal fish resources sustainability. Subsidy on the price of fuel oil also led to the addition of a long trip, the fishing fleet and fishing capacity which in turn tend to use fishing gear that is more active. Simple economic model that can explain how subsidies can increase profits and led to enhancing the number of effort results in the condition of the stock of fish resources [27][28][29][30].

CONCLUSION

The social domains with indicators of low environmental knowledge, education level of fishermen and the many conflicts in Madura Strait fisheries have impact on the economic and ethics domain. The economic and ethic domain have significant effect on environtmentally unfriendly fishing technology used. The indicators of economic which have negative impact are average income of fishermen and subsidies granted to the fishermen. The indicators of ethical domains which have a negative impact are geographical proximity, the entry of fishermen on fishing activities, the lack of involvement of fishermen in the process of co-management, the practice of illegal fishing, lots of boats without a license based on the status of fish resources and fish discard. Indicators of technology domain which have negative impact on sustainability of biology and demersal fish resources are gear activity, gear selectivity, fish aggregate devices, an increasing number of fleet and trip length .

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