Technical and economical analysis of milkfish farming on the coastal area of Kendari Bay after sedimentation

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Abstract. This study aims to analyze the technical and economical aspects of milkfish (*Chanos chanos*) cultivation on Kendari Bay coastal area after sedimentation which has a negative impact on water quality that affects the production and income of fish farmers. This research was carried out in the area around Kendari Bay coastal area, with the consideration that around Kendari Bay coastal area, there are people who work as fish farmers and are affected by Kendari Bay sedimentation. The population samples in this study were all milkfish farmers around Kendari Bay, which were used as research respondents. The research variables consist of technical aspects and economic aspects of milkfish cultivation. Data analysis was carried out to find out the technical aspect of milkfish cultivation applied by farmers on Kendari Bay coastal area by describing the adaptation forms of fish farmers in dealing with the decline in the quality of Kendari Bay water. Quantitative analysis was conducted to find out the economical aspects of milkfish cultivation on Kendari Bay coastal area by using revenue analysis, cost analysis, income analysis, and revenue cost (R/C) ratio analysis. Based on the results of the study, it can be concluded that in order to maintain the production, milkfish farmers in Kendari Bay coastal area adapted to Kendari Bay conditions by modifying the technical aspects of milkfish cultivation to adjust to the poor conditions of Kendari Bay waters due to sedimentation by not changing water from time to time and relying on the ability of milkfish to adapt to changes in water quality parameters. The economical aspect includes revenue, production costs and income of milkfish farmers with an average income received of IDR 8,303,972/season. The income is still higher so that sedimentation that occurs around Kendari Bay which results in ecological damage in Kendari Bay area does not really disturb the income of milkfish farmers if cultivation techniques are carried out efficiently with an RC ratio of 4.6.

Key Words: farming, R/C ratio, milkfish, sedimentation, Kendari Bay.

Introduction. Indonesia has around 17,506 islands and 81,000 km of coastline (Welly 2008), and as many as 1,596,795 households work as fishermen, fish farmers, or marine aquaculture (BPS RI 2019). Coastal sustainability will affect the welfare of fishermen but it cannot be denied that various types of development activities in the coastal area have an impact on the environment which directly has a positive or negative influence on the socio-economic conditions of coastal communities (Limi 2018).

Kendari Bay is the estuary of several large rivers in Koa Kendari including Wanggu River. Te Wanggu River will always pose a threat of damage to Kendari Bay due to the high economic activity in the area and the direction of development carried out so far is still concentrated along Wanggu River and in Kendari Bay coastal area, so that the effects caused by development activities, lead to very severe sedimentation for Kendari Bay (Limi 2018).

Sedimentation is the process of forming sediments or sedimentary rocks caused by the deposition of material due to development and changes in land use so as to provide an influence on economic, social, and environmental conditions in coastal communities (Septi & Arif 2012). Based on the analysis using the Sediment Delivery Ratio (SDR) method, the sedimentation rate in Kendari Bay originating from Wanggu River is 110,113.49 m^3 $year^{-1}$, or 143,147.54 tons $year^{-1}$ (Catrin et al 2011).

Land conversion and sedimentation in Kendari Bay has led to a decrease in the water quality of the Bay. The measurements of water quality in Kendari Bay over a period of 3 years show that some water quality parameters have exceeded the allowed environmental quality standards in the period of 2016, 2017 and 2018 (Winnarsih et al 2016; Putra et al 2017; Limi et al 2018). The measurement results are sufficient to indicate that the water quality in Kendari Bay has decreased and is no longer to be used in aquaculture activities.

Based on the results of research conducted by Limi et al (2018), it is known that one of the marine aquaculture businesses that experienced a decline in production due to decreased water quality and Kendari Bay sedimentation was seaweed cultivation with current business efficiency of only 1.16. Such decrease of water quality is also sensed by fish farmers of Kendari Bay with the total fish pond area is 134.8 ha. Generally, fish farmers complained about the murky water of Kendari Bay when it would be used for cultivation activities especially during the rainy season. Such condition makes many fish farmers to stop the farming activities in which based on the results of the agricultural census, the number of fish farmers in Kendari Bay was 39 people (BPS RI 2013) and currently based on the field observation in 2018, the number of pond farmers were only 9 fish farms. As a result of the water quality decline in Kendari Bay, various forms of efforts were made by farmers to maintain fish farming by adapting to environmental changes and changing cultivation techniques and fish species being cultivated.

Fish farming in Kendari Bay coastal area is still productive due to the farmers' efforts to keep trying to survive and continue their fish farming business, which suggests that farmers can adapt to unfavorable environmental conditions for aquaculture activities by applying technical efficiency of cultivation to increase productivity and use milkfish (*Chanos chanos*) which is a type of fish that has a high level of adaptation to the environment (Tang et al 2010; Naca Project 2012; Bayang 2015). Furthermore, according to Naca Project (2012) and Yusuf et al (2014), milkfish is a desirable species for aquaculture in overcoming the impacts of climate change due to its high tolerance and adaptability to changes in salinity; it is also herbivorous so that benthic algae that grows from pond bottom is a suitable food; the milkfish growth rate is much faster than other herbivorous fish; and it has a high resistance to disease. According to Tama et al (2017), the reliability of milkfish fisheries will be able to increase the income of small and medium fish farmers.

According to Naca Project (2012), modification of the traditional culture system will provide the most practical profitability because it is not susceptible to climate change and utilizes benthic algae as food for milkfish. The modification of traditional milkfish cultivation systems carried out in Kendari Bay will be more economical based on the technical aspects of the location, maintenance process, harvesting of milkfish and traditional cultivation which is still feasible with a moderate level of production efficiency (Romadon & Subekti 2011; Suharno et al 2017; Handayani et al 2019) so that the cultivation process carried out by milkfish farmers in Kendari Bay is different from the semi-intensive and intensive cultivation techniques that have been recommended with high production costs (Sulu et al 2016).

According to Bank Indonesia (2008), traditional milkfish farming uses natural food and what is available on the pond as the main source of feed. Milkfish farmers in Kendari Bay utilize the herbivorous characteristics of milkfish by providing natural food (clap) as the main source of food and provide additional feed only when the availability of natural food is not sufficient to meet the needs of milkfish. According to Jaspe et al (2012), the combination of natural foods and supplementary feeding can be an alternative approach in milkfish production. Furthermore, Sumagaysay & Borlongan (1995) state that the greater the amount of feed given, the faster the growth of the milkfish, and result in higher milkfish production. The optimal use of natural food is intended to maintain water quality and reduce operational costs to be more technically efficient as stated by Chiang et al (2004) that increasing technical efficiency can increase milkfish productivity so that milkfish pond farming can survive and continue to produce at lower costs while the costs of agricultural inputs are high (Naca Project 2012) and provide maximum income for farmers who are negatively affected by the bay sedimentation. Based on the background outlined above, the objective in this study was to analyze the technical and economical aspects of milkfish cultivation in Kendari Bay coastal area after sedimentation which negatively affects the water quality that affects the production and income of pond farmers.

Material and Method. This research was conducted in January-April 2018 in Kendari Bay coastal area, with the consideration that there are people around Kendari Bay coastal area who work as fish farmers and feel the impact of Kendari Bay sedimentation. Map of the research location can be seen in Figure 1.

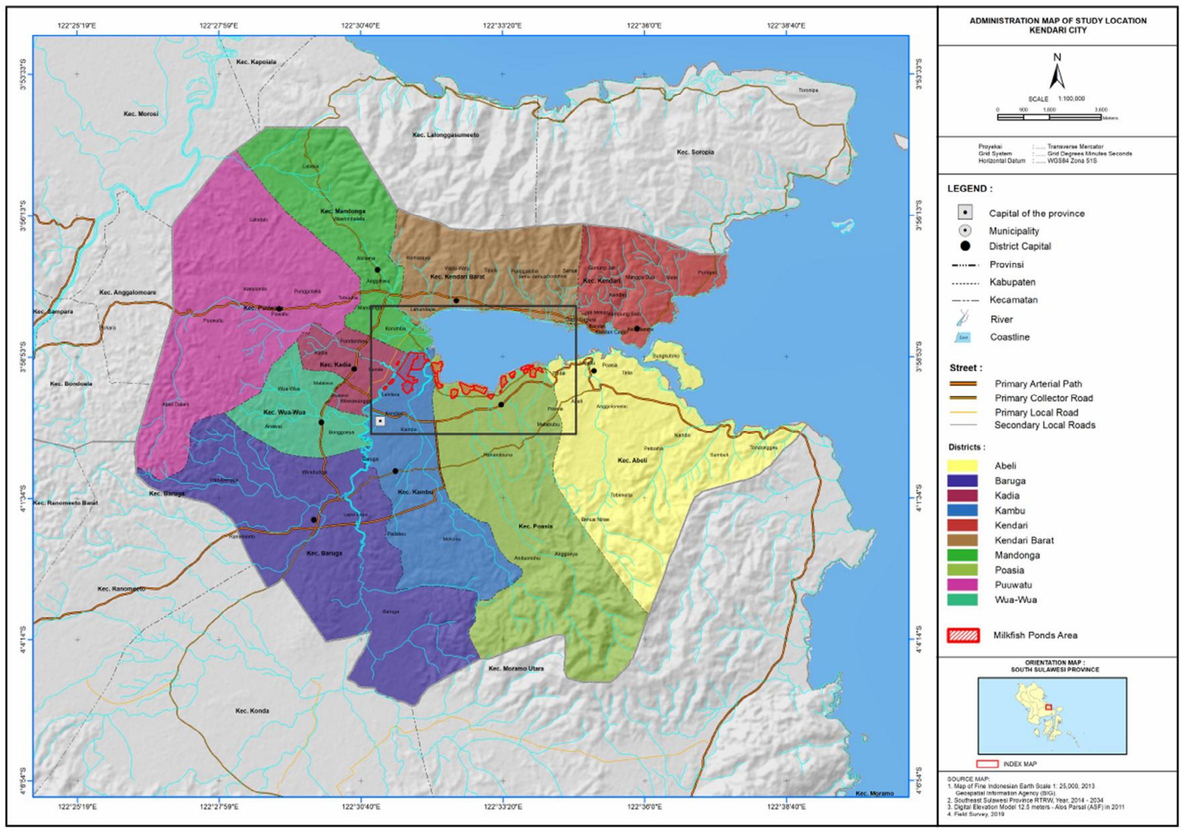

Figure 1. Map of milkfish cultivation area in Kendari Bay coastal area.

The population and sample in this study were all milkfish farmers around Kendari Bay, which were used as research respondents. The research variables consisted of technical aspects and economical aspects of milkfish cultivation. Data analysis was carried out to find out the technical aspects of milkfish cultivation applied by farmers on Kendari Bay coastal area by describing the adaptation forms of fish farmers in dealing with the quality decrease of Kendari Bay waters. Quantitative analysis was carried out to find out the economical aspects of milkfish cultivated by farmers on Kendari Bay coastal area.

Revenue analysis. Revenue analysis was carried out to find out how much revenue is obtained by milkfish farmers from the sale of milkfish production results with the formula according to Hernanto (1991) as follows:

$$TR = P \times Y$$

where: TR = total revenue (IDR/season);
P = price (IDR);
Y = total production (kg).

Cost analysis. Cost analysis was carried out to find out how much cost was used by milkfish farmers during the milkfish production process with the formula according to Hernanto (1991) as follows:

$$TC = FC + VC$$

Where: TC = total cost (IDR/season);
FC = fixed cost (IDR/season);
VC = variable cost (IDR/season).

Income analysis. Income analysis was carried out to find out the amount of milkfish farmer income in Kendari Bay coastal area after reducing the income received from the costs used by the formula according to Hernanto (1991) as follows:

$$I = TR – TC$$

Where: I = income (IDR/season);
TR = total revenue (Kg/season);
TC = total cost (IDR/season).

RC ratio analysis. RC ratio analysis was performed to determine the ratio between revenue and costs used during the production process with the formula according to Suratiyah (2006) as follows:

$$RC\ ratio = TR/TC$$

Where: RC = revenue cost (ratio);
TR = total revenue (IDR/season);
TC = total cost (IDR/season).

With the following criteria:

- if the RC ratio is greater than 1, the milkfish cultivation business is efficient;
- if the RC ratio is equal to 1, the milkfish cultivation business is not lost and no profit;
- if the RC ratio is smaller than 1, the milkfish cultivation business is not efficient.

Results and Discussion

Water quality. Water management is an important part of the overall cultivation business (Naca Project 2012). The results of Kendari Bay coastal water quality measurements can be seen in Table 1.

Based on Table 1, it is known that there has been a change in the parameters of water quality in the area of aquaculture/ponds and the central part of the Kendari Bay from 2000 to 2018. Based on the comparison of Kendari bay water quality with milkfish cultivation criteria according to Alifuddin (2003), Sulu et al (2016), and Prabakusuma (2016) we found that the conditions of Kendari Bay water quality parameters including pH, temperature, and brightness are still suitable for milkfish cultivation but in regard to the parameters of salinity and dissolved oxygen (DO), it is not suitable for milkfish cultivation. According to Sulu et al (2016), good salinity for the growth of milkfish is at 20 ppt salinity. In semi-intensive and intensive cultivation practices, actions can be taken to improve salinity and DO conditions through periodic water changes as proposed by the Naca Project (2012). Yusuf et al (2014) stated that water exchange from time to time by utilizing tidal conditions can be done to manage salinity and DO levels, but for milkfish farmers in the coastal area of Kendari Bay, it cannot be done at any time because Kendari Bay as the main source of water can only be used when turbidity decreases.

Table 1

The water quality in Kendari Bay

No	*Parameter*	*Unit*	*Water quality values at various measurement locations*											*Milkfish cultivation criteria*[g]	*Description*
			2000[a]		*2003*[b]		*2010*[c]		*2016*[d]		*2017*[e]		*2018*[f]		
			A	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*C*		
1	pH	mg L^{-1}	5.9	8.1	7.7	8.1	7.4	8.5	-	-	8.79	8.78	8.6	6.5-9	Feasible
2	Temperature	^oC	29.1	28.8	29.0	28.0	29.5	28.5	28	30	-	-	28.5	28-30	Feasible
3	Secchi disk reading	m	-	-	-	-	-	-	0.45	0.55	0.78	0.38	2	> 0.25	Feasible
4	Salinity	ppt	-	-	-	-	-	-	30	31	28.7	28.4	28-31	12-20	Not feasible
5	DO	mg L^{-1}	4.4	5.5	3.0	3.5	2.6	3.2	-	-	-	-	-	> 5	Not feasible

Note: A = area of cultivation / pond; B = middle part of the bay; C = area of seaweed cultivation;
Source: [a]Atlas Pesisir Teluk Kendari (2000), [b]Bapedalda (1996) *in* Alwi (2012), [c]Alwi (2012), [d]Winnarsih et al (2016), [e]Putra et al (2017), [f]Limi et al (2018), [g]Alifuddin (2003), [g]Bank Indonesia (2008), [g]Yusuf et al (2014), [g]Sulu et al (2016), [g]Prabakusuma (2016).

The conditions of poor water quality parameters (salinity and DO) at Kendari Bay can still be tolerated by milkfish because they have euryhaline properties that are able to adapt and survive in conditions of salinity and DO with a very wide range. Milkfish is a species of marine aquaculture that exhibits sufficiently large euryhaline properties but has a low tolerance for sudden drops in water temperature in winter (Swanson 1998; Naca Project 2012; Hu et al 2015). Furthermore, Alava (1998), Naca Project (2012), and Hanke et al (2019) stated that a decrease in temperature outside the optimal range can reduce DO in water and increase water salinity which can trigger stress responses in milkfish so that the growth of milkfish will decrease and will affect the fish farming productivity.

Land management and maintenance. The processing of milkfish farming is greatly influenced by the area of milkfish farming and also will greatly affect the density of milkfish in each production. The wider the farm owned by the farmer, the greater the opportunity for the farmer to obtain higher production and income. The area of ponds owned by farmers is on average of 1.5 ha and classified as farmers with a medium land area (Hernanto 1991). Not all farms owned by farmers are used for milkfish cultivation activities because the water conditions that are good for milkfish growth are very limited, especially during the rainy season with high turbidity levels.

The milkfish farmers in Kendari Bay carry out land management and water management only at the beginning of the cultivation and when the Kendari Bay water conditions are not muddy. The pond is filled with water only at the beginning of cultivation after tillage and fertilizing to grow natural food and dried only for harvest. Farmers do not change the water during the milkfish maintenance process due to turbid bay water conditions. The main flood gates and drains are not used to control the flow of water and are only used when harvesting. Traditional milkfish ponds on Kendari Bay coastal area have a main water gate which is the main water entrance that supplies the entire pond system and secondary water gates control the water supply into the maintenance pond.

Fertilizer is provided to grow natural food (*klekap*) which is a food for milkfish. The Naca Project (2012) states that *klekap* contains about 6-20% protein and is preferred by all sizes of milkfish. Furthermore, Naca Project (2012) states that other natural ponds food that are important for milkfish are "moss" (filamentous green algae) and phytoplankton that float on ponds. Yusuf et al (2014) explains that milkfish have a habit of taking food from the top layer of the seafloor, in the form of microscopic plants, whose structure is the same as the *klekap* in a pond consisting of gritty algae (Bacillariophyceae), bacteria, protozoa, worms, and tiny shrimps, or commonly called "microbenthic biological complex" so that in ponds, milkfish food is adjusted to the opening of the mouth and adapted for aquaculture activities, which utilizes the nature as natural food.

Milkfish seed is a production facility that is absolutely necessary for farming and one of the factors that determine the high and low of production that will be produced in the milkfish cultivation business. In some countries, milkfish production is faced with seed limitations, the most significant of which is the unpredictable and limited supply of seeds (Martinez et al 2006). Naca Project (2012) states that milkfish seeds are usually stocked into rearing ponds of different sizes. The number of milkfish seeds used by farmers can affect the products produced, assuming that the quality of the seeds is good and the treatment is in maintenance. The average amount of milkfish used by farmers is 3,600 ha^{-1}. This amount is still far from the ideal number where according to Sunarto & Husaeni (2014) the number of seeds per half a hectare in Bali can reach 2,500 or around 5,000 head ha^{-1} and according to Bank Indonesia (2008) the density of traditional pond stocking reaches 5,000 head ha^{-1} and according to Yusuf et al (2014), and Handayani et al (2019) for a production target of 1.5 tons with a maintenance period of 4-6 months, seeds are needed around 7,500-10,000 for 10 cm logs. The use of seeds is far from recommended due to the limited availability of natural food without using artificial feed as additional feed while the cultivation time can reach 4-6 months. Naca Project (2012) also states that milkfish cultivation cycle to reach market size usually lasts for 4-5 months and growers can produce up to two seasons per year. Furthermore, Yusuf et al (2014) said that the maintenance of milkfish in an enlarged pond last for 2-3 months, until the milkfish is consumed (4 fish kg^{-1}). Meanwhile, according to Bank Indonesia (2008), milkfish consumption generally weighs around 3 per kg. Milkfish farmers do not use artificial feed to save costs, in addition to maintain the quality of pond water that cannot be replaced at any time due to poor quality of Kendari Bay water so that the replacement of pond water is done only when Kendari Bay water is not cloudy during the dry season due to during the rainy season, Kendari Bay water becomes turbid due to the Wanggu river flow which carries sediment particles.

Production. Martinez et al (2006) state that milkfish production mostly come from aquaculture, and every fish farmer always strives so that the farms they manage can provide maximum results, therefore they are able to meet the needs of their family. The success of fish farmers in farming is the result of the collaboration of the factors of production, the high or low of production obtained depends on the ability of farm farmers to use the factors of production as efficiently as possible. The average production of milkfish cultivation in Kendari Bay can be seen in Table 2.

Table 2

The average production of milkfish on the coast of Kendari Bay

No	*Variables*	*Unit*	*Average*
1	Production (Y)	kg ha^{-1} $season^{-1}$	1,107

Source: Processed primary data, 2019.

Based on Table 2, it is known that milkfish production is 1,107 kg ha^{-1} $season^{-1}$ with a size between 300 and 350 gr. Tristian (2011), Yusuf et al (2014), and Handayani et al (2019) mention that good pond waters and natural feed (*klekap* and moss) available in inadequate conditions, within a maintenance period of 3-6 months will make the milkfish can reach sizes of 300-350 g $head^{-1}$ or more (3 heads kg^{-1}) and milkfish can be harvested in stages (selective harvesting). Each farm has a varying amount of production because the average number of production factors used in farming also varies. Variation in the amount of production obtained by milkfish farmers is due to differences in the amount of capital use, pond area and number of seedlings cultivated. Farmers who are able to process ponds more broadly, more production is obtained, the area of aquaculture ponds is always supported by greater capital ownership, the wider the farms are cultivated, the greater the cost to buy inputs in the form of seeds, fertilizers, feed, pesticides and more labor costs. Indra (2016) claims that to get efficiency, milkfish farmers must optimize production factors significantly.

Economic analysis

Selling price and revenue. Selling prices affect income. The higher the selling price, the more the income obtained. The average selling price obtained by milkfish farmers in Kendari Bay can be seen in Table 3.

Table 3

The average price of milkfish on the coast of Kendari Bay

No	*Variables*	*Unit*	*Average*
1	Price (P)	IDR kg^{-1}	11,000

Source: Processed primary data, 2019.

Based on Table 3, it is known that the average price of milkfish on Kendari Bay coastal area is IDR 11,000/kg. Bank Indonesia (2008) mentions that the price of normal size milkfish (3-4 heads kg^{-1}) reaches IDR 8,000/kg and continues to increase in price from year to year. The selling price of milkfish received by farmers influences the income in each season. The size of the acceptance of milkfish farmers from farming is influenced by the amount of milkfish production obtained by farmers. Thus, if production and prices are high, milkfish farmers have the opportunity to obtain greater revenues and vice versa, if production and prices are low, then the income received by milkfish farmers will also be low. The average acceptance of milkfish farmers on Kendari Bay coastal area is IDR 10,603,222 per six months of the cultivation process which is the result of the multiplication of the total production and prices obtained by the milkfish farmers as a whole.

Production cost. Production costs represent the total value spent by milkfish farmers during the six months (one season) milkfish production process. The production costs incurred by milkfish farmers can be seen in Table 4.

Table 4

The average production cost of milkfish farmers on the coast of Kendari Bay

No	*Variables*	*Unit*	*Average*
1	Variable cost (VC)	IDR ha^{-1} $season^{-1}$	1,662,111
2	Fixed cost (FC)	IDR ha^{-1} $season^{-1}$	637,139
3	Total cost (TC)	IDR ha^{-1} $season^{-1}$	2,299,250

Source: Processed primary data, 2019.

Based on the data in Table 4, it shows the average value of costs used by fish farmers in the production process of IDR 2,299,250 ha^{-1} $season^{-1}$. Such costs can be divided into two types of costs namely variable costs with an average value of IDR 1,662,111 ha^{-1} $season^{-1}$ and fixed costs with an average value of IDR 637,139 ha^{-1} $season^{-1}$. Fixed costs incurred by milkfish farmers include farm tax, farming equipment, depreciation of equipment and variable costs including costs for seeds, fertilizers, feed, pesticides, and pond preparation costs. Costs incurred by milkfish farmers are influenced by the area of ponds managed, the wider the farms owned by farmers, the greater the costs incurred.

Income. The income of milkfish farmers is the difference between revenue and all costs incurred by milkfish farmers for one season (6 months). The size of the income received by milkfish farmers depends on the size of the income received by farmers. The size of the income received is a measure of the success of farming managed by milkfish farmers. The amount of income obtained by milkfish farmers can be seen in Table 5.

Table 5

The average income of milkfish farmers on the coast of Kendari Bay

No	*Variables*	*Unit*	*Average*
1	Revenue (R)	IDR ha^{-1} $season^{-1}$	10,603,222
3	Income (I)	IDR ha^{-1} $season^{-1}$	8,303,972
4	RC	Ratio	4.6

Source: Processed primary data, 2019.

Based on Table 5, it shows that the average income earned by fish farmers amounted to IDR 8,303,972. This result was obtained from a reduction in average revenues of IDR 10,603,222 ha^{-1} $season^{-1}$ with an average total cost spent as much as IDR 2,299,250 ha^{-1} $season^{-1}$. Yusuf et al (2014) claim that milkfish farmer acceptance in one production cycle can reach IDR 6,800,000 ha^{-1} $season^{-1}$ with a total cost of IDR 3,145,000 ha^{-1} $season^{-1}$. The size of the income received by farmers for each harvest can be influenced by the area of the pond, the amount of production and the selling price. The income received by fish farmers must have been reduced by all costs used during the production process. The costs referred to in this study are variable costs, namely costs incurred for the procurement of seeds, fertilizers, feed, pesticides, and labor, while the fixed costs are procurement of equipment in the milkfish cultivation business and pond tax payment.

According to Bank Indonesia (2008), the gross income of milkfish farmers reaches IDR 9,300,000 ha^{-1} $season^{-1}$. The amount of farmer's income on the Kendari Bay coastal area is IDR 8,303,972 ha^{-1} $season^{-1}$ in one production and for some farmers who rent land to do farming business, they must share the income obtained with the land owner so that the net income received by farmers ponds can still be reduced. If the income is compared with the Minimum Wage Standard of Southeast Sulawesi Province (UMP) in 2018, amounting to IDR 2,177,052, the income of farmers is greater than the Southeast Sulawesi UMP which is the minimum standard for one's income. Based on the results of the analysis obtained an RC ratio value of 4.6 so that every IDR 1,000,000 costs incurred by the milkfish farmers will receive an income of IDR 4,600,000.

Conclusions. Based on the results of the study, it can be concluded that to maintain the production, milkfish farmers in Kendari Bay coastal area adapted to Kendari Bay conditions by modifying the technical aspects of milkfish cultivation to adjust to the poor condition of Kendari Bay waters due to sedimentation by not changing water from time to time and rely on the ability of milkfish to adapt to changes in water quality parameters. Economic aspects include revenue, production costs and income of milkfish farmers with an average income received of IDR 8,303,972/season. The income is still higher so that sedimentation that occurs around Kendari Bay which results in ecological damage in the Kendari Bay area does not really interfere with the income of milkfish farmers if cultivation techniques are carried out efficiently with an RC ratio of 4.6.

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