Asian Journal of Fisheries and Aquatic Research

Volume 21, Issue 5, Page 40-48, 2023; Article no.AJFAR.97902
ISSN: 2582-3760

Productivity Analysis of Fish Farming in Floating Net Cages in Lake Toba (Case Study in Pangururan Subdistrict, Samosir District, Indonesia)

Wenny A. Siringoringo [a*], Iwang Gumilar [a], Atikah Nurhayati [a] and Asep Agus H. Suryana [a]

[a] Department of Fisheries, Faculty of Fisheries and Marine Science, Padjadjaran University, West Java, Indonesia.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJFAR/2023/v21i5554

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/97902

Original Research Article

Received: 02/02/2023
Accepted: 23/03/2023
Published: 25/03/2023

ABSTRACT

Lake Toba has fishery potential that needs to be managed properly, one of which is the use of Lake Toba for fish farming with floating net cage systems. This study aims to analyze the productivity of carp and tilapia aquaculture on the floating net cages system in Lake Toba, Pangururan District, Samosir Regency, North Sumatra Province and what factors affect productivity, This research was conducted from June 2022 to January 2023 in Pangururan District, Samosir Regency, North Sumatra Province using the case study method. Respondents in this study were 60 carp and tilapia farmers. The data collected were primary data and secondary data. Data were analyzed using productivity analysis with Microsoft Office Excel 2010, while multiple linear regression analysis was analyzed using the 2019 minitab program. The results of the analysis show that the average value of carp productivity is 22.32 kg/m^3/season, this value is

**Corresponding author: Email: wenny17003@mail.unpad.ac.id, wennysiringoringo23@gmail.com;*

higher than the value of tilapia productivity which has a value of 17.2 kg/m^3. The results of multiple linear regression statistical tests obtained factors that affect the productivity of floating net cages carp farming on Lake Toba, Pangururan District, Samosir Regency, North Sumatra Province are feed and pond volume, while the factors that affect the productivity of floating net cages tilapia farming on Lake Toba, Pangururan District, Samosir Regency, North Sumatra Province are seeds, feed, pond volume, and age of cultivators.

Keywords: Carp; tilapia; productivity; farmers.

1. INTRODUCTION

Indonesia is the largest archipelago in the world that has enormous potential for marine and fisheries resources. In 2018, Indonesia was the second largest aquaculture producer in the world, with a volume of 14.7 million tons of which 9.3 million tons of seaweed and 5.4 million tons of fish [1]. One of the provinces that has promising fisheries prospects is North Sumatra. Total cultured fish production increased by 1.54 percent from 223,604.95 tons in 2017 to 243,829.47 tons in 2018.

One of the priorities of the Regional Medium-Term Development Plan of North Sumatra Province in 2019-2023 is to increase agricultural and tourism competitiveness which is outlined through a program to increase production, added value and competitiveness of fishery commodities [2]. The fishery activity that is developing in Lake Toba is the cultivation of floating net cages. Lake Toba has a multi-sectoral role, both for the benefit of the local community and interests that are national, maybe even international [3].

One of the utilization of Lake Toba is for the fish farming business of the floating net cage system. Floating net cages are one of the ideal aquaculture containers by applying intensive system cultivation patterns, which are placed in deep water bodies, such as reservoirs, lakes, and the sea. Fish species that are widely cultivated are carp and tilapia, in addition to the economic price of this fish are also favored by the community and carp are widely used as signs that have very important meanings and functions in local traditional culture (Batak cultural marriage ceremony) [4]. The phenomenon of floating net cages first appeared in Lake Toba in 1988 [3]. Fish production from floating net cages in 2012 reached 75,559 tons consisting of 40,009 tons of tilapia from PT Aquafarm Nusantara 1,800 tons of tilapia from PT Arta Lautan Mulia and 33,750 tons of tilapia and carp from the community [5].

Based on the results of research [6] regarding the analysis of rearing business of carp (*Cyprinus carpio*) in floating net cages in Parit Mayor Village, East Pontianak Subdistrict, it was concluded that the productivity of the rearing business in floating net cages in Parit Mayor Village has not reached the standardized limits. This is caused by the production factors of pool volume, seeds, feed, labor and medicines that have not been utilized optimally so that the yields have not met standard production targets.

Aquaculture is one of the sectors that can be expected to improve the welfare of the community because the future growth of aquaculture can stabilize the supply of fish in the fisheries system for national, regional and world food, create jobs, and keep fish available at a decent price level for resource-poor consumers. The floating net cage system underwent several phases of change in accordance with the ecological, technological, economic, social and regulatory conditions prevailing in the management of the Cirata reservoir [7].

Productivity as a comparison between the totality of expenditure at a certain time divided by the totality of inputs during that period, thus, the measure of productivity success is seen from two sides at once, namely: the input side and the output side [8]. The advantage of floating net cage system fish farming is that this system is one of the efficient and effective ways of cultivating fish enlargement. Floating net cages use a minimal media area but the yield can be multiplied without having to add large costs.

Considering the importance of aquaculture activities in floating net cages, a study was conducted to analyze the productivity of floating net cage aquaculture in Lake Toba (case study in Pangururan District, Samosir Regency). Research on fisheries productivity is also still rarely researched. This research is expected to provide benefits for related parties as a consideration in supporting fisheries management in Lake Toba and provide

information for readers regarding the productivity of carp and tilapia enlargement.

2. METHODS

2.1 Time and Place

This research on productivity analysis of floating net cage farming was conducted at carp and tilapia fish farmers in the floating net cage system on Lake Toba, Pangururan District, Samosir Regency, North Sumatra. This research was conducted from July 2022 to January 2023.

2.2 Research Methods

The data sources used in this research are primary data and decunser data. Primary data was obtained from questionnaires and direct interviews with farmers. Secondary data in this study were obtained by downloading data from the websites of related agencies and the central statistics agency, as well as from previous research. The sampling method used was purposive sampling method with the number of research samples as many as 40 carp farmers and 55 tilapia farmers.

2.3 Data Analysis Methods

Data were analyzed using Microsoft Office Excel 2010 and Minitab 2019 programs. Feed conversion ratio and productivity calculations using Microsoft Office Excel 2010, while multiple linear regression analysis was analyzed using the Minitab 2019 program.

Feed Conversion Ratio is a measure that states the ratio of the amount of feed needed to produce 1 kg of cultivated fish [9]. Feed conversion ratio is the amount of feed given to fish fry based on fish weight and can be calculated by the formula [10].

$$FCR = \frac{F}{Wt - Wo}$$

Where:

FCR = Feed Conversion Ratio
F = Weight of feed given
Wt = biomass of test fish at the end of the study
Wo = Biomass of test fish at the beginning of the study

Productivity is seen from the difference between the amount of expenditure and input expressed in a general unit [8]. Production data is the yield of fish obtained directly from farmers while the volume of floating net cages is calculated based on the area of the pond multiplied by the height of the pond, so that productivity can be formulated as follows.

$$\text{Productivity}(kg/m^3) = \frac{\sum Production\ (kg)}{\sum Volume\ of\ floating\ net\ cage\ (m^3)}$$

Factors affecting the productivity of floating net cage aquaculture can be analyzed using Multiple Linear Regression. Regression analysis is a statistical analysis tool that utilizes the relationship between two or more variables [11]. The equation is formulated as follows.

$$Y_{1,2} = a + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \varepsilon$$

Where :

$Y_{1,2}$: Carp and tilapia productivity (kg/m^3)
A : costant
X_1 : The amount of fish seeds (kg)
X_2 : The amount of fish feed (kg)
X_3 : Volume of floating net cage (m^3)
X_4 : Age (years)
X_5 : Education
X_6 : Length of cultivation experience (years)
X_7 : Amount of labor
β_1 : The amount of fish seeds regression coefficient
β_2 : The amount of fish feed regression coefficient
β_3 : Volume of floating net cage regression coefficient
β_4 : Age regression coefficient
β_5 : Education regression coefficient
β_6 : Length of cultivation experience regression coefficient
β_7 : The amount of labor regression coefficient
ε : Error

3. RESULTS AND DISCUSSION

3.1 General Situation

Floating net cage aquaculture is located in Pangururan District, Samosir Regency, North Sumatra Province. The area of Samosir Regency is 254,715 ha consisting of a land area of 144,455 ha (Samosir Island land area of 69,280 ha plus Sumatra Island land area of 75,175 ha) and Lake Toba waters area of 110,260 ha and is located in the Bukit Barisan mountain range. Samosir Regency consists of 9 sub-districts, 6

urban villages and 111 villages. Pangururan sub-district has an area of 121.43 km^2 with a population of 35,178 people. Pangururan sub-district is the capital of the district and is located 108 km from Medan City (the provincial capital). Geographically, pangururan sub-district is located on the boundaries of 20321 - 20451 LS and 980421 - 980 471 BT. The boundaries of Pangururan District are to the east by Ronggur Nihuta District, to the west by Sianjur Mulamula District, to the north by Simanindo District, to the south by Palipi District.

Samosir Regency is classified as a wet tropical climate with temperatures ranging from 170C-290C and an average air humidity of 85%. The topography of the Lake Toba region is generally hilly, valley, and coastal areas vary sloping, steep and very steep which are scattered in the Bukit Barisan area. The Lake Toba region is located in the Bukit Barisan area with altitudes ranging from 900-3000 meters above sea level. The lake water surface area is approximately 1,100 km^2 and the water content is 2,860 million tons. The Lake Toba region is included in the Asahan watershed, which empties into the east coast of North Sumatra.

3.2 Characteristics of Respondents

Respondents used in this study were carp and tilapia fish farmers in floating net cages in Pangururan District, Samosir Regency, North Sumatra Province. Based on the data obtained, the age of farmers in Lake Toba ranges from 26-81 years. According to Labor Law No.13 of 2003, the age of 15-64 years is the age of labor (manpower) that can produce goods and services. Farmers in Lake Toba who have productive age ranged from 26-64 as many as 55 people or 91% of the total respondents.

Based on data from 60 respondents, the percentage of farmers who have the most work experience is > 10 years, namely 47% as many as 28 people. The next percentage of cultivators had work experience ranging from 10-20 years at 42% as many as 25 people, followed by work experience between 21-30 at 10% as many as 6 people and the remaining 2% above 30 years as many as 1 person.

Based on the data, it is also known that cultivators who have an elementary school education level are 1 person or 1.6%, cultivators who have a junior high school education level are 3 people or 5%, cultivators who have a high school education level are 49 people or 81.65%, and cultivators who have a bachelor's degree are 7 people or 11.6%. Education is one of the factors that determine the success in the application of new technology in the floating net cages system. Education provides provisions for cultivators to be able to better understand their roles and functions in cultivation, so as to anticipate problems that arise in cultivation. The higher a person's educational base, the easier it will be for him to recognize problems in his work [12].

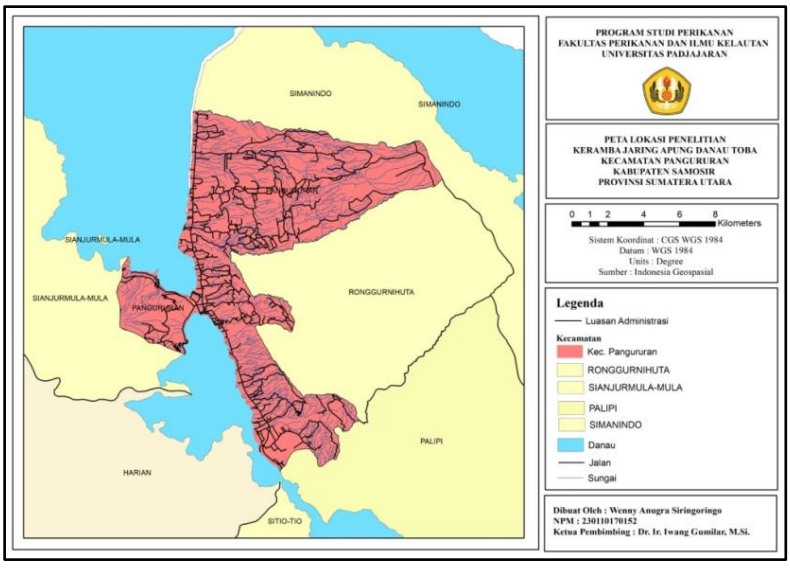

Fig. 1. Map location of research

3.3 Cultivation Technique

The carp and tilapia enlargement cultivation of floating net cages systems carried out in Pangururan District is a cultivation with a monoculture system (single layer), where fish cultivation is carried out by keeping only one type of fish in one pond. Fish farmers in Lake Toba mostly choose to cultivate tilapia because the price of seeds is relatively cheap compared to carp, more resistant to unfavorable water conditions, and faster harvesting. Carp rearing time is generally 12 months while tilapia is 6 months. Fish farmers in a year can do 1 growing season of carp cultivation and 2 growing seasons of tilapia cultivation.

In general, floating net cages in Lake Toba is made of wooden and iron frames made in the form of rectangles using iron drums and plastic drums as floats so that they can float above the water surface. The net used is a polythelence net which is useful for accommodating fish. The anchor is used as a tool to keep the floating net frame from moving according to the water current. Usually anchors use stones tied using a rope and placed at the corners of the raft, but there are also farmers who use cast cement as an anchor.

Feed is an important factor in floating net cages fish farming. Feeding serves to accelerate the growth rate of fish. Most farmers in Lake Toba use floating feed with trademarks, sapphire, topaz, sinta, global feed, comfeed, hi pro vite 781-1 which is 30 kg per sack. The feed used is pellet feed. The price of the feed used varies depending on the brand, generally 30 kg of feed IDR.290,000-IDR.330,000. Feeding is done on average twice a day, in the morning and in the afternoon.

3.4 Productivity Analysis

The carp produced has one cropping cycle of 12 months, while tilapia has one cropping cycle of 6 months. Farmers who produce carp in one pond unit produce a range of 0.7-4.2 tons, while farmers who produce tilapia can produce a range of 0.6 - 3 tons. Production and productivity results in Pangururan Subdistrict can be seen in Table 1.

Based on Table 1, carp and tilapia production per rearing season (kg) amounted to 594,200 and 930,750. The average productivity of carp and tilapia (kg/m^3) is 22.3 and 17.2, and the range of carp and tilapia productivity (kg/m^3) is 12.5 - 31.25 and 9.9-25.4. It can be interpreted that carp and tilapia enlargement business farmers in floating net cages will obtain 22.3 kg and 17.2 kg from every 1 m^3 of floating net cage volume.

The amount of tilapia production in Pangururan District is still considered low. Based on research [13] on the study of the production of floating net cage businesses in the Haranggaol village of Simalungun Regency, the amount of tilapia production was 9,428.16 tons / season or 18,856.34 tons / year and carp production was 72.84 tons / season or 145.68 tons / year. The magnitude of this production figure occurs because of the density of the existing floating net cages so that it causes the production to increase along with the increase in the scale of the cultivation unit.

Based on Table 1, the average value of carp productivity is 22.32 kg/m^3, this value is higher than the value of tilapia productivity which has a value of 17.2 kg/m^3. The range of carp productivity is 12.5 - 31.25 kg/m3, while the range of tilapia productivity is 9.92 - 25.4 kg/m3. These values are the minimum and maximum values of fish production produced in 1 growing season. Compared to research [14] on "Productivity Analysis of Floating Net Cage Aquaculture in Cirata Reservoir (case study in mande sub-district, cianjur district)" suggests that the level of carp productivity is 53.22 kg/m2, while tilapia productivity is 10.10 kg/m3. So that the value of carp productivity in Pangururan District, Samosir Regency is still considered low. While the value of tilapia productivity is considered high.

Table 1. Production, FCR, and Productivity in Pangururan District

Productivity	Carp	Tilapia
Production by season (kg)	594.200	930.750
Production by year (kg/year)	594.200	1.861.500
Average food convetion rasio	1,57	1,36
Average productivity (kg/m^3)	22,3	17,2
Range of productivity (kg/m^3)	12,5 - 31,25	9,92 - 25,4

3.5 Analysis of Factors Affecting Productivity

The field data in this study have been tested with a series of classical assumption tests using the Minitab 2019 and statistical data processing program which consists of normality test, multicollinearity test, and heteroscedaticity test.

Based on the normality test in this study using the P-Plot output graph and the Kolmogrov Smirnov test. If the distribution of data is spread evenly around the diagonal line and no data is too far off, then it can be said that the data is in the regression model it passes the assumption of normality [15]. This research data meets these criteria. Testing the data using the Kolmogrov Smirnov test produces a value of 0.150. It can be said that the data used is normally distributed because the value is >0.05. The heteroscedasticity test was carried out to find out whether there is an inequality of variance from the residuals in the regression model by looking at the Scatterplot graph of the regression results, if the points on the Scatterplot spread evenly above and below the number 0 on the Y axis and do not determine a particular pattern, then the regression model does not occur heteroscedasticity [16]. The research data meets the requirements of the Scatterplot chart. The results of the heteroscedasticity test can also be seen from the table above which shows that the significance value of t count > 0.05 means that there is no heteroscedasticity. One way to measure the presence or absence of multicollinearity is to look at the tolerance value or variance inflation factor (VIF) where the tolerance value limit is 0.10 or the VIF value is 10 [17]. Based on the data analysis conducted, it was found that the research data met the criteria for tolerance values > 0.1 and VIF < 10.

Multiple linear regression analysis is intended to determine the effect of independent variables on the dependent variable. Factors that are thought to affect the productivity of aquaculture of the floating net cages system in Pangururan District are seeds (X_1), feed (X_2), pool volume (X_3), age (X_4), education (X_5), cultivation experience (X_6), and labor (X_7). The results of multiple linear regression equations are as follows.

$$\text{Productivity } (Y_1) = 25{,}72 + 0{,}000697\ X_1 + 0{,}004516\ X_2 - 0{,}1811\ X_3 - 0{,}0488\ X_4 - 0{,}179\ X_5 + 0{,}0610\ X_6 - 0{,}23\ X_7$$

Table 2. Regression results of carp productivity

Variable	P-Value	Description
X_1	0,324	Seed
X_2	0,000	Feed
X_3	0,000	Pond size
X_4	0,157	Age
X_5	0,438	Education
X_6	0,331	Experience
X_7	0,828	Labor
R-square(adj)	74,67%	
N	40	

Based on Table 2, it can be seen that the variables that significantly affect carp productivity are feed and pond area and age. The regression results have an R-Suare (adjusted) value of 74.67% which means that the factors that affect productivity are 74.67% while the remaining 25.33% are other factors outside the factors mentioned. These other factors are other things outside of the physical factors of cultivation activities in floating net cages.

The results of the analysis show that the seed variable has no significant effect on productivity. This occurs because of the high mortality of carp seeds due to Koi Herper Virus (KHV). The carp virus attack known as Koi Herpes Virus (KHV) attacked Lake Toba in October-November 2004. The KHV attack is still continuing until now although fish mortality has decreased. KHV causes damage to the gills which begins with the pallor of the color of the gills on the gill sheets and some even rot.

Carp mortality can also be caused by seed quality. Referring to [18], that the stocking density of good carp seeds in floating net cagesis required to be 140 fish/m3 and in quality, good seeds for stocking in floating net cages are seeds that have reached a size of 80-100 gr / tail or 12-15 cm in size. Meanwhile, the size of carp seeds used by farmers is 3-5 cm with a stocking density of 55/m3. At this size the seeds have not been able to adapt optimally and the stocking density of the seeds is still not optimal either.

The p-value for variable X_2 (feed) is 0.000, where the p-value < 0.05 (alpha 5%) or 0.000 < 0.05, meaning that X_2 (feed) has a significant influence on Y (productivity). The variable (X_2) feed has a directly proportional relationship with productivity. Carp farmers in Lake Toba generally use artificial feed, namely pellets, cultivators use various brands of pellet feed. The brand of pellet feed

used is such as sapphire, topaz, sinta, global feed, comfeed. The feed has advantages and disadvantages such as the protein content. Feed with the trademark sapphire has a protein content of 34%, topaz 32-34%, sinta 33%, global feed 34%, and comfeed 25-31%. Based on the SNI standard for carp feed, the feed meets the nutritional standards.

Food conversion rate (FCR) is a parameter that can be used to see fish growth related to the amount of feed given. In Table 1, it can be seen that the average FCR of carp is 1.57. This can be interpreted that carp growers in the floating net cage system in Pangururan District will spend 1.57 kg of feed for every 1 kg increase in fish weight.

The p-value for variable X_3 (poolvolume) is 0.000, where the p-value <0.05 (alpha 5%) or 0.000 <0.05, meaning that X_3 (pool volume) has a significant effect on Y (productivity). The influence given is a negative influence or the best opposite. These results are in accordance with the results of [19] which state that the pool area has a significant and inversely proportional (negative) effect on the productivity of aquaculture ponds. This is due to the pool area which is a divider to the amount of production in accordance with the productivity formula. Therefore, if there is an increase in pond volume, the productivity index will decrease.

The p-value for the variables of age, education, length of cultivation experience and labor has no significant effect on Y (productivity), it can be seen from the p-value> 0.05 (alpha 5%). This happens because in carrying out floating net cages cultivation activities on Lake Toba, mature age, high education, a lot of experience, and labor do not affect the high production of fish. The labor factor does not affect productivity because labor only spreads seeds and feeds, while harvesting is borne by the Bandar so it is not directly related to the cultivator. The number of workers is around 1-2 people who are owners and workers who are still related to the cultivators. In research [14] states that the variables of age, education and labor do not significantly affect the productivity of carp.

$$\text{Productivity } (Y_2) = 24{,}10 + 0{,}001190\ X_1 + 0{,}001878\ X_2 - 0{,}09032\ X_3 - 0{,}0648\ X_4 - 0{,}381\ X_5 - 0{,}0097\ X_6 - 0{,}061\ X_7$$

Based on Table 3, it can be seen that the variables that significantly affect the productivity of tilapia are seed, feed, pond area and age. The regression results have an R-Suare (adjusted) value of 69.81% which means that the factors affecting productivity are 69.81.5% while the remaining 30.19% are other factors outside the factors mentioned. These other factors are other things outside of the physical factors of cultivation activities in floating net cages.

Tabel 3. Tilapia productivity regression results

Variabel	P-Value	Description
X_1	0,028	Seed
X_2	0,022	Feed
X_3	0,000	Pond size
X_4	0,037	Age
X_5	0,057	Education
X_6	0,840	Experience
X_7	0,863	Labor
R-Square (adj)	69,81%	
N	55	

The results of multiple linear regression analysis show that the seed variable has a significant effect and the coefficient value is also positive, meaning that the stocking density of these seeds can still be added again. Along with the addition of stocking density of tilapia seeds, this must also be supported by good quality and quantity of feed. the number of fish stocked depends on the productivity of waters such as quantity, quality and level of water management [20]. If the increase in density is not appropriate, it will interfere with the physiological processes and behavior of fish towards space which ultimately reduces health and physiological conditions, food utilization, growth and survival rates. Referring to [21], that in quality, good seeds for stocking in floating net cagesare seeds that have reached a size of 4.5 gr / tail or a minimum size of 5-8 cm. While the size of tilapia seeds used by farmers is 3-5 cm. At this size the seeds have not been able to adapt optimally.

In addition to the number of seeds, the amount of feed also has a significant effect on productivity with a positive effect. Similar to carp feed, tilapia farmers in Lake Toba generally use artificial feed, namely pellets, farmers use various brands of pellet feed. The pellet feed brands used are such as sapphire, topaz, sinta, global feed, comfeed, and Hi pro vite 781-1. Food conversion rate (FCR) is a parameter that can be used to see the growth of fish related to the amount of feed given. Table 1 shows that the average FCR of tilapia is 1.36. This can be interpreted that tilapia

fish growers in the floating net cage system in Pangururan District will spend 1.36 kg of feed for every 1 kg increase in fish weight.

The p-value for variable X_3 (pon0lvolume) is 0.000, the p-value <0.05 (alpha 5%) or 0.000 <0.05, meaning that X_3 (pool volume) has a significant effect on Y (productivity). The influence given is a negative influence or the best opposite. Similar to tilapia, it is caused by the volume of the pond which is a divider to the amount of production in accordance with the productivity formula. Therefore, if there is an increase in pond volume, the productivity index will decrease. The p-value for variable X_4 (age) is 0.037, the p-value <0.05 (alpha 5%) or 0.037 <0.05, meaning that X_3 (pond volume) has a significant effect on Y (productivity). According to the Labor Law No.13 of 2003, the age of 15-64 years is the age of productive labor (manpower), so based on the data, the average cultivator is still relatively productive, which ranges from 40-45 years [22].

The p-value for the variables of education, experience and labor have no significant effect on Y (productivity). It can be seen from the p-value > 0.05 (alpha 5%). This happens because in carrying out cultivation activities on Lake Toba, high education, a lot of experience, and labor do not affect the high production of fish. The labor factor does not affect productivity because labor only spreads seeds and feeds, while harvesting is borne by the Bandar so it is not directly related to the cultivator. The number of workers ranges from 1-5 people who are owners and workers who are still related to the farmers.

4. CONCLUSIONS

The conclusion that can be drawn from this study is that the average value of carp productivity is 22.32 kg/m^3/season, this value is higher than the value of tilapia productivity which has a value of 17.2 kg/m^3. The results of multiple linear regression statistical tests obtained factors that affect the productivity of carp cultivation in Lake Toba are feed and pond volume, while the factors that affect the productivity of tilapia cultivation in Lake Toba are seeds, feed, pond volume, and age of cultivators. Suggestions that can be given regarding this research are in accordance with the results of research where the research variable in the form of water quality is not examined, so it is better to do further research on the productivity of aquaculture floating net cage systems by expanding research variables such as water quality, climate, and marketing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Food and Agriculture Organization (FAO). World Food and Agricuture- Satistical Yearbook 2020. Food and Agriculture Organization of The United Nation, Rome; 2020.
2. Department of Maritime Affairs and Fisheries of North Sumatra. Strategic Plan of Marine Affairs and Fisheries Office of North Sumatra Province for 2018-2023. DKP North Sumatra, Medan; 2018.
3. Lukman. Lake Toba: Limnological Characteristics and Mitigation of Environmental Threats from Floating Net Cage Development. Jakarta: LIPI Press; 2013.
4. Silaban, A. The Meaning of Signs in the Marriage Ceremony of the Toba Batak Community in Berampu District, Dairi Regency. Thesis, University of North Sumatra; 2020.
5. Directorate General of Aquaculture. Strategic Plan of Directorate General of Aquaculture 2020-2024. Ministry of Marine Affairs and Fisheries of the Republic of Indonesia, Jakarta; 2020.
6. Mudlofar, R., E. Yurisinthae, A. Santoso. Analysis of Growing Carp (Cyprinus carpio) Business in Floating Net Cages in Parit Mayor Village, East Pontianak District. Exos Journal. 2013;9(3).
7. Nurhayati A. Resource managemnet analysis of aquaculture sustainability (the case study at floating net cages reservoir cirata. Proccedings Sustainability Science Symposium; 2014.
8. Effendie. Introduction to Aquaculture. Jakarta: Independent Spreader; 2004.
9. Kusriani, P. Widjanarko, N. Rohmawati. Test the effect of sublethal pesticide diazinon 60 EC on feed conversion ratio (FCR) and growth of carp (*Cyprinus carpio* L.). Journal of Fisheries Research. 2012;1(1):36-42.
10. Sinungan, M. Productivity. Jakarta: First Printing Gramedia, Main Library; 2008.
11. Qudratullah, Farhan. Applied Regression Analysis Theory, Case Examples, and

Applications with SPSS. Yogyakarta: Andi; 2013.
12. Dehotman, Khornelis. The Effect of Education on the Performance of Baitul Mal Wat Tamwil Employees in Riau Province. Journal of Islamic Economics and Business. 2016;1(2).
13. Simanjuntak, A., Hendrik, T. Syofyani. Study on the Production of Floating Net Cage business in Haranggaol Village, Simalungun Regency, North Sumatra Province. Journal of Coastal Socio-Economics. 2021;2(4).
14. Latifah, Gumilar I, Haetami K. Productivity analysis of floating net cage aquaculture in cirata reservoir (case study of Mande District). Thesis. Faculty of Fisheries and Marine Science, Padjadjaran University; 2013.
15. Ghozali I. Application of multivariate analysis with the SPSS program. Semarang (ID): Diponegoro University; 2011.
16. Priyatno D. Correlation, Regression and Multivariate Analysis with SPSS. Jakarta: Gava Media; 2013.
17. Santoso, Singgih. Complete Guide to SPSS Version 20. Jakarta: PT Elex Media Komputindo; 2012.
18. Indonesian National Standard. Production of carp (*Cyprinus carpio* Linneaus) Majalaya Strain Growing Class in Floating Net Cages. SNI. 01 6494.1.2000. Jakarta. 2000;12-18.
19. Nashrullah F, Nurhayati A, Subiyanto AAH. Suryana. Factors affecting productivity and income of tilapia fish farmers (case study: Tasikmalaya City). Journal of Socio-Economic Research in Fisheries and Marine. 2021;5(2):107-121.
20. Khairuman, Amri K. Tackling Disease in Carp and Koi. Jakarta: Agromedia Pustaka. 2002;28-39.
21. SNI. 6140: 2009. Production of Tilapia (Oreochromis Niloticus Bleeker) Growing Class in Calm Water Ponds. Ministry of Maritime Affairs and Fisheries. Jakarta; 2019.
22. Law of the Republic of Indonesia Number 13 of 2003 concerning Manpower.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/97902