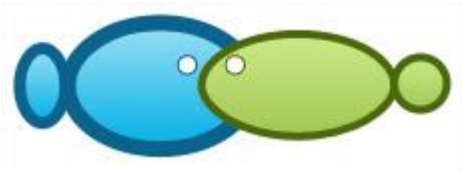

Determinants of fish farmers' welfare in brackish water pond culture in Indonesia: fish farmer terms of trade index

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Abstract. The present study was designed to estimate fish farmers' welfare and determine the factors that affect it. Fish farmer terms of trade (FTT) index and Tobit regression were applied on this purpose. Data from 200 fish farmers were collected with the cross-sectional technique. Results indicated that the FTT index value was 1.49, suggesting an adequate prosperity of fish farmers' average population. Moreover, results also showed that education, pond age, pond type, giant tiger prawn, Indian white prawn, speckled shrimp and milkfish variables are significantly associated with the FTT index. The fish farmers' welfare can be improved by providing education facilities, through incentives for recovering old age pond and by policy interventions promoting the adoption of the brackish water culture technologies.
Key Words: Tobit regression, Mahakam Delta, SDGs, poverty reduction.

Introduction. In the last two decades poverty alleviation has long been a concern for many countries. Progress on poverty alleviation has become one of the primary measures of a global sustainable development achievement. Poverty reduction was included in the 17 goals of Sustainable Development Goals (SDGs) stated by the 193 United Nations members in 2015 to conduct fundamental transformation leading a more sustainable prospect by the year 2030 (UN 2015). Although globally there is a good progress in alleviating poverty and reducing inequality, poverty remains the main priority that must be resolved by the developing countries, particularly in rural areas. Globally, nearly 689 million people still live in extreme poverty in 2017. On the other hand, about 48% of the global poverty rate originated from rural areas, with 62.2% of the world's poor people working in agriculture (World Bank 2020).

Indonesia also has a similar fate regarding the poverty issue. The poverty rate in this country declines slowly. In 2019, Indonesia counted 25.14 million poor people, which declined only at 2.06% from the previous year (Statistics Indonesia 2020). Nationally, 15.15 million poor people are living in rural or coastal areas (60.26%), compared to 9.99 million poor people living in the urban areas (39.74%). The government currently launched some programs to alleviate poverty, such as the Healthy Indonesia Programme, Family Welfare Deposit Programme, and Smart Indonesia Programme.

One of the poverty reduction alternatives in coastal areas is the aquaculture system. Aquaculture, including brackish water pond culture, has been widely promoted in developing countries for poverty reduction and food security by enhancing fish farmers' welfare. Aquaculture consists of the aquatic organisms farming in both inland and coastal areas, including fish, crustaceans, mollusks and aquatic plants (FAO 2020). Aquaculture

has direct and indirect benefits and contributes to the coastal communities' livelihood through new employment, food security and enhanced farmers' income (Edwards 2000; Stevenson & Irz 2009; Kassam & Dorward 2017). Previous studies have demonstrated the potential contributions of aquaculture to poverty reduction and food security (Murshed-e-Jahan et al 2010; Belton & Little 2011; Bene et al 2016). About 6.61% of the global food from aquaculture and fishing originated from Indonesia, whose aquaculture was reported at 5.43 million tons in 2018, as one of the sector's world leaders (FAO 2020). Indonesia is also one of the significant shrimp producers and contributes with 8.8% to the global shrimp production (Portley 2016).

In recent years, the indicator of farmer income changes has been used to measure the farmers' welfare. However, this indicator still has weaknesses in accurately describing the increase in their welfare due to the consumption needs as an expenditure variable not included. The Ministry of Marine Affairs and Fisheries of the Republic of Indonesia introduced the terms of trade indicator for fishers and fish farmers to measure their welfare. The fish farmer's terms of trade (FTT) has an advantage over the old indicator because it considers fish farmers' revenue and expenditure simultaneously. FTT describes the fish farmers' purchasing power to meet their daily needs (Bidarkota & Crucini 2000; Anna et al 2019). Moreover, although the aquaculture potential of poverty reduction and its contribution to the national income have been well documented, little has been done to investigate factors affecting the fish farmers' welfare as a proxy of poverty, in the brackish water pond culture, particularly in Indonesia coastal zones. Therefore, the study aimed to fill these gaps and to add knowledge in poverty studies by measuring the fish farmers' welfare, by using the FTT index and investigating the determinants of the fish farmers' welfare in brackish water pond culture.

Material and Method

Study area and data collection. The study focuses on fish farmers' welfare in the Mahakam Delta. This area is one of Indonesia's areas where brackish water pond cultures' fish farmers and fishers dominate communities' livelihoods (about 32% of the population) (Susilo et al 2017a). The Mahakam Delta covers an area of 5,200 km^2 and has five sub-districts with 20 villages. This area's total population is approximately 28,609 households (Central Bureau of Statistics of Kutai Kartanegara 2017; Susilo et al 2017b). The survey was conducted from June to August 2020 by face-to-face interviews using a questionnaire. Two hundred fish farmers were selected from five villages where brackish water pond culture is one of the main livelihoods. The five villages are Muara Badak, Salok Palai, Tani Baru, Muara pantuan, and Sepatin.

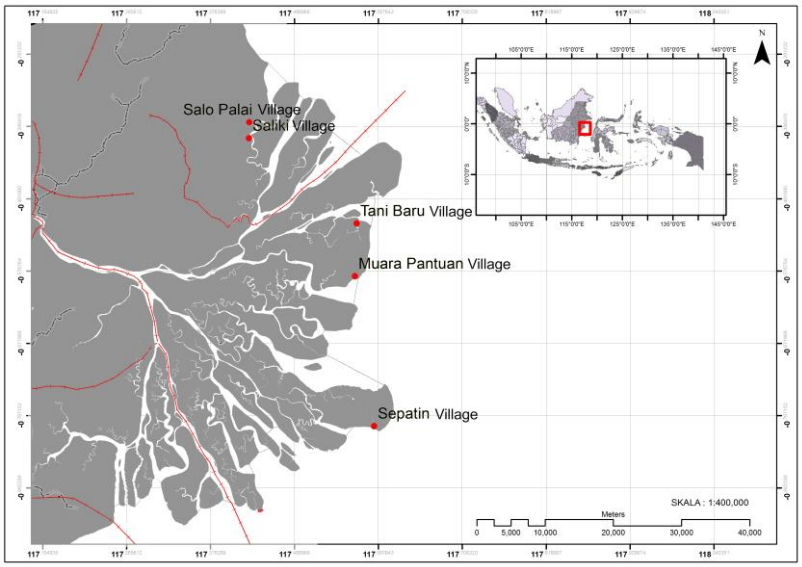

Figure 1. Study sites.

Welfare analysis. FTT, also known as subsistence terms of trade, is employed to measure fish farmers' welfare and is based on the fish farmers' ability to meet their subsistence needs. FTT indicates the ratio of the revenue obtained from brackish water pond culture and other sources to the expenditure, including the operational cost of brackish water pond culture and the consumption needs. FTT interpretation is that if the FTT is greater than or equal to one, fish farmers are prosperous and vice versa. FTT is formulated as follows (Basuki et al 2001):

$$FTT = \frac{\sum_{i=1}^{n} P_{xi} Q_{xi} + \sum_{i=1}^{n} R_i}{\sum_{i=1}^{n} P_{yi} Q_{yi} + \sum_{i=1}^{n} C_i}$$

Where:
FTT - the fish farmers' terms of trade;
P_{xi} - the brackish water pond culture commodity price;
Q_{xi} - the brackish water pond culture commodity quantity;
P_{yi} - input price of the brackish water pond culture;
Q_{yi} - the input quantity of brackish water pond culture;
R_i - revenue from sources other than brackish water pond culture;
C_i - farmer household expenses.

Determinants of fish farmers' welfare. Further, the Tobit regression is applied to estimate the factors affecting fish farmers' welfare. The formula can be expressed as follows (Tobin 1958):

$$FTT_i^{Tobit} = \boldsymbol{X_i'\beta} + e_i, \quad e_i \sim N(0, \sigma^2)$$

Where:
FTT_i^{Tobit} - an unobserved continuous dependent variable;
X_i' - a vector of independent variables;
β - a coefficients vector;
e_i - an independently distributed error term expected to be normal, with a zero mean and constant variance σ^2;
i - individuals in the sample.
The observed FTT_i^{Tobit} variable can be rewritten as follows (Tobin 1958):

$$FTT_i^{Tobit} = \begin{cases} \boldsymbol{X_i'\beta} + e_i & if\ FTT_i^{Tobit} > 0, \\ 0 & if\ FTT_i^{Tobit} \leq 0. \end{cases}$$

Results and Discussion

Descriptive statistics. Table 1 presents a descriptive analysis of the respondents. On average, the FTT index is 1.49, indicating the fish farmers in the study area can fulfill their daily needs, meaning that most of the fish farmers are adequately prosperous. The majority of the fish farmers are in the productive life shown by a mean actual age of 39.48 years. In general, the fish farmers' education level is the primary school or 7.98 years, indicating that working as a fish farmer does not necessitate any educational background. Generally, the experience of fish farmers is 14.14 years, suggesting that most of the fish farmers are experienced.

In terms of farm characteristics, the pond size is somehow large, as shown by an average surface of 11.33 ha. Moreover, the average pond age for the entire sample is 16.16 years. About 50% of respondents have adopted a polyculture system. The table further displays the mean production of giant tiger prawn (*Penaeus monodon*) of 177.53 kg year^{-1}. Similarly, the Indian white prawn (*Penaeus indicus*) and the speckled shrimp (*Metapenaeus monoceros*) average annual productions are approximately 247.75 kg and

154.34 kg, respectively. Furthermore, the average annual productions of milkfish (*Chanos chanos*) and crab (*Scylla* spp.) are 80.86 kg and 61.12 kg, respectively.

Table 1

Descriptive statistic of fish farmers

Variables	*Description*	*Mean*	*SD*
	Dependent		
FTT index	Fish farmers' welfare indicator	1.49	0.37
	Independent		
	Fish farmers' demographics		
Age	Actual age of fish farmers in years	39.48	10.54
Education	Formal education level of fish farmer in years	7.98	2.82
Experience	Number of years in fish farmer experience	14.14	8.12
	Farm characteristics		
Pond size	Brackish water pond area in hectares	11.33	7.34
Pond age	Age of brackish water pond in years	16.16	4.75
Pond type	Type of brackish water pond culture (1=polyculture, 0=otherwise)	0.50	0.50
	Production factors		
Giant tiger prawn	Giant tiger prawn production in kg year^{-1}	177.53	96.95
Indian white prawn	Indian white prawn production in kg year^{-1}	247.75	16.46
Speckled shrimp	Speckled shrimp production in kg year^{-1}	154.34	25.99
Milkfish	Milkfish production in kg year^{-1}	80.86	102.22
Crab	Crab production in kg year^{-1}	61.12	13.93

SD-standard deviation.

Fish farmer terms of trade index. Table 2 shows the FTT index calculation. As mentioned earlier, the FTT index is a fish farmers' welfare indicator referring to the ratio between the index of the price received by the fish farmers for their brackish water pond cultures' product and the index of the costs incurred. As shown in the table, the average fish farmers' revenue is valued at USD 7,336 year^{-1}, consisting of a brackish water pond (USD 6,821) and a non-brackish water pond (USD 514). The average fish farmers' expenditure is valued at USD 4,929 year^{-1}, consisting of brackish water pond costs (USD 3,214) and household expenses (USD 1,714). Thus, fish farmers' welfare using the FTT index is valued at 1.49, greater than 1, implying that most fish farmers are adequately prosperous.

Table 2

Fish farmer terms of trade estimation

Description	*Average (USD year^{-1})*
Revenue of brackish water pond	6,821
Revenue of non-brackish water pond	514
Brackish water pond costs	3,214
Household expenses	1,714
Fish farmer terms of trade	1.49

Factors influencing the fish farmers' welfare. In the Tobit regression, the FTT index's influence factors are defined as a proxy of fish farmers' welfare. Table 3 displays the estimated parameters and marginal effects from 11 independent variables, which are grouped into 3 factors: fish farmers' demographics, farm characteristics and production factors. The estimated Tobit regression is rated to be a good fit model, due to the value of the Likelihood Ratio-Chi-Square test (112.87) at a level of significance of 1%.

Of the 11 variables examined in the Tobit regression, seven variables influenced the FTT index. Based on the obtained results, only the education variable is statistically significant at 5% and has a positive coefficient for the fish farmers' demographics. In

terms of farm characteristics, the pond age has a significantly negative impact on an FTT index's increased probability. Meanwhile, the pond type is statistically significant at 10% and has a positive coefficient. Among the production factors, the giant tiger prawn, the Indian white prawn, the speckled shrimp and the milkfish variables have a positive coefficient with a statistically significant effect on the FTT index at 1%, 10%, 5% and 5%, respectively.

Education had a significantly positive relationship with the FTT index ($p<0.05$), indicating that well-educated fish farmers were more likely to have better welfare than the fish farmers who had a lower education level. Fish farmers' welfare is greatly influenced by an increased income and productivity, and by the technology adoption. Previous studies revealed that education was significant for those (Nguyen et al 2016; Amankwah & Quagrainie 2019; Yigezu et al 2018; Erwiantono et al 2020). The marginal effect showed that the probability of FTT index value increases by 1.24% when there is a single-year improvement in the education level.

Additionally, the pond age had a negative and significant influence on the FTT index ($p<0.05$). It demonstrated that fish farmers with older ponds had a lower chance of increasing welfare. The estimated marginal effect of the pond age variable indicated that the probability of FTT index value decreases by 0.5% when there is a single-year increase in pond age. This result might be due to a decline in the shrimp production after five years of brackish water pond operation and to a gradual acidification of mangrove soils in the study area. Previous studies revealed these phenomena (Avnimelech & Ritvo 2003; Noryadi et al 2006; Bosma et al 2012; Susilo et al 2018). Meanwhile, the pond type had a positive and significant effect on the FTT index ($p<0.10$), implying that the polyculture system adoption was more likely to increase the welfare level than the monoculture system. This finding is in line with Susilo et al (2019) and Erwiantono et al (2020), who reported that a polyculture system increased the fish farmers' annual income by USD 65.81 ha^{-1}. The marginal effects also showed that when a fish farmer decided to adopt a polyculture system, the probability of the fish farmers' FTT index value increased by 7.20%.

Table 3

Tobit model estimates of fish farmers' welfare

Variables	*Coefficient*	*Std. error*	*Marginal effect*
Fish farmers' demographics			
Age	-0.0004	0.0024	-0.0002
Education	0.0148**	0.0073	0.0124
Experience	0.0046	0.0031	0.0023
Farm characteristics			
Pond size	-0.0013	0.0029	-0.0002
Pond age	-0.011**	0.0048	-0.005
Pond type	0.1433*	0.0794	0.0720
Production factors			
Giant tiger prawn	0.0008***	0.0002	0.0007
Indian white prawn	0.003*	0.0016	0.0010
Speckled shrimp	0.0021**	0.0009	0.0010
Milkfish	0.0009**	0.0004	0.0004
Crab	-0.0011	0.0020	-0.0006
Constant	0.2332	0.4320	
Model diagnosis			
Log–likelihood	-29.43		
LR Chi Square	112.87***		
Pseudo R^2	0.65		
Observations	200		

***, **, and * indicate significance level at 1%, 5%, and 10%, respectively.

Giant tiger prawn, Indian white prawn, speckled shrimp and milkfish variables were significantly associated with the FTT index. The marginal effect of those variables was 0.07%, 0.10%, 0.10% and 0.04%, respectively. Interestingly, the crab variable was found not significant in the production factor and had a negative sign. Several reasons might explain this finding. First, the owner pond does not take advantage of the crab production: all profits of the crab production are given to the pond caretaker according to the initial agreements. Second, crabs are predators and one of the pests of a brackish water pond, which threatens shrimp seeds' growth. Third, crabs are one of the primary causes of water leakage by punching holes in pond dikes result in costly pond maintenance.

Conclusions. The present study aimed to estimate fish farmers' welfare by using fish farmer terms of trade and to determine the factors influencing these by applying the Tobit regression. The findings show that the FTT index value is 1.49, meaning that most of the fish farmers are adequately prosperous. Moreover, the probability of an increased welfare is affected by the fish farmers' demographics, the farm characteristics and the production factors. The study's findings are relevant for the stakeholders involved in decision-making to identify the factors that can improve the fish farmers' welfare. It is argued that with the improvement in the education level, the income and productivity of fish farmers will increase, which will have a positive influence on their welfare (provided that education facilities address the knowledge related to the brackish water culture). Since the pond age has a negative and significant impact on the fish farmers' welfare, incentives for recovering old age ponds should be paid by stakeholders to the farmers, in order to support an increased productivity, which indirectly improves the welfare of the fish farmers. The pond type is the only determinant farm characteristic, providing a positive influence on the fish farmers' welfare. Thus, policy interventions promoting the polyculture system to increase productivity and incomes could encourage farmers to adopt it.

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Conflict of interest. The authors declare no conflict of interest.

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