Investment analysis of rainbow trout cage farming in the inland waters

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Abstract

The study aims to conduct an investment analysis of inland water cage farms for rainbow trout. The investigation was conducted in Türkiye's Western Mediterranean region, in the Karacaören-I Dam Lake. The material was collected by the survey method from all farms (21 farms) and they were divided into three groups based on their capacities. The net present value of the investment was 145,214.08, 451,399.11, and 6,485,245.11 in Groups I, II, and III, respectively. This value increased in tandem with the farms' capacity. The internal rates of return were 29.09%, 82.23%, and 204.09%, respectively, in Groups I, II, and III, and they rose as farm capacity did. Additionally, the benefit-cost ratios increased as farm capacity rose. Accordingly, all farm groups' investments have positive net present values, benefit-cost ratios that are larger than one, and acceptable internal rates of return. Comparing farm groups, it was discovered that large farms were more advantageous.

Keywords: Inland waters. Cage farming. Rainbow trout. Investment analysis.

1. Introduction

Animal foods are one of the important sources of protein in human nutrition. Among the foods of animal origin, fish is rich in nutritional value and especially in protein ratio. The protein value of fish meat is around 18–20%. Fish oil contains more omega-3 fatty acids than other oils (Ornekci, 2018). The rapid increase in the global population, rising living standards, and changes in consumption habits increase the demand for fish and other fishery and aquaculture products day by day (Sakima and Cevrimli, 2021). Aquaculture is an highly important sector in terms of economic and social development within the livestock sector due to its close relationships with the food, health, environment, tourism, manufacturing, and logistics sectors (Dogan, 2018). Aquaculture also plays a significant role not only in nutrition but also in terms of creating employment, providing foreign exchange income for many countries, contributing to rural development and providing cheap animal protein in the fight against poverty (Ornekci, 2018). A report published by the Food and Agriculture Organization of the United Nations (FAO) emphasized that fisheries and aquaculture are vital for the food, nutrition and employment of millions of people, many of whom struggle to have decent livelihoods (FAO, 2018). While the World Health Organization (WHO) recommends the consumption of 2-3 meals a week to increase its consumption worldwide, the United Nations General Assembly declared the year 2022 as the "International Year of Fisheries and Aquaculture" (IYAFA-2022). Under the leadership of FAO, within the scope of IYAFA-2022, emphasis will be placed on the importance of millions of small-scale fishermen, fish farmers, and fish workers who provide healthy and nutritious food to billions of people and help to achieve "zero hunger" (FAO, 2022).

Türkiye has a sea coastline of 8,333 km with various ecological characteristics such as natural ponds, dams, and lakes, the number of which is increasing every day due to its geographical location and being a peninsula surrounded by sea on three sides (Boran, 2018). Türkiye, like the rest of the world, produces aquaculture in two ways: fishing and aquaculture. Between 2000 and 2021, Türkiye's total aquaculture production increased by 37.34%, from 582,376 tonnes to 799,851 tonnes. While the share of total aquaculture production produced by the fishing method decreased, the share of total aquaculture production produced by the aquaculture method increased. Between 2000 and 2021, the share of total aquaculture production produced by fishing decreased from 86.43% to 41.03%, while the share of production produced by aquaculture increased from 13.57% to 58.97% (TSI, 2022). Aquaculture production has surpassed fishing production in the last two years (2020 and 2021). It is expected that aquaculture production will continue to increase in the future, as will its share of total production. According to data for 2021, the amount of aquaculture produced by the aquaculture method in Türkiye was 471,686 tonnes, with 71.16% produced in the seas and 28.84% produced in inland waters. Rainbow trout accounted for nearly all of the aquaculture produced in inland waters. Total inland rainbow trout production was 135,732 tonnes, and its share of total production was 99.77% (TSI, 2022).

The aquaculture sector in Türkiye is also significant in terms of exports. In parallel with the developments in aquaculture and processing technologies, substantial increases are observed in aquaculture exports. In 2021, Türkiye's aquaculture exports amounted to 238,732 tonnes and 1.37 billion dollars in value (TSI, 2022).

This research was carried out in the Karacaören-I Dam Lake area in the Western Mediterranean region of Türkiye. The dam lake is located at the crossroads of Burdur, Isparta, and Antalya provinces. Two-thirds of the lake is within the borders of Burdur, and one-third is within the borders of Isparta. Water retention began in Karacaören-I Dam Lake in 1990. The average depth of the lake is 27 m, the deepest point is 80 m, and the normal water level surface area is 45.5 km². The Aksu and Göksu Streams constitute the biggest sources of the dam lake built on the Aksu Stream. Apart from this, the Kızıllı Stream forms an important source in the winter and spring seasons (Karabacak, 2010).

This study aimed to analyze the investment made by the rainbow trout producers in cages in the Karacaören-I Dam Lake area. Rainbow trout cage farms were divided into three groups based on their capacities. Fixed investment and operating expenses were calculated; cash flow analysis charts were prepared; and investment evaluation criteria were used to calculate net present value, internal rate of return, benefit-cost ratio, break-even point, and payback period. Farm groups were compared in terms of evaluation criteria, and it was emphasized which group was more advantageous. The findings of this study are expected to be useful to policymakers, rainbow trout producers, entrepreneurs, and researchers interested in investing in cage aquaculture.

2. Literature Review

There have been a lot of scientific studies conducted on an investment analysis of inland water cage farms. Among the most valuable are the following;

Afero et al. (2010) examined an economic analysis of tiger and humpback grouper at different production scales in Indonesia. With a five-year projected negative cumulative cash flow and a negative net present value, their findings stressed the non-viability of small-scale tiger grouper farming. The larger production scale for tiger grouper reveals marginal viability for medium-scale farms and a financially feasible large-scale cage culture. The economic analysis of humpback grouper at various production scales showed a positive cumulative cash flow and net present value, a benefit-cost ratio greater than two, an internal rate of return greater than 300%, and a payback period of one year. Furthermore, increased profitability was linked to lower significant production costs, increased production, and higher product prices.

Di Trapani et al. (2014) aimed to compare the net present value, discounted payback time, and internal rate of return of two Italian mariculture farms that produce European sea bass to the economic performance of the inshore production system. In the study, despite the fact that sensitivity analysis revealed that the financial indicators of both aquaculture production systems were extremely sensitive to changes in market conditions, the offshore farm was found to be more economically profitable. According to their results, an offshore production system may provide an opportunity for fish farmers to increase their profitability, achieve more sustainable production, and avoid potential conflicts with other human activities in coastal areas.

Pangemanan et al. (2014) assessed the environmental and economic feasibility of the floating fish cage system for fish culture. The study's respondents were fish farmers and fishermen, and the economic analysis included analyses of the benefit-cost ratio and net present value. All coastal areas, except north Tondano Lake, were found to be viable for the floating fish cage system and fish culture farm.

The economic viability of cobia cage culture was assessed by De Bezerra et al. (2016) using the actual investment and operational costs of a large-scale operation off the coast of Recife, northeastern Brazil (industrial system), and a family-run farm in a near-shore area of Rio de Janeiro (familiar system). Profitability (gross revenue, operational profit, cost price, and break-even production) and investment (net present value and payback time) analyses were conducted in this research. A sensitivity analysis was also performed. The industrial system required an initial investment of approximately $1.5 million, whereas the familiar system required a relatively small initial investment of approximately $16,000, making it more adaptable to changes in production parameters and market fluctuations. Both systems had a positive net present value, and the payback times were estimated to be 3.88 years for the industrial system and 2.07 years for the familiar system. Consequently, they demonstrated that cobia cage culture in Brazil may be considered economically feasible in offshore production systems as well as in near-shore, familiar systems.

Valsalan et al. (2020) carried out a study to assess the socioeconomic status of cage culture farmers in Kerala, as well as the resulting economic benefits. The most important species cultured were Etroplus suratensis (Pearl Spot) (CE), Lates calcarifer (Asian Sea Bass) (CL), and Genetically Improved Farm Tilapia (GIFT). Because of the fast growth rate of CL and the higher market price of CE, these were the most popular species for farming. Economic indicators such as net profit, rate of return, undiscounted benefit to cost (B/C) ratio, and payback period were used to compare the economic efficiency of the two systems, namely the cage stocked with CE and the cage stocked with CL. Despite CL's higher net profit, the undiscounted B/C ratio was the same.

A profitability analysis model was performed by Musa et al. (2021) as the primary decision support tool to assess the economic viability of tilapia cage culture in Lake Victoria. One and five 8 m^3 (A), 62.5 m^3 (B), and 471 m^3 (C) cages were evaluated. They found that the break-even price (\$4.6 kg^{-1}) for one cage of A appeared to be higher than the tilapia farm gate price in Kenya (\$3.5 kg^{-1}), indicating the venture's unprofitability. Also, they revealed that the decreased break-even price as cage numbers increased demonstrated economies of scale across all cage volume ranges. According to the study, A's eight-year payback period suggested a risky venture. This finding was supported by a 50% internal rate of return and a negative net present value in the first two years of operations.

Arifa et al. (2022) sought to determine the best profitability indicators for two catfish species, Pabda and Shing, cultured in a RAS farm by estimating net cash flow, net present value, profitability index, payback period, discounted payback period, internal rate of return, and sensitivity analysis. According to the analysis, the internal rate of return for Pabda and Shing production was 4% and 16%, respectively. However, the payback periods for Pabda and Shing productions were 15 years and four months and six years and two months, respectively. The net present value of shingle production was positive, while it was negative for Pabda. In contrast, the profitability index for Pabda production was less than one, and it was greater than one for Shing production. As a result, the findings revealed that the Shing production in the RAS facility may be economically feasible; however, the Pabda production in RAS may not be viable due to lower production and a longer culture period.

3. Materials and Methods

The main material of the study was the data collected through face-to-face interviews with the producers who rear rainbow trout in cages in Karacaören-I Dam Lake. The data was obtained by the survey method. In addition to this data, similar studies, reports, and statistics on the subject were also used. The survey data is for the 2021 production period.

A list of producers who rear rainbow trout in cages in Karacaören-I Dam Lake was obtained from the Burdur and Isparta Provincial Directorates of Agriculture and Forestry. According to the list, data was collected by interviewing all of the farmers (21 farms) producing in 2021. The farms were divided into three groups according to their cage capacities. According to this, farms with a capacity of 1–50 tonnes (6 farms) were classified as Group I, farms with a capacity of 51–100 tonnes (6 farms) were classified as Group II, and farms with a capacity of 101+ tonnes (9 farms) were classified as Group III. The average operating capacities of Groups I, II, and III were 33.86, 63.33, and 518.72 tonnes, respectively. The data collected by the survey method from the determined farms was transferred to the computer environment, where calculations were made in Microsoft Excel (MC, 2010) and SPSS (SPSS, 2019) programs, and tables were created and interpreted.

Fixed investment and operating expenses were first calculated on the examined farms. Then, the net cash flow chart was prepared, and investment evaluation criteria were found. All data related to fixed investment expenses, operating expenses, and income were determined as a result of the surveys conducted with the producers. In calculating the depreciation costs, the values of the fixed capital elements and the depreciation rates are taken into account. Depreciation rates are 12.5% for boat, cage, vault, chain, anchor and buoy, 20% for grading machine, net and rope, 25% for the pickup truck, 15% for generator, 10% for the ice machine, 6.66% for bait tank and container (Anonymous, 2022). Unexpected expenses are calculated by taking 3% of fixed investment and operating expenses (Yurdakul, 1999).

The entrepreneur has to consider the profitability and risk of the capital s/he will use for the investment s/he will make. The main goal for the entrepreneur is to make a maximum profit in return for the capital invested. For this reason, careful evaluation of an investment is important in terms of allowing the investment owner to determine and compare the benefits and costs it will provide (Yurdakul, 1999). Certain criteria are used to assess investments. These criteria are divided into two categories: those that consider the time value of money and the economic life of the investment; and those that do not. The time value of money must be considered for investments with a life span of more than one year. Inflation comes to mind when considering the time value of money. However, it should be noted that, apart from inflation, a unit of money we have today is more than a unit of money we will obtain in the future. The most obvious indicator is interest. For example, if the interest rate is 10%, one unit will be 1.1 units at the end of a year. The first step in applying the criteria that take into account the time value and economic life of money is to prepare a cash flow statement in which investment expenses and incomes are shown over the economic life. In the cash flow statement, revenues show cash inflows, expenses show cash outflows, and the differences between revenues and expenses show net cash flows (Rehber and Erkus, 2014). The criteria that consider the time value of money and the economic life of the investment are the more accepted objective criteria in the evaluation of investments.

In the study, some criteria were calculated to evaluate the producers' investments in producing rainbow trout in cages. The net present value of the investment, the internal rate of return, and the benefit-cost ratio are among the criteria that consider the time value of money and the economic life of the investment. The break-even point and the payback period of the investment are the criteria that do not consider the time value of money and the economic life of the investment.

a) Net Present Value (NPV)

According to a certain discount rate of the income-expense differences (net cash flows) of the investment, the basis of this method is to find the total value of the investment discounted to the present within its economic life. The formula for calculating the net present value is given below (Rehber, 1999).

$$NPV = \sum_{t=0}^{n} \frac{NCF}{(1+r)^t} \quad (1)$$

where NPV denotes net present value, NCF denotes net cash flow, t = 0, 1, 2,..., n (time), n is the number of years, and r represents the discount rate.

To determine whether to implement an investment, the net present value must be at least zero or a positive value, as calculated using Equation (1). The discount rate used in the formula is determined by the real interest rate or the opportunity cost of capital in the capital market. In countries with medium development levels, this rate can range between 6% and 9%. In this study, the discount rate was considered at 8% (Yurdakul, 1999).

b) Internal Rate of Return (IRR)

The internal rate of return is a widely used investment evaluation criterion. Most other international financial institutions, including the World Bank, employ this method in their economic and financial assessments. In this method, the discount rate that makes the total net cash flow of the investment equal to zero is calculated. Therefore, the internal rate of return is the discount rate that reduces the difference between the benefits and costs of the investment to zero. This expression can be formulated as follows (Gittinger, 1982).

$$IRR = \sum_{t=0}^{n} \frac{NCF}{(1+r)^t} = 0 \tag{2}$$

where

IRR: internal rate of return

NCF: net cash flow

t = 0, 1, 2, ..., n (time)

n: number of years

r: discount rate

The internal rate of return indicates the rate of return on the capital used for any investment. Investment can be implemented if this ratio is equal to or higher than the opportunity cost of capital (Yurdakul, 1999).

Except by chance, it is not possible to choose a discount rate that will make the incremental net benefit stream equal to zero. Unfortunately, there is no formula for calculating the internal rate of return. We are forced to use a structured process of trial and error to determine the discount rate that will equalize the present value of the incremental net benefit stream. Constructing the initial estimate is the most challenging part of trial and error. If the estimate is too far off from the actual result, several trials will be required to find two rates that are close enough together to allow accurate interpolation (interpolation is the method of determining the desired value among two other values) (Gittinger, 1982).

$$IRR = Lower\ discount\ rate + Difference\ between\ discount\ rates * \left[\frac{present\ worth\ of\ the\ incremental\ net\ benefit\ stream\ at\ the\ lower\ discount\ rate}{the\ sum\ of\ the\ present\ worth\ of\ the\ incremental\ net\ benefit\ streams\ at\ the\ two\ discount\ rates, signs\ ignored}\right] \tag{3}$$

c) Benefit-cost Ratio (B/C)

The benefit-cost ratio is the third discounted measure of investment worth. This is the ratio calculated by dividing the present worth of the benefit stream by the present worth of the cost stream. When the cost and benefit streams are discounted at the opportunity cost of capital, the proper selection criterion for the benefit-cost ratio measure of investment worth is to concede all independent investments with a benefit-cost ratio of one or greater (Gittinger, 1982).

$$\frac{B}{C} = \frac{\sum_{t=0}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=0}^{n} \frac{C_t}{(1+r)^t}} \tag{4}$$

where B/C represents the benefit-cost ratio, B_t is the benefit in each year, C_t is the cost in each year, t = 1, 2, ..., n (time), n is the number of years and i denotes the discount rate**.**

d) Break-even Point (BEP)

The break-even point shows the volume of production at which farms make a profit after all costs are covered. Therefore, this point represents the minimum capacity required for the operation of the farms. The formula used to calculate the break-even point on the examined farms is provided below (Yurdakul, 1999).

$$BEP = \frac{FC}{P-VC} \tag{5}$$

where

BEP: break-even point (tonne/farm)

FC: total fixed cost ($/farm)

P: fish price ($/tonne)

VC: total variable cost per unit ($/tonne)

e) Payback Period (PP)

The payback period is based on finding out how long it will take to recover the invested capital—in other words, how long it will take for the investment to finance itself. The payback period is calculated by dividing the investment capital by the value it will create. It is calculated using the formula shown below (Rehber and Erkus, 2014).

$$PP = \frac{I}{NCF+D} \tag{6}$$

where

PP: payback period (year)

I: total investment amount ($/farm)

NCF: yearly net cash flow ($/farm)

D: depreciations ($/farm)

4. Results and Discussion

Fixed investment expenses cover all of the investment costs required until the operation phase of an investment. These expenses constitute the assets of the investment, and in the future, they (tools and equipment, vehicles, buildings, etc.) are faced with wear and obsolescence (Yurdakul, 1999). Total fixed investment expenses by farm groups are given in Table 1. It was discovered that as operating capacities increased, so did fixed investment expenses. Average fixed investment expenses per farm in Groups I, II, and III were found to be $91,105.82, $73,725.28, and $393,097.16, respectively. Although the order varied between groups, the cost elements in the first three rows for Group I: cage (45.81%), vehicle (17.67%), and net and equipment (9.30%); for Group II: vehicle (27.01%), cage (19.31%), and net and equipment (10.78%); for Group III: vehicle (29.90%), net and equipment (18.29%), and cage (14.50%). In other studies on similar subjects, the cage has the largest share of total investment costs (Afero et al., 2010; Vieneetha Valsalan et al., 2020).

Table 1: Fixed investment expenses by farm groups ($/farm)

Components of fixed investment expenses	Farm Groups (tonne)					
	Group I		Group II		Group III	
	$	%	$	%	$	%
Survey and project expenses	1,906.88	2.09	2,542.51	3.45	3,178.13	0.81
Cage setup	4,661.26	5.12	7,839.40	10.63	13,842.54	3.52
Cage	41,739.50	45.81	14,238.04	19.31	56,994.54	14.50
Boat	3,093.38	3.40	3,538.32	4.80	36,725.11	9.34
Grading machine	1,419.57	1.56	5,296.89	7.18	32,063.85	8.16
Net and equipment	8,475.03	9.30	7,945.34	10.78	71,896.46	18.29
Vault	2,394.19	2.63	2,548.86	3.46	14,019.10	3.57
Rope	1,837.49	2.02	3,432.39	4.66	18,291.93	4.65
Chain	42.38	0.05	42.38	0.06	3,771.39	0.96
Vehicle	16,102.55	17.67	19,916.31	27.01	117,520.35	29.90
Floating houses	5,508.77	6.05	4,237.51	5.75	7,203.77	1.83

Other expenses	1,271.25	1.40	0.00	0.00	6,140.55	1.56
Unexpected expenses (3%)	2,653.57	2.91	2,147.34	2.91	11,449.43	2.91
Total fixed investment expenses	91,105.82	100.00	73,725.28	100.00	393,097.16	100.00

Operating expenses are the costs incurred after the investment is operational (Rehber and Erkus, 2014). As a result, these costs appear at the start of production. Table 2 shows the operating expenses of the farms under consideration. According to the farm groups, the average operating expenses ranged between $64,959.34 and $697,900.93, with the average operating expenses increasing as the operating capacity increased. Feed and fingerling purchases accounted for the majority of total operating expenses across all farm groups. The share of feed expenses in total operating expenses was determined as 53.34%, 54.78%, and 57.04% in farm Groups I, II, and III, respectively. In the same groups, the cost of purchasing fingerling was found to be 21.85%, 20.73%, and 25.26%, respectively. Di Trapani et al. (2014), in their study in Italy, determined that the cost of feed and fingerling in the production of European sea bass in the sea far from the coast and close to the coast are the inputs with the highest share in the total production costs.

Table 2: Operating expenses by farm groups ($/farm)

Components of operating expenses	Farm Groups (tonne)					
	Group I		Group I		Group I	
	$	%	$	%	$	%
Bait	34,647.68	53.34	57,442.20	54.78	398,115.85	57.04
Fingerling	14,195.67	21.85	21,738.44	20.73	176,294.65	25.26
Labor	2,235.29	3.44	4,322.26	4.12	13,863.73	1.99
Veterinary - medicine - disinfectant	741.56	1.14	1,716.19	1.64	4,915.51	0.70
Tool - machine oil - fuel	578.84	0.89	1,546.69	1.48	10,664.41	1.53
Tool - machine and cage repair maintenance	1,695.01	2.61	2,235.29	2.13	4,449.39	0.64
Tool - machine depreciation	7,222.20	11.12	11,453.20	10.92	61,483.18	8.81
Building depreciation	381.29	0.59	296.63	0.28	498.50	0.07
Electric	165.26	0.25	222.47	0.21	2,648.45	0.38
Rent	335.82	0.52	213.99	0.20	1,437.93	0.21
Other expenses	868.69	1.34	635.63	0.61	3,298.20	0.47
Unexpected expenses (3%)	1,892.02	2.91	3,035.62	2.89	20,231.15	2.90
Total farm expenses	64,959.34	100.00	104,858.61	100.00	697,900.93	100.00

A cash flow statement is prepared to see the movement of money used in investment over the life of the investment. It is created by considering the economic life of the investment. In the cash flow statement, expenses show cash outflows, revenues show cash inflows, and net cash flow represents the difference between cash inflows and outflows. Cash flow expresses the financial needs and financial balance of the investment for each year. Understanding the size of the investment gap during the investment and implementation periods, as well as determining the medium- and long-term loan needs, requires knowledge of the annual cash flow values. The cash flow is an indicator of the value of an investment for farms that invest. In the cash flow statement, depreciation is not included in expenses because fixed investments are included as expenses; showing depreciation means showing fixed investments twice. In addition, debt interest and installments are not accounted for in the cash flow statement. Since all investment expenditures will be included in the statement as cash outflows, the inclusion of debt installments as an expense in the statement will create a double-counting error (Yurdakul, 1999; Rehber and Erkus, 2014). The cash flow chart for the examined farms was prepared to take into account the 15-year economic life. The first year of the investment was accepted as the base year and was shown as the zeroth year in the statement. Rainbow trout sale, support, and scrap value were included in the income section, while fixed investment and operating expenses were in the expenses section. Net cash flow is defined as the difference between revenues and expenses. Net cash flow was negative in all farm groups in year zero because the investment was made in year zero, and thus only fixed investment expenses were incurred. There was no production this year, and it started in the first year. As a result, net cash flow took a positive value from the first year. There was scrap value in the 15th year, which was the end of the investment's economic life. It was observed that as operating capacity increased, so did net cash flow (see Table 3).

Table 3: Net cash flow ($/farm) by farm groups

Farm Groups		Years		
		Year 0	Year 1-14	Year 15
Group I	1. Revenues			
	Rainbow trout sale	-	81,627.68	81,627.68
	Support	-	2,676.053	2,676.05
	Scrap value	-	-	18,009.43
	Total	-	84,303.73	102,313.20
	2. Expenses			
	Fixed investment expenses	91,105.816	-	-
	Operating expenses	-	57,355.85	57,355.85
	Total	91,105.82	57,355.85	57,355.85
	3. Net cash flow	-91,105.82	26,947.88	44,957.31
Group II	1. Revenues			
	Rainbow trout sale	-	149,068.70	149,068.70
	Support	-	4,671.86	4,671.86
	Scrap value	-	-	20,128.18
	Total	-	153,740.50	173,868.70

	2. Expenses			
	Fixed investment expenses	73,725.28	-	-
	Operating expenses	-	93,127.86	93,127.86
	Total	73,725.28	93,127.86	93,127.86
	3. Net cash flow	-73,725.28	60,612.69	80,740.87
Group III	1. Revenues			
	Rainbow trout sale	-	1,410,896	1,410,896
	Support	-	27,278.99	27,278.99
	Scrap value	-	-	40,256.37
	Total	-	1,438,175	1,478,432
	2. Expenses			
	Fixed investment expenses	393,097.16	-	-
	Operating expenses	-	636,018.20	636,018.20
	Total	393,097.16	636,018.20	636,018.20
	3. Net cash flow	-393,097.20	802,157.00	842,413.30

The net present value of the investment, as explained in the materials and methods section, represents the total value of the net cash flows over the economic life of the investment, discounted to this specific day at a certain discount rate. It was determined that the net present values of the investment in the examined farms increased in parallel with the capacities of the farms. The net present value of the investment was calculated as $145,214.08, $451,399.11, and $6,485,245.11 for farm Groups I, II, and III, respectively (see Table 4). For an investment to be acceptable, the net present value must be at least zero or positive. As a result, investments in all groups can be considered acceptable. However, when deciding between alternative investments, it is necessary to consider more than just the net present values of the investments. It is because any investment, regardless of its net present value, can be more profitable. Consequently, in addition to the net present value of the investment, the internal rate of return and benefit-cost ratio must be considered.

Table 4: Net present value of the investment ($/farm) by farm groups

Farm Groups	Year	Total expense	Total revenue	Net cash flow	Discount factor (8%)	Discounted net cash flow
Group I	0	91,105.82	-	-91,105.82	1.000	-91,105.82
	1-14	57,355.85	84,303.73	26,947.88	8.244	222,158.34
	15	57,355.85	102,313.2	44,957.31	0.315	14,161.55
	Total	-	-	-	NPV	145,214.08
Group II	0	73,725.28	-	-73,725.28	1.000	-73,725.28
	1-14	93,127.86	153,740.5	60,612.69	8.244	499,691.02
	15	93,127.86	173,868.7	80,740.88	0.315	25,433.38
	Total	-	-	-	NPV	451,399.11
Group III	0	393,097.20	-	-393,097.16	1.000	-393,097.16
	1-14	636,018.20	1,438,175	802,156.97	8.244	6,612,982.07
	15	636,018.20	1,478,432	842,413.34	0.315	265,360.20
	Total	-	-	-	NPV	6,485,245.11

The internal rate of return is the discount rate that results in a zero total present value of the net cash flows generated by the investment over its economic life. It displays the capital's profitability ratio (Rehber and Erkus, 2014; Yurdakul, 1999). The materials and methods section went into great detail about calculating the internal rate of return. Internal rates of return were calculated automatically for various farm groups using the necessary data (net cash flow and economic life) in the Excel program. The calculations revealed that as farm groups grew in size, the internal rate of return rose. Internal rates of return were found to be 29.09%, 82.23%, and 204.09% in farm Groups I, II, and III, respectively (see Table 5). If the calculated internal rate of return is equal to or greater than the opportunity cost of capital, the investment can be made. According to the data for 2021 in Türkiye, the current interest rate as the opportunity cost of capital was 17%. Investments are acceptable since the internal rates of return of the examined farms are higher than this ratio. When deciding between alternative investments prepared for the same purpose, those with a high internal rate of return should be chosen in terms of resource efficiency. In their study in Indonesia, Afereo et al. (2010) determined the internal rate of return for tiger grouper cage aquaculture as 88% for medium-scale farms and 157% for large-scale farms. In small-scale farms, since the net cash flow and the net present value of the investment are both negative, the internal rate of return could not be calculated. In the same study, the internal rate of return for small-, medium-, and large-scale farms were found to be 361%, 430%, and 506%, respectively, in humpback grouper aquaculture. The study determined that as the size of the farm increased, so did the internal rate of return. In another study in Italy, Di Trapani et al. (2014) determined the internal rate of return for the production of European sea bass as 18.50% in the offshore production system and 18.35% in the inshore production system.

Table 5: Internal rate of return by farm groups (%)

Farm Groups	Internal rate of return
Group I	29.09
Group II	82.23
Group III	204.09

The benefit-cost ratio is the ratio of discounted revenues to discounted expenses over the economic life of the investment. The benefit-cost ratio represents the amount of income obtained for one unit of expense. If the benefit-cost ratio is equal to or greater than one, the investment can be made (Yurdakul, 1999). This is explained in greater detail in the materials and methods section. It was discovered that as the capacities of the examined farms increased, so did the benefit-cost ratios. The benefit-cost ratios in farm Groups I, II, and III were found to be 1.25, 1.52, and 2.11, respectively. The fact that the benefit-cost ratios in all farm groups were greater than one indicated that the investments made were feasible (see Table 6). According to Musa et al. (2022), the benefit-cost ratios for growing tilapia in cages with 8 m^3, 62.5 m^3, and 471 m^3 capacities in Lake Victoria in Kenya were determined as 1.1, 1.5, and 1.8, respectively. In the study of Afereo et al. (2010) in Indonesia, the benefit-cost ratios were calculated as 0.84, 1.25, and 1.33 for small-, medium-, and large-sized farms in tiger grouper aquaculture in cages and as 2.36, 2.69, and 2.52 in humpback grouper aquaculture, respectively.

Table 6: Benefit-cost ratio ($/farm) by farm groups

Farm Groups	Year	Total expense	Total revenue	Discount rate (%8)	Discounted expense	Discounted revenue
Group I	0	91,105.82	-	1.000	91,105.82	-
	1-14	57,355.85	84,303.73	8.244	472,841.60	694,999.94
	15	57,355.85	102,313.16	0.315	18,067.09	32,228.64
	Total	-	-	NPV	582,014.51	727,228.60
B/C = 727,228.60 / 582,014.51 = 1.25						
Group II	0	73,725.28	-	1.000	73,725.28	-
	1-14	93,127.86	153,740.55	8.244	767,746.04	1,267,437.06
	15	93,127.86	173,868.73	0.315	29,335.27	54,768.65
	Total	-	-	NPV	870,806.60	1,322,205.71
B/C = 1,322,205.71 / 870,806.60 = 1.52						
Group III	0	393,097.16	-	1.000	393,097.16	-
	1-14	636,018.20	1,438,175.17	8.244	5243,334.03	11,856,316.10
	15	636,018.20	1,478,431.54	0.315	200,345.73	465,705.94
	Total	-	-	NPV	5,836,776.93	12,322,022.04
B/C = 12,322,022.04 / 5,836,776.93 = 2.11						

The minimum capacities that the farms should work with were determined using the break-even analysis. Table 7 shows the break-even point for the farms under consideration. The break-even point was calculated to be 15.60 tonnes for farms in Group I, 20.71 tonnes for farms in Group II, and 66.34 tonnes for farms in Group III. When 46.07% of Group I capacity, 32.70% of Group II capacity, and 12.79% of Group III capacity were used, total expenses and total incomes equalled each other, and the break-even point was reached. Farms began to profit after this point. It was discovered that as the farms' capacities increased, they reached the break-even point sooner. Bezerra et al. (2016) found the break-even point for cobia (*Rachycentron canadum*) cage aquaculture in Brazil to be 2.46 and 255.6 tonnes, respectively, for small- and large-scale production systems.

Table 7: Break-even point by farm groups

	Farm Groups		
	Group I	Group II	Group III
Capacity (tonne/farm)	33.86	63.33	518.72
Fixed costs ($/farm)	12,587.79	20,031.04	101,611.70
Fish sales ($/tonne)	2,410.81	2,353.96	2,719.98
Variable costs ($/farm)	54,304.95	87,820.74	616,416.80
Variable costs ($/tonne)	1,603.86	1,386.79	1,188.35
Break-even point (tonne/farm)	15.60	20.71	66.34
Break-even point (%)	46.07	32.70	12.79

The payback period is one of the criteria to consider when evaluating investments. The payback period indicates how quickly the total investment capital can be repaid. The materials and methods section contains detailed information on the payback period. Table 8 shows the payback period of the investment based on the farm group. According to the research, as farm capacities increased, the capital used could be recovered in a shorter period. The payback periods of the investments for farm Groups I, II, and III were found to be 2.6, 1.0, and 0.5 years, respectively. Accordingly, while the farms in Group III could recoup their capital in an average of six months, the farms in Group I could get it back in 2.6 years. Afereo et al. (2010) calculated the investment payback period for medium- and large-scale farms in tiger grouper aquaculture in cages to be 0.99 and 0.57 years, respectively. Payback periods were not calculated since small-scale farms incurred losses. In the same study, the payback period of the investment in humpback grouper farming in small-, medium-, and large-scale farms was calculated as 0.23, 0.20, and 0.16 years, respectively. According to Bezerra et al. (2016), the payback period of investment in cobia aquaculture was determined as 2.07 and 3.88 years for small- and large-scale production systems, respectively. On the other hand, Vineetha Valsalan et al. (2020) found the payback period of the investment to be 0.65 and 0.45 years in the aquaculture of *Etroplus suratensis* and *Lates calcarifer* in cages in their study in India.

Table 8: Payback period of investment by farm groups (years)

	Farm Groups		
	Group I	Group I	Group I
Fixed investment amount ($/farm)	91,105.82	73,725.28	393,097.16
Annual net cash flow ($/farm)	26,947.88	60,612.69	802,156.97
Depreciations ($/farm)	7,603.50	11,749.83	61,981.68

Payback period (years)	2.6	1.0	0.5

5. Conclusion

As a result, the net present values of all of the investigated farm groups were positive, the benefit-cost ratios were greater than one, and the internal rates of return were greater than the opportunity cost of capital. However, as the farm's size increased, the net present value of the investment, the benefit-cost ratio, and the internal rates of return all rose. These are more accepted objective criteria because they consider the time value of money and the economic life of the investment. Furthermore, the break-even point, which is one of the other evaluation criteria, and the minimum capacity with which the farms should operate were discovered. When 46.07% of the capacity for farms in Group I, 32.70% of the capacity in Group II, and 12.79% of the capacity in Group III were used, the total expenses and total incomes were equal, and the break-even point was reached. It was determined that as the capacities of the farms increased, they reached the break-even point earlier. The payback period was calculated to determine how long the total capital used for the investment could be recovered. It was determined that as the capacities of the farms increased, the capital used could be recovered in a shorter time. The payback periods of the investments for farm Groups in I, II, and III were found to be 2.6, 1.0, and 0.5 years, respectively. According to the investment evaluation criteria, it was revealed that large-scale farms are more advantageous. For this reason, it is critical to provide the necessary incentives and support to increase the operating capacity of the cage aquaculture.

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