Analysis of factors affecting income of common carp (*Cyprinus carpio* Linnaeus, 1758) cultivation business in Warukapas Village, Dimembe Sub-District, North Minahasa Regency, Indonesia

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Abstract. Fisheries become one of the supporting sub-sectors in agriculture, the products of the fisheries sub-sector include marine and freshwater biota which include animals, plants, coral reefs etc. Common carp (*Cyprinus carpio* Linnaeus, 1758) is an important fish for freshwater aquaculture, because of the high demand in many local markets in Indonesia. Warukapas Village is one of the freshwater aquaculture business centers in North Minahasa regency. Common carp farmers in this area have difficulties in increasing income due to high feed prices, disease attacks (viruses), and the lack of demand for common carp due to high prices of common carp at the consumers end. This study aims to analyze the factors that influence the income of common carp cultivation business in Warukapas Village, Dimembe Sub-District, North Minahasa Regency, Indonesia. The method used in this research is descriptive, analytical method, using purposive sampling technique in gathering data. The data analysis method uses multiple linear regression analysis. The results showed that the factors affecting income are feed costs which have a negative effect on income, while pond area and production volume have a positive effect on income from common carp cultivation businesses and farmer experiences did not affect the income of common carp cultivation businesses in North Minahasa Regency.
Key Words: feed costs, freshwater biota, ponds.

Introduction. The agricultural sector encompasses five sub-sectors: food crop farming, plantations, fisheries, animal husbandry, and forestry. Fisheries are one of the high potential sub-sectors of agricultural activities and are the Indonesian government's hope to contribute significantly to advancing economic activities in various region (Markisman 2016). The area of freshwater aquaculture ponds in Indonesia from 2014 to 2018 tended to increase, as described below in Table 1. North Sulawesi is generally known as a producer in freshwater fish cultivation. The types of cultivation developed are diverse, such as common carp (*Cyprinus carpio*), and Nile tilapia (*Oreochromis niloticus*). Therefore, it is not surprising that North Sulawesi is a portrait of freshwater fish farming in the eastern part of Indonesia (Kowarin et al 2014).

Table 1

Area of freshwater aquaculture ponds in Indonesia (BPS 2019)

No	*Year*	*Area of cultivation ponds*
1	2014	7,385 ha
2	2015	7,720 ha
3	2016	9,264 ha
4	2017	9,264 ha
5	2018	9,264 ha

Common carp belongs to the freshwater fish species but can be found in brackish water or estuaries as well, they are omnivorous animals, meaning they eat both plants and other animals. Common carp have been cultivated since 475 BC in China (Nakajima et al 2019). In Indonesia, common carp were first known in the Galuh area, Ciamis, West Java, around 1810. However, it began to be cultivated by fish farmers around 1860. The common carp found in Indonesia are those brought from China, Europe, and Russia (Amri & Khairuman 2008). This fish has high economic value in the market and a large demand, especially for some local markets in Indonesia. Common carp are globally recognized, but in the local name of North Sulawesi is called ikan mas. Common carp are preferred by most Indonesians as a staple food and a delicious dish at parties. This certainly provides opportunities for common carp cultivation development (Suseno 2000). Common carp farmers aim to obtain decent income, as this being their main livelihood source. This income is obtained from the proceeds of their business minus the variable costs of common carp cultivation. The urgency of researching the income of fish farmers in this area are Warukapas Village, Dimembe Sub-District, North Minahasa Regency, as one of the areas that produce common carp. Fishery cultivation businesses have factors that typically influence the income of the cultivation business itself, so it is important for fishery cultivation entrepreneurs to know these factors, also by knowing the income generated, farmers can plan their business more effectively, including in terms of expenses, investments, and business development, also information about income can help farmers identify areas where they can reduce expenses and improve business efficiency. For the government, data on fish farmers' income can help policymakers and farmers make better decisions regarding fish farming management. These are the reasons why the authors of this paper choose the research topic on factors influencing the income of common carp cultivation businesses.

Material and Method. Field research was conducted in Warukapas Village, Dimembe Sub-District, North Minahasa Regency, Indonesia. This research was conducted in this area because Warukapas Village is one of the common carp production centers in North Sulawesi. The research was carried out in one period of cultivation (September – December 2021). The data collected in this study consists of primary data and secondary data. Primary data were obtained through a survey method, which involved directly interviewing 30 common carp farmers, with one pond per farmer, using a questionnaire provided to common carp breeders as a data collection tool (Arikunto 2002). Although farmers usually culture more ponds, for each farmer only one pond was chosen for this research, which has already been harvested at the time of data collection, with the purpose to reduce variability. Secondary data were obtained from literature studies, reports, publications, and other relevant sources related to this research, as well as from institutions/agencies involved in this study.

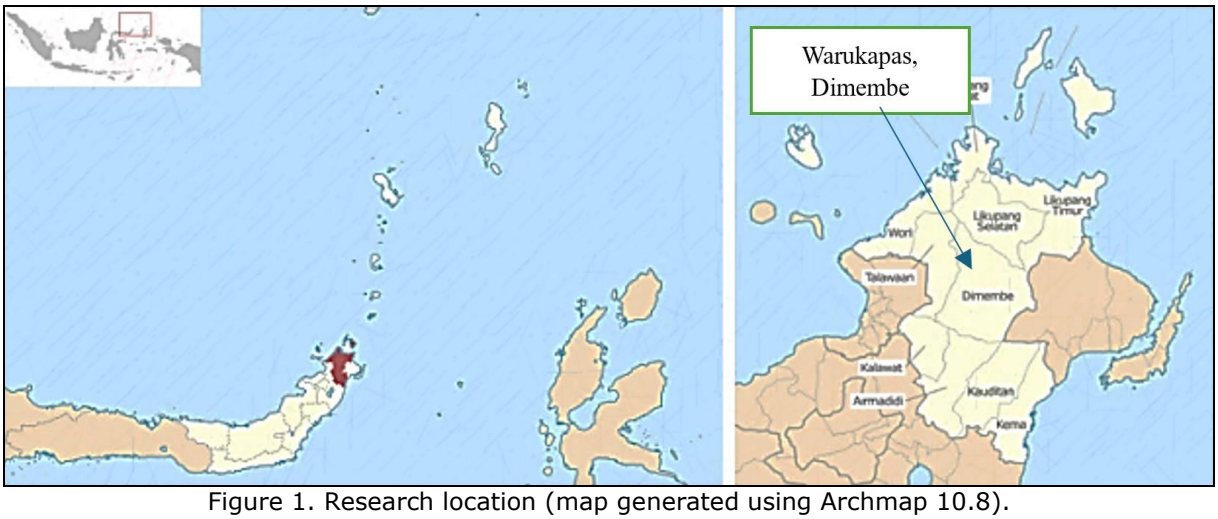

Figure 1. Research location (map generated using Archmap 10.8).

This type of research is quantitative research, which emphasizes numerical data processed using statistical methods (Azwar 2007). According to Subana and Sudrajat (2005), quantitative research is used to test a theory, present facts, or describe statistics, show relationships between variables, and develop concepts, understanding, or describe various things. According to Suprapto (2001), the measurement tool in quantitative research is in the form of a questionnaire, and the data obtained are responses from respondents to questions or items posed. This study uses multiple linear regression analysis because there is more than one independent variable. Variables that influence are called independent variables, and variables that are influenced are called dependent variables (Ghozali 2016). This study consists of 4 independent variables: feed cost, farmer experience, pond area, and production volume, while the dependent variable is income.

The sampling technique used was purposive sampling, involving 30 common carp farmers who have harvested, aiming to determine the amount of expenses incurred and production volume (Nurdiani 2014).

The variables measured in this study are:

- Income: total revenue for one production process (per month).
- Feed cost: expenses incurred to purchase feed for one production process (IDR/month).
- Farmer experience: length of time or duration of an individual's farming activity (years).
- Pond area: The size of the pond used for common carp cultivation, measured in square meters (m²).
- Production volume: The quantity of fish produced per production process (per month), measured in kilograms (kg).

Data analysis. In analyzing the factors affecting common carp farming income, multiple linear regression analysis is used. The formula for the regression equation (Sugiyono 2007) used is as follows:

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4 + ... + \beta nX$$

Where:
Y = dependent variable (income)
α = constant
X1 - n = independent variables
β1 - n = regression coefficients
e = error

Since this study involves several independent variables, the formula can be expressed as follows:

$$Y = \alpha + \beta 1X1 + \beta 2X2 + \beta 3X3 + \beta 4X4$$

Where:
Y = dependent variable/income (IDR)
α = constant
X1 = feed cost (IDR)
β1 = regression coefficient of variable X1
X2 = farmer experience (years)
β2 = regression coefficient of variable X2
X3 = pond area (m²)
β3 = regression coefficient of variable X3
X4 = production volume (kg)
β4 = regression coefficient of variable X4
e = error

Simultaneous F test. The F-statistic test measures the goodness of fit, indicating the accuracy of the regression function in estimating actual values. If the significance value of F < 0.05, the regression model can be used to predict independent variables. The F statistic test also indicates whether all independent variables included in the model have a simultaneous effect on the dependent variable. The significance level for the F statistic test is 0.05.

Partial t test. The t statistic test essentially indicates the extent to which one explanatory variable (independent) individually explains the variation in the dependent variable. The t-test has a significant level of α = 5%.

Hypothesis formulation. Formulation of hypotheses for F test:

H0: it is suspected that the variables feed cost, farmer experience, pond area, and production volume together do not affect income.
Ha: it is suspected that the variables feed cost, farmer experience, pond area, and production volume together affect income.

Acceptance or rejection criteria are described next. H0 is accepted if: Fcalculated ≤ Ftable, then H0 is accepted, and Ha is rejected, meaning there is no simultaneous effect by variables X and Y. Fcalculated ≥ Ftable, then H0 is rejected, and Ha is accepted, meaning there is a simultaneous effect by variables X and Y.

Formulation of hypotheses for t test:

H0: B1 = 0 Ha: B1 ≠ 0
H0: B2 = 0 Ha: B2 ≠ 0

The critical region is determined by the t-table value with degrees of freedom n-k and significant level α. According to Suharyadi and Purwanto (2011), to determine the t-value, the formula used is:

$$\text{T-value} = (b-B)/Sb$$

Where: T-value = magnitude of t-value
B = regression coefficient
Sb = standard error

Determining the decision region bases on the decision region to accept H0 or accept Ha. Determining the hypothesis where H0: accepted if t-value ≤ t-table. Ha: accepted if t-value ≥ t-table.

Results. In this area, the characteristics of respondents based on age, number of dependents, length of business, and pond area will be discussed. The number of male respondents is higher at 50.5% compared to the female population, which is 49.5%. The age range of common carp (*Cyprinus carpio*) farmers is between 24-55 years old. The distribution of respondents by age group among common carp farmers in Warukapas Village, Dimembe District, North Minahasa Regency, is largest in the age interval of 36 - 55 years, with 26 farmers or 86.7%. Meanwhile, the distribution of respondents in the youngest age group, 24 - 35 years old, is the smallest with 4 farmers or 13.3%. The distribution of respondents according to the level of education is largest at the high school level, with 18 common carp farmers, accounting for 60%. Meanwhile, the smallest distribution of respondents by education level is at the bachelor's degree (S1) level, with one common carp farmer, or 3.3%. The distribution of the number of family dependents shows that the highest number of respondents have 3-4 dependents, with a total of 17 individuals or 56.7%. Conversely, the smallest distribution is with 5 dependents, totaling 3 individuals or 10%.

The duration of experience in the common carp farming business varies among respondents. The distribution of respondents with the longest duration of experience falls within the 11–20 year interval, totaling 18 individuals or 60%. Conversely, the smallest distribution of experience duration in the common carp farming business falls within the 21–30 year interval, totaling 3 individuals or 10%. The size of the ponds used by common carp farmers varies. Common carp farmers are predominantly engaged in fish farming in ponds ranging from 100-500 m² in size, totaling 18 individuals or 60%. Conversely, the smallest number of common carp farmers use ponds ranging from 1001-1500 m² in size, totaling 2 individuals or 6.7%.

The size of carp available in local markets is typically around 1-2 kg per fish. This size range is often preferred by consumers as it is large enough to be considered a significant meal, yet small enough to be easily handled and cooked. Larger carp can be difficult to handle and require specialized equipment for handling and processing, which can increase costs and logistical efforts. On the other hand, smaller carp may be less attractive to consumers who prefer a more substantial meal. Therefore, the 1-2 kg range is generally considered optimal for marketability in local markets.

The average common carp farmer stocks around 1,292 fingerlings per pond. Fingerlings typically are around 1.5-2.5 cm in length. The number of common carp fingerlings to be stocked by common carp farmers is influenced by several factors, including:

a) Pond size factor:
Common carp fish farmers adjust the number of fingerlings according to the pond's size, aiming for optimal common carp growth.

b) Weather factor:
Unpredictable weather conditions affect sunlight intensity and water quality, which in turn impacts the development of common carp.

c) Competitor factor:
The presence of competitors in the same fish type (common carp) increases the total production. However, if not supported by high consumer purchasing power, it may result in low income for common carp farmers.

d) Disease (virus) factor:
Viral diseases affecting common carp lead to fish mortality. Due to the risk of viruses spreading through water from other fish farmers' ponds, some common carp farmers choose to rear a smaller number of fish.

e) Consumer purchasing power factor:
Consumer purchasing power for common carp is relatively low compared to other fish types like tilapia. This is because common carp are priced higher, with wholesalers typically selling them for IDR 40,000 and end consumers purchasing them for IDR 50,000.

The average price of common carp fingerlings purchased by common carp farmers in Warukapas Village is IDR 1,117 per fingerling. As for the price of feed, it varies depending on the place of purchase and the quantity of fingerlings bought. The average total cost of common carp fingerlings incurred to purchase common carp fingerlings is IDR 1,444,667. This is because in purchasing common carp fingerlings, the prices of fingerlings bought by common carp farmers vary, as well as the quantity of fingerlings purchased.

The average amount of feed used by common carp farmers is 12.2 sacks (50 kg) per month. Regarding the feed itself, common carp farmers often adjust it based on the quantity of fingerlings stocked and their previous experience. The average price of common carp feed paid by common carp farmers in Warukapas Village is IDR 436,734 per sack. The price of the feed is determined by the place of purchase and the quantity of feed purchased.

The average cost of common carp feed spent by common carp farmers in Warukapas Village is IDR 5,329,200. The amount spent on common carp feed is influenced by the quantity of feed purchased (in sacks/kilograms) and the place (store)

where the feed is purchased. From Table 2, it can be observed that the average production of common carp in Warukapas Village is 371.7 kg. The quantity of production is influenced by:

1) The quantity of fingerlings stocked: the number of fingerlings stocked is one of the factors affecting the quantity of production.
2) Water quality: water quality is one of the factors affecting the quantity of production. This is because the development and mortality of fish due to viruses affect the quantity of common carp fish production generated by common carp farmers.

Table 2

The selling price of common carp (IDR kg^{-1}) (primary data)

No	*Price*	*No*	*Price*
1	40,000	16	40,000
2	35,000	17	35,000
3	40,000	18	35,000
4	42,000	19	40,000
5	40,000	20	40,000
6	40,000	21	40,000
7	40,000	22	40,000
8	40,000	23	35,000
9	35,000	24	40,000
10	40,000	25	38,000
11	42,000	26	42,000
12	40,000	27	35,000
13	38,000	28	40,000
14	40,000	29	40,000
15	35,000	30	40,000
Total		IDR 1,167,000	
Average		IDR 38,900/kg	

It is known that the average selling price of common carp is IDR 38,900/kg. From the research results, most farmers sell at a price of IDR 40,000/kg, which is done by 18 individuals. As for the selling price itself, the farmers use the commonly used selling price or the market price of common carp. However, the selling price is adjusted based on the quantity of fish (kg) being purchased, whether the buyer is a regular customer or not, whether the buyer is a collector or an end consumer, and the selling price also depends on the negotiation process between the buyer and the farmers.

Table 3

Total revenue (IDR) (primary data)

No	*Total revenue*	*No*	*Total revenue*
1	10,800,000	16	16,000,000
2	10,500,000	17	21,000,000
3	12,000,000	18	21,000,000
4	10,500,000	19	18,000,000
5	19,200,000	20	13,600,000
6	16,000,000	21	11,600,000
7	14,000,000	22	14,000,000
8	12,800,000	23	21,000,000
9	17,500,000	24	10,800,000
10	6,800,000	25	15,200,000
11	10,500,000	26	9,6650,000
12	8,400,000	27	19,250,000
13	16,400,000	28	18,000,000

14	13,600,000	29	14,000,000
15	16,450,000	30	11,600,000
Total		IDR 427,820,000	
Average		IDR 14,260,667	

From Table 3, the average total revenue obtained by 30 common carp farmers in Warukapas Village is IDR 14,260,667. The total revenue is obtained from the total amount of common carp fish production (kg) multiplied by the selling price of common carp fish (IDR).

Table 4

Income of farmers (IDR) (primary data)

No	*Income*	*No*	*Income*
1	6,346,538	16	7,418,662
2	5,576,834	17	11,303,756
3	6,194,940	18	10,334,331
4	4,635,662	19	10,564,532
5	10,495,584	20	6,234,470
6	9,239,513	21	4,917,052
7	6,462,472	22	5,826,524
8	5,544,402	23	10,371,551
9	8,410,273	24	4,145,329
10	3,375,746	25	7,013,489
11	6,026,245	26	5,991,524
12	3,635,830	27	11,308,573
13	7,234,847	28	8,629,996
14	6,431,840	29	6,879,442
15	8,341,552	30	4,347,384
Total		IDR 213,238,893	
Average		IDR 7,107,963	

From Table 4, it can be observed that the average income obtained by 30 common carp fish farmers in Warukapas Village is IDR 7,107,963. The income itself is obtained by subtracting the total costs from the total revenue. With the results above, several tests were conducted. Hypothesis testing was carried out using multiple linear regression analysis. To facilitate data analysis, all data processing was done using the SPSS (Statistical Package for Social Science) program for Windows version 16.0. The regression results obtained from this research data are depicted in continuation of the article.

Multiple correlation analysis (R). According to Sugiyono (2007), the guidelines for interpreting correlation coefficients are as follows:

0.00 - 0.199 = very weak
0.20 - 0.399 = weak
0.40 - 0.599 = moderate
0.60 - 0.799 = strong
0.80 - 1.000 = very strong

The result of the multiple correlation (R) test is an R value of 0.970 is obtained. This indicates a very strong relationship between the cost of feed, years of experience, pond area, and production volume on the income of common carp fish farming businesses in Warukapas Village.

Coefficient of determination test (R^2). The result of the determination test (R^2) can be seen from the coefficient of determination, which is the obtained R^2 (R square) is 0.942 or (94.2%). This indicates that the percentage of feed costs, years of experience,

pond area, and production volume on the income of common carp fish farming businesses in Warukapas Village is 94.2%. In other words, the income variable can be influenced by feed cost, years of experience, pond area, and production volume by 94.2%, while the remaining 5.8% is influenced by other variables not examined.

Simultaneous regression coefficient test (F test). The F test is used to determine whether independent variables together significantly affect the dependent variable. The result of testing the influence of feed costs, years of experience, pond area, and production volume together on income is as follows:

Formulate hypotheses:

Ho: it is suspected that feed cost, farmer experience, pond area, and production volume together do not significantly affect the income of common carp fish farming businesses in Warukapas Village.
Ha: it is suspected that feed cost, farmer experience, pond area, and production volume together significantly affect the income of common carp fish farming businesses in Warukapas Village.

After calculating the F value, based on the table, the obtained F value is 100.815 with a significance value of 0.000. This indicates that the calculated F value is greater than the table value of F (2.78), and the significance value is less than 0.05. Therefore, the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted. It means that feed costs, years of experience, pond area, and production volume together have a significant effect on the income of common carp farming businesses in this research area.

From the hypothesis testing conducted, the null hypothesis (Ho) is rejected, and the alternative hypothesis (Ha) is accepted. This indicates that feed costs, farmer experience (years of experience), pond area, and production volume collectively have an influence on the income of common carp farming businesses. This can be observed from the coefficient of determination (R^2) value. Based on the calculation results, an R^2 value of 0.942 is obtained. This means that feed costs, farmer experience (years of experience), pond area, and production volume have a very significant influence, accounting for 94.2%, on the income of common carp farming businesses. The remaining 5.8% is influenced by other factors not examined in this study.

Discussion. The research findings indicate that feed costs, when analyzed individually, have an impact on the income of common carp (*Cyprinus carpio*) farming businesses because the high or low cost of feed significantly affects the income received by the farmers. The high cost of feed purchased by common carp fish farmers in Warukapas Village will reduce the income of the farmers. Conversely, a decrease in feed prices compared to high feed prices is the hope of most common carp fish farmers in Warukapas Village, as lower feed prices will drive an increase in income from common carp fish farming businesses. Feed costs are a significant factor in the profitability and income of fish farming operations. Managing feed costs effectively is essential for maintaining profitability and sustainability in the aquaculture industry (Engle 2012). Additionally, the research findings show that farmer experience (years of experience) individually does not have a significant effect on the income of common carp farming businesses. This is because the length of time a farmer has been engaged in farming does not guarantee an increase in income from the farming business, given the biological nature of the aquaculture process, which is highly influenced by external factors beyond the control of the farmers, such as water quality (Kaunang et al 2017), diseases (Kaunang et al 2018), and other factors. Experienced farmers often have established networks within the industry, including suppliers, buyers, and other farmers (USDA 2018). These networks can provide valuable information and opportunities that can increase income.

Furthermore, the research results indicate that pond areas individually have an impact on the income of common carp farming. This is because a larger farming pond is

more conducive to the growth and development of common carp fish. A larger pond area can provide more space for natural food sources to grow, reducing the need for artificial feeding. This can lower feed costs and improve the efficiency of the farm, leading to higher income (Hitchcock 2022; Susilowati et al 2022). Larger pond areas can lead to higher production capacity and potentially higher income, as they can accommodate more common carp and allow for more efficient use of resources such as feed and labor (Mukhlis 2020; Lestari et al 2023). Similarly, the research findings suggest that production volume individually also has an impact on the income of common carp farming businesses in Warukapas Village. This is because a higher production volume of common carp increases the income of the farming business, especially when supported by a higher selling price of common carp. These findings are consistent with previous studies, indicating a positive correlation between common carp production and income (Antari & Utama 2019). Managing a larger production volume often requires implementing more efficient production processes and technologies. These improvements can lead to cost savings and higher profitability (Mukhlis et al 2023).

Conclusions. The research showed that the factors influencing the income of common carp (*Cyprinus carpio*) farming businesses in Warukapas Village, Dimembe District, North Minahasa Regency are as follows:

- Feed costs have a negative effect on the income of common carp farmers, meaning that an increase in feed costs will decrease the income of common carp farmers.
- Pond area and production volume have a positive effect on the income of common carp farmers, indicating that increasing the pond area and production volume will increase the income of common carp farmers.
- Farmer experience did not affect the income of common carp farmers.

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

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