Improvement of capture fisheries marine ecosystems using mapping of fishing areas in Pariti waters

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Abstract. This research aims to analyze the increase in fishermen economy through mapping fishing areas in Pariti waters, Indonesia. This research uses primary and secondary data. The primary data comes from interviews. It includes the amount of fish caught by fishermen, measured in kilograms (kg), selling prices of fish caught, education, age, number of family dependents, and experience in Pariti Village, Sulamu District, Kupang Regency. Secondary data were obtained from several websites and publications. This research uses the effect on production (EoP) analysis technique. Based on the calculation results of the utility effect on production (Ueop), a value of 2278.29 USD per fisherman per year was obtained. The total economic value (TEV), based on the total fishing area in accordance with the total catchment area of the Kupang Regency RPJMD in 2019, was 703991.74 USD. This value is the total economic value of the fisheries ecosystem in the fish catching area in Pariti Village, Sulamu District, Kupang Regency annually. The results of this calculation when calculated per ha is 410.68 USD per year. Calculation of the resulting TEV can show the economic value of the capture fisheries ecosystem divided into two types of catch, namely shrimp and fish. The calculation results for the shrimp catchment area yield a value of 3610.21 USD for TEV per ha per year, while for the fish catchment area there is a value of 463.4 USD for TEV per ha per year. This shows that the TEV for the shrimp catchment area is greater than for the fish catchment area. The strategy to increase the economy of Pariti village fishermen can be carried out by maximizing the catch of shrimp and their distribution to the community with a more competitive selling price.
Key Words: effect on production, total economic value, valuation.

Introduction. Kupang Regency has an area of sea waters of approximately 3278.25 km^2 with a coastline length of approximately 442.52 km, as well as an aquaculture area with an area of 1714.2 ha, which can be developed for inland fisheries to become a leading regional sector (RPJMD 2019). The administrative area of Kupang Regency includes 24 sub-districts. One of them is the Sulamu district, which has an area of 271.12 km^2. Likewise with the distribution of the potential that is owned in the region, Sulamu has been designated as a Marine Natural Tourism Park (TWAL) of Kupang Bay. According to Sulamu District in Figures (2021), marine fishery production in the Sulamu district for all species of fish reaches 98 tons and the full number of fishermen in the Sulamu district reaches 510 and 206 for the part-time fishermen. The distribution of the number of fishermen is obtained from several urban villages with a relatively large number of fishermen, such as Pariti Village. Sulamu district has high potential fish resources and should be able to be empowered in order to improve the economic welfare of fishermen.

Based on Sulamu District in Figures (2021), Pariti is one of the administrative areas that has large capture fisheries potential. This is supported by the number of fishermen reaching 62 fishermen consisting of full-time and part-time fishermen. However, the catch of fish, which is one of the leading commodities, cannot boost the economic welfare of fishermen in the Pariti sub-district, Sulamu sub-district, Kupang district, East Nusa Tenggara province. This is because the distribution of fishing areas is not based on the mapping of fishing areas. Thus, the contribution of fish catches to the economic level of fishermen is relatively small because the number of fish catches is low. This is in line with research from Wulandari et al (2017), which explains that the fishing area (DPI) is important for the sustainability of capture fisheries activities, and a fishing area is not necessarily a high potential fishing area.

Fishing areas in Pariti waters include two fishing areas, namely shrimp fishing areas and ordinary fishing areas. These two areas have economic potential, but the total economic value has not yet been calculated. Total economic value (TEV) is an all-encompassing framework that is used by economists to identify and categorize environmental benefits. The concept of TEV first came into general use in the late 1980s and early 1990s (Pearce et al 1992). It has now become one of the most widely used and commonly accepted systems for classifying wetland economic benefits and for attempting their integration into decision-making (Barbier et al 1997). This study attempts to analyze economic improvements using total economic value as an analytical framework for two fishing areas, namely shrimp fishing areas and regular fishing areas in Pariti waters, Indonesia.

Material and Method

Research method. The analysis technique used in this research uses the effect on production (EoP) technique. According to Emerton (2018), total economic value distinguishes between use values and nonuse (or passive use) values. Valuation approaches or techniques using EoP can be analyzed using a demand approach or estimating the demand function and calculating consumer surplus. The effect on production methods is also explained further in several previous research, including by Costanza et al (1997), De Groot et al (2002), MEA (2003), De Groot et al (2012), and Costanza et al (2014). The EoP approach in this research also calculates TEV and consumer surplus obtained based on the results of the EoP calculation. The first step of EoP analysis is to convert all data obtained from field studies (primary data) into logarithms. In determining the demand function for fishermen's catch using the EoP, econometrics is used, namely multiple linear regression (Fauzi 2004). According to Adrianto (2006), the valuation steps using EoP with a demand approach or estimating the demand function and calculating consumer surplus are as follows.

Estimation of the demand function for direct uses value:

$$Q = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} X_6^{\beta_6}$$

Where: Q is amount of resources requested (fish and shrimp); X1 is selling price of fish or shrimp; X2 is age of fishermen; X3 is fishermen education; X4 is number of family dependents; X5 is experience as a fisherman; X6 is fishermen income; β_0 is constant coefficient; $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6$ are variable coefficients.

In this context, the relationship between price (X1) is assumed to be negative towards resource demand. A more expensive the price of a resource will produce a lower level of demand for that resource.

Estimation of economic value:

Demand function transformation

$$LnQ = \beta_0 - \beta_1 LnX_1 + \beta_2 LnX_2 + \cdots + \beta_n LnX_n$$

$$LnQ = ((\beta_0 + \beta_2(Ln\bar{X}_2) + \cdots + \beta_n(Ln\bar{X}_n)) - \beta_1 LnX_1$$

$$LnQ = \beta' - \beta_1 LnX_1$$

Logarithmic transformation of the last demand function to the original demand function

$Q = exp(\beta')\, X^{\beta_1}$or $Q = \beta X^{\beta_1}$

Plug Q into the price function

$X_1^{\beta_1} = \frac{Q}{\beta}$ or $X_1 = \frac{Q^{1/\beta^1}}{\beta^{1/\beta^1}}$

Estimating total willingness to pay (economic value of resources)

$$U = \int_0^a f(Q)dQ$$

Where: U - utility to resources; a - limit on the average amount of resources consumed/demanded; f(Q) - demand function.

Estimating surplus consumers

$$CS = U - TP_t$$

$$TP_t = X_1 \times \bar{Q}$$

Where: CS - consumer surplus; TPt - total price paid; Q - average amount of resources consumed/demanded; X1 - price per unit of resource consumed/demanded.

The impact of economic valuation on the benefits and impacts provided by the management of natural resources and the environment is very necessary for policy making and economic analysis (Freeman III et al 2014). Estimation of economic value can also be done by calculating the value of the utility EoP, which will produce the value of total benefit (TB) and consumer surplus. The utility value, which is an economic value, is evaluated based on the value of ecosystem services based on the EoP valuation technique. Wahyudin (2007) explains that calculating the utility value of ecosystem services based on EoP assessment technique can be carried out with the following calculation stages (Table 1).

Table 1

Utility value of ecosystem services based on the effect on production (Eop) valuation technique

	Effect on production (EoP) valuation technique
Linear	$U^{EOP} = \frac{1}{2b}\bar{Q}^2 - \frac{a}{b}\bar{Q}$
Non-linear	$U^{EOP} = \frac{1}{a^{\frac{1}{b}}} \frac{1}{\left(\frac{1}{b}+1\right)} \bar{Q}^{\left(\frac{1}{b}+1\right)}$
Total benefit	$TB^{EOP} = U^{EOP} P_Q$
Total benefit per hectare per year	$TB^{EOP}_{ha/yr} = \frac{U^{EOP} P_Q}{L}$

Note: Wahyudin et al (2022); U^{EOP} - the utility value of the goods and services provided and/or presented by the ecosystem; $\bar{Q}$ - the average quantity obtained by the beneficiary of the products produced/provided by the ecosystem during a year; TB^{EOP} - the total benefit of the goods and services provided and/or presented by the ecosystem; $TB^{EOP}_{ha/yr}$ - value of ecosystem service benefits calculated per hectare per year; L - area of natural resources and the environment assessed.

The next objective of this research was to determine the local institutional values found on the fishing coast of Pariti village. Strengthening local economic institutions aims to increase the role of local communities. This research used a qualitative research method that seeks to construct reality and understand its meaning, so that it pays close attention to processes, events and authenticity, to examine the condition of the subject, by searching and finding information through limited, but in-depth case studies with holistic depictions.

The qualitative approach characterizes the meaning of quality as referring to natural aspects and not describing calculations (Maleong 2017).

The analysis was carried out using a validity and reliability process when collecting data through focus group discussion (FGD). Through this data collection technique, the process of checking the validity and reliability of the data runs independently through discussions between local communities, which are carried out by involving fishermen as fisheries business actors. The selection of subjects involved in the FGD was taken using a purposive sampling technique which allows researchers to choose based on consideration of their specific knowledge or expertise in the field of research.

Results. Mapping of fish catchment areas in Pariti waters was carried out using an interview scheme with Pariti village fishermen. The results of interviews with 30 respondents showed that there was a division of two fishing areas, namely the fishing area for ordinary fish and the fishing area for shrimp. The fish catchment area is 1519.2 ha while the shrimp catchment area covers 195 ha. This is based on the total area of fish caught in the waters of Sulamu, because Pariti village fishermen also catch fish in these waters. The division of the catchment area between fish and shrimp catches is seen based on the distribution of fish in Sulamu waters in general and Pariti waters in particular. Based on the interviews conducted, the shrimp catch area is usually in shallow water areas. The shallow waters in question are water areas planted with mangroves. Thus, the fishing method is carried out conventionally, without using modern tools or machines. The shrimp catches that can be produced per day per fisherman are less than optimal. This is different in the fishing area. The fish catchment area has a wide coverage when compared to the shrimp catchment area. The fish catchment covers 88.6% of the Sulamu waters, but the income generated is not optimal. This is due to two main factors: the fishing mechanism with conventional boats and the distribution of caught fish, which is through third parties or middlemen.

Effect on production (EoP) approach. The data in Table 2 has been converted to logarithms based on the assumption that the previous data was nonlinear, so it needs to be linearized using logarithms. Then the data that has been logged is analyzed by the demand function. The demand function is determined using multiple linear regression econometric analysis.

The results of the multiple regression analysis show that the variable LnX1, which is the variable selling price of fish caught, does not affect the variable LnQ, which is the variable number of fish caught partially (Table 3). From an analytical perspective, regression analysis is utilized to determine the demand function by examining the estimated variable coefficients. The variable coefficient value of LnX1 is -2.44204, which has a negative relationship direction. This is in line with research conducted by Hutagalung et al (2014), which explains that if there is a price increase, it will cause a decrease in weighted fish prices. However, fish production is positively related to income, time and dependents. This is proven by the results of the analysis carried out showing that the variable LnX4, which is the family dependent variable and LnX6, which is the fishermen income variable, partially affect the number of catches (0.01096 and 0.00543, respectively, smaller than alpha 5%).

Economics valuation of capture fisheries using effect on production (EoP). The utility effect on production (Ueop) is 2278.29 USD per fisherman per year. This value also serves as the consumer surplus value, calculated based on the interpolation of the results of the regression analysis above. If this value is calculated to find the TEV, which is based on the total fish catch area in accordance with the total catchment area of the 2019 Kupang Regency RPJMD, the result is a value of 703991.74 USD. This value is the TEV of the fisheries ecosystem in the fish catching area in Pariti village, Sulamu District, Kupang Regency, annually. The result of this calculation per ha is 410.68 USD per year.

Table 2

Variable analysis

LnQ	*LnX1*	*LnX2*	*LnX3*	*LnX4*	*LnX5*	*LnX6*
6.9077	11.2898	2.9444	2.4849	1.6094	1.3863	16.3004
5.0106	11.2252	3.6889	1.7918	1.6094	3.2189	16.3004
4.6051	11.2898	3.5835	1.7918	1.6094	2.9957	15.8950
4.6051	11.2898	3.8712	2.1972	1.6094	2.4849	16.4546
3.9120	11.2898	3.3673	2.4849	0.6931	2.3026	15.8304
3.9120	11.2252	3.1355	2.1972	0.6931	2.3026	15.8304
3.9120	11.2898	3.4012	2.1972	0.6931	2.3026	15.8304
3.9120	11.2898	3.7377	1.7918	1.7918	2.4849	16.3004
3.9120	11.2898	3.6376	1.7918	1.3863	2.5649	14.5087
3.9120	11.2898	3.3322	1.7918	1.0986	2.3026	15.6073
2.4849	11.2898	3.2958	2.1972	1.0986	2.3026	15.6073
2.4849	11.2898	4.2627	1.7918	0.6931	2.9957	16.3004
4.6051	11.2898	3.4657	2.1972	1.3863	2.7081	16.9066
7.3132	11.2252	3.9512	1.7918	1.6094	3.4012	16.9936
5.1929	11.2898	3.9890	2.1972	1.3863	3.4012	16.3004
7.3132	11.2898	3.9120	1.7918	1.0986	3.4012	17.3990
7.3132	11.2898	3.6376	1.7918	1.6094	3.3322	16.8112
7.3132	11.2898	3.5835	1.7918	2.0794	2.9957	16.8112
7.4955	11.2898	3.8918	1.7918	1.3863	2.9957	16.8112
7.4955	11.2898	3.8067	1.7918	1.7918	3.4012	16.8112
5.0106	11.2898	3.5553	1.7918	1.6094	2.9957	16.3004
4.6052	11.2898	3.5835	1.7918	1.6094	2.9957	15.8950
4.6052	11.2898	3.3322	2.1972	1.6094	2.4849	16.4546
3.9120	11.2898	3.3673	2.4849	0.6931	2.3026	15.8304
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3.9120	11.2898	3.4012	2.1972	0.6931	2.3026	15.8304
2.4849	11.2898	3.2958	2.1972	0.6931	2.3026	15.6073
2.4849	11.2898	3.4012	1.7918	0.6931	2.3026	16.3004
4.6052	11.2898	3.4657	2.1972	1.3863	2.7081	16.9066
7.3132	11.2898	3.4657	1.7918	1.6094	2.7081	16.9936

Note: Q - number of fish catches; X1 - selling price of fish or shrimp; X2 – age of fishermen; X3 - fishermen education; X4 - number of family dependents; X5 - experience as a fisherman; X6 - fishermen income.

Table 3

Results of multiple regression analysis

	Coefficients	*T Stat*	*p-value*
Intercept	*10.96936*	*0.09003*	*0.92904*
LnX1	-2.44204	-0.22590	0.82327
LnX2	-1.25224	-1.09347	0.28551
LnX3	0.18684	0.16406	0.87112
LnX4	1.57987	2.76735	0.01096
LnX5	0.89490	1.09323	0.28561
LnX6	1.29902	3.06888	0.00543
R-squared	0.646994778		
F Stat	7.025807255		
Significance F	0.000242803		

Calculation of the resulting TEV can also show the economic value of the capture fisheries ecosystem, which is divided into two types of catch, namely shrimp and fish. Based on the results of interviews with fishermen from Pariti village, Sulamu District, Kupang Regency, using the help of the virtual globe program (Google Earth), the catchment area for shrimp is 195 ha, while the fishing area for fish is 1519.2 ha. The calculation results for the shrimp catchment area yield a value of 3610.21 USD for TEV per ha per year while for the fish catchment area it produces a value of 463.40 USD for TEV per ha per year. This shows that the TEV for the shrimp catchment area is greater than that for the fish catchment area. The strategy to increase the economy of Pariti village fishermen can be carried out by maximizing the catch of shrimp species and their distribution mechanism to the community, with a more competitive selling price.

Demand function. Based on the results of calculating the TEV for shrimp and fish catches, a utility curve can be made from the demand function. Figure 1 presents a utility curve of the demand function reflects consumer surplus based on the total quantity of fish caught, which is influenced by several variables that have been analyzed above, namely the amount of fish caught, the selling price of fish or shrimp, the age of the fisherman, the education of fishermen, the number of family dependents, experience as a fisherman and income.

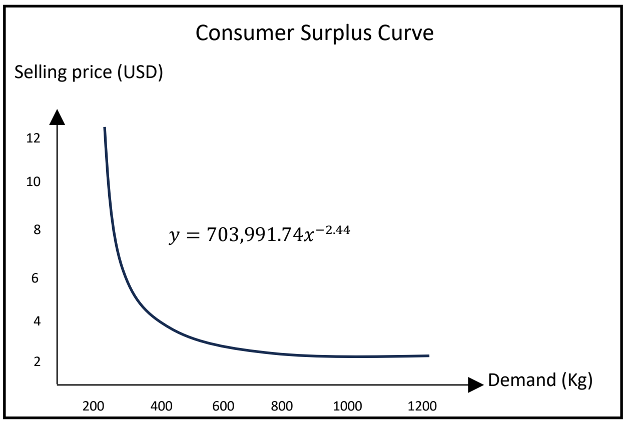

Figure 1. Consumer surplus curve.

The curve illustrates the negative relationship between the quantity of fish demanded and the selling price of fish. Consumer surplus and TEV were calculated for shrimp and fish catches. The analysis covered 30 fishermen and a fishing area of 1714.2 ha. The individual utility value or TEV was estimated at 410.68 USD per ha per year.

Institutional analysis. Strengthening local economic institutions is one of the efforts to simplify and increase their effectiveness by involving local communities. The local economic institutions in question are social ties that are built based on social networks of community social capital, which are used to carry out community development. According to Aliim & Darwis (2023), strengthening local economic institutions is the result of strengthening the social capital of the community in an area to achieve sustainable economic growth, which will have an impact on increasing economic welfare and the quality of life of all surrounding communities.

Pariti village has large potential and resources in the fisheries and marine sectors, consisting of fish and non-fish marine products, namely shrimp, crabs and shellfish. Shrimp catches dominate the marine products of Pariti village. The large mangrove areas in Pariti village indicate that the water is fertile for fisheries resources. The catch of shrimp is influenced by seasonal factors, namely the summer season, from April to October and the rainy season, from October to April.

The development of Pariti village will focus more on marine products, especially on shrimp, which is the most dominant marine product. The problems faced by villages are the level of productivity of fishing businesses, sub-optimal, the business institutional system, insufficiently developed, insufficient capital and production technology, and the lack of systematic product marketing. It is important to develop marine products by strengthening institutions through village-owned enterprises (BUMDes) in Pariti Village to improve the local coastal economy, as the village currently lacks a business entity to manage fishery resources and support the bargaining power of small fishermen.

The role of middlemen or 'papalele' is dominant in determining prices. Most of them use their role to provide debt, because fishermen do not have many choices in marketing, except to middlemen. The results of the FGD show the importance of strengthening BUMDes institutions by focusing on aspects of village recognition and subsidiarity, because recognition of village rights and origins is an inseparable part of the institutional formation process. The development of the maritime sector as an adaptive opportunity is carried out by strengthening economic institutions that centralize the economic chain of local products to become centralized as governance that regulates transactions/interactions between individuals/parts. Transactions with external parties (outside governance) are influenced by the external institutional environment at a higher level. Changes in the external institutional environment affect transactions that occur between individuals/parts of governance. Transactions in governance are also influenced by the nature of individuals who tend to be opportunistic, self-interested, greedy, etc. In this institutional model, the involvement of BUMDes supported by skilled human resources and active stakeholder participation is essential to expand market access, improve product quality, and increase fishermen's income. Figure 2 presents an institutional development model.

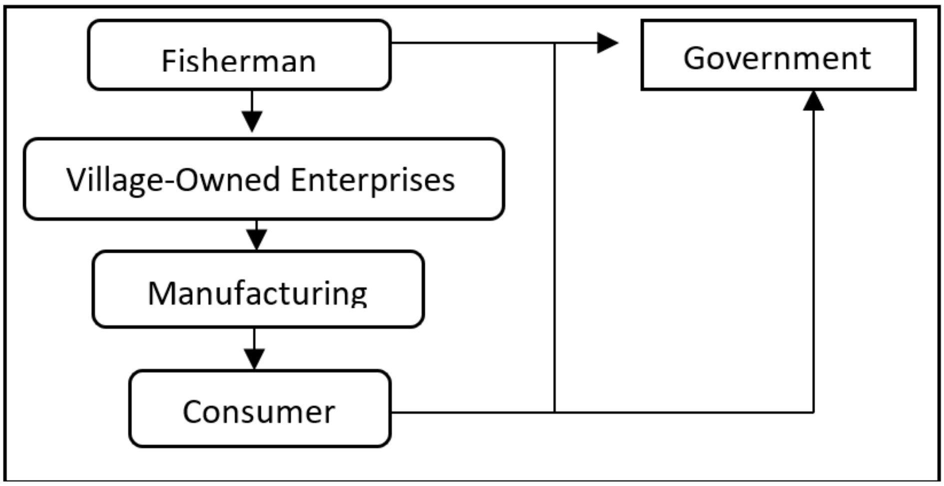

Figure 2. Institutional development model.

Based on the problems discussed, commitment is needed from each stakeholder to be able to optimize their role through institutional strengthening by optimizing the role of BUMDesa as well as financial institutions, universities and the government. The results of this study support the results of Arif & Pradini (2020), highlighting the importance of institutional strengthening to optimize fisheries resources, improve support facilities, enhance fishermen's business capital through government and private programs, and capitalize on market opportunities. The results of this analysis align with the study by Greve & Argote (2015), which discusses Ronald Coase's theory that transaction costs are influenced by institutional factors and individual economic choices (Coase 1993). This is also supported by Harold Demsetz's property rights paradigm, which emphasizes that efficient resource allocation depends on ownership structures that function as market institutions (Demsetz 1974).

Conclusions. Based on the consumer surplus and TEV calculations for shrimp and fish catches by 30 fishermen in a 1714.2 ha fishing area, the individual utility value is estimated at 410.68 USD per ha per year. The large economic potential of capture fisheries in Pariti waters is not supported by good capture fisheries institutional mechanisms. This has an impact on the distribution of fish catches and determining prices that are adjusted to market prices, to generate optimal income from the sale of caught fish.

Fishing business actors receive assistance in financing the fishing process and in distributing their catch at market-adjusted prices. This process can be carried out by creating an institutional mechanism for capture fisheries in Pariti village, so that the process of determining the price of caught fish and its distribution can be done without going through a third party. The capture fisheries institution through village-owned enterprises (BUMDes) aims not only to address pricing and distribution issues, but also to serve as a platform for information and product development through diversification, adding value to capture fisheries and supporting tourism.

Conflict of Interest. The authors declare that there is no conflict of interest.

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