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Economics of growing salmon in recirculating aquaculture systems (RAS)

Abstract

The article discusses the economic aspects of salmon farming in recirculating aquaculture systems (RAS) and highlights the differences between RAS and traditional hatcheries. The fast growth rates achieved in ideal conditions make RAS projects highly profitable, with an internal rate of return (IRR) of up to 30%. However, several factors need to be considered when evaluating the investment efficiency, including growth periods, mortality rates, feed conversion ratios, and fish purging before slaughter. The high energy consumption required to power pumps and chillers for water cooling adds to the operational costs of RAS farms, and designing farms should be done to align with ESG principles. The article outlines the main principles that should be taken into account when considering investment in RAS salmon farming projects.

Keywords: salmon farming, recirculating aquaculture systems, RAS, ESG, economics of fish farming, principles of salmon farming

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Abbreviations: RAS, recirculating aquaculture systems; IRR, internal rate of return; ESG, environmental, social, and governance; FCR, feed conversion ratio

Introduction

Fish farming is a rapidly growing industry that is gaining popularity across the globe. One of the most promising technologies for raising fish in a sustainable manner sustainably raising fish is recirculating aquaculture systems (RAS). RAS is a type of fish farming that involves the use of tanks on land where fish are raised in a controlled environment. RAS or Recirculating Aquaculture Systems have revolutionized fish farming and made it possible to grow fish free from environmental risks and climatic factors.

Benefits of farming salmon in RAS

Let's look more deeply to at the economics of fish farming. First, it is needed to decide what fish to raise. There are several reasons why salmon is one of the preferred fish species for cultivation in Recirculating Aquaculture Systems (RAS).

Firstly, salmon is a highly valued fish species in many markets, including Europe, North America, and Asia. This makes it a profitable species to cultivate, with the potential for high market demand and premium prices. In the US market, there is a shortage of the own produced salmon. Most of it is imported[1] and the local demand is high. There is a large and established market for salmon, making it an attractive option for fish farmers.

Secondly, salmon is a carnivorous fish species, which means that it requires a high-protein diet. The price for salmon comparing compared with the cost of feed is relatively high. In RAS, the water is continuously recycled, which can result in high levels of ammonia and nitrite, which can be toxic to fish. To maintain water quality, RAS facilities must have effective bio filtration systems. Salmon's high protein diet means that it produces more waste than other fish species, which in turn means that it requires a more efficient bio filtration system. Therefore, growing salmon in RAS is a good fit, as it allows for effective nutrient removal and water treatment.

Thirdly, salmon has a relatively fast growth rate, which makes it a more productive fish to grow. Salmon farming can be highly profitable due to the high market price of the fish. However, this profitability is dependent on several factors, including the cost of production and the ability to meet market demand. Salmon is also known for its fast growth rates and good feed conversion ratios, making it an efficient species to cultivate in RAS.[2]

Salmon is a cold-water fish species and the optimal temperature to grow is 13-17 degrees Celsius. To grow it there should either be access to the cold water or the chillers should be used to decrease the temperature. So, there is a technological option to decrease the temperature of the water and to locate the farm closer to the consumer's market.

Also, there is a need of for salted water and its discharge. Ideally, the farm should be located with the access to the sea water. But there are also options to locate the farm in the freshwater environment and to add salt artificially. A similar project has already been implemented by Aquamaof in Poland.[3]

Overall, these factors make salmon an ideal fish species for cultivation in RAS, and the preferred choice for many fish farmers looking to establish profitable and sustainable aquaculture operations.[4]

Necessary capital investments for the construction of the farm

According to the largest RAS equipment suppliers the minimum volume of fish farming at which construction is economically feasible is around 2.5 thousand metric tons. Most suppliers of technological equipment offer to build farms with a capacity of 5 thousand metric tons. However, one should not forget about the risks and capital investments required to implement such a project.

The volume of capital expenditures for the construction of 2.5 thousand tons of salmon amounts to about $60 million, with approximately 45% being spent on technological equipment and the rest on construction, design, land, and permits. In addition to the necessary capital expenditures, it is also important to consider financing working capital in the amount of the cost of 2 years of fish cultivation until the first sale, which for this size of the facility will amount to about $10 million. Also, funds will be needed to pay interest during the investment phase until the project begins to generate profits independently.

It is important to note that the cost of technological equipment depends on the supplier and the level of automation required. However, regardless of the supplier, technological equipment makes up a significant part of the total cost of the project. Therefore, it is necessary to conduct a thorough analysis of the market and select the most cost-effective option.

Growing salmon in RAS: key factors to consider

RAS allows you to achieve ideal conditions for the growth of fish by maintaining temperature, oxygen and other conditions at an optimal living standard for fish. Here are the key factors that need to be considered while analyzing the feasibility of a Salmon RAS project.

Growth rate, mortality, and FCR

The growth rate of Salmon in RAS is influenced by various factors like water temperature, oxygen levels, and water quality.

Assuming the construction of its own hatchery and fry factory, the growth of fish from eggs to a large commercial weight of about 5 kg (which is optimal for sales to both processors and retailers) takes 24 months. At the same time, the average size of the fish at maximum weight will be 5.5 kg, but before the sale, purging is required during which the fish are not fed and lose between 3 to 7% of their weight.

Purging is a process used in fish farming where the fish are kept in clean water and not fed for a period of time some time before being harvested. The purpose of this process is to clean out the fish's digestive system, allowing it to eliminate any impurities and waste products that may affect the taste and quality of the fish's flesh. Purging also helps to firm up the fish's flesh, which improves its texture and makes it more appealing to consumers.[5]

The mortality rate is another crucial factor to consider as it impacts the production and profitability of the project.

The overall mortality rate during the growing period is approximately 40%. However, the majority of fish deaths occur from the egg stage to the first feeding (up to 20%).

The next significant jump in mortality can occur during the smoltification process. Smoltification in RAS usually occurs when the average weight reaches around 100 grams. Smoltification is a natural physiological process that occurs in salmonids, as they prepare to migrate from freshwater to saltwater environments. During smoltification, the fish undergo a series of changes in their body, including the development of silvery scales, the reduction in the size of their internal organs, and the adaptation of their metabolism to the new environment. These changes allow the fish to survive in the saltwater environment and to swim long distances to their feeding grounds. Smoltification is an important stage in the life cycle of salmonids, as it marks the transition from freshwater to marine habitats and has significant implications for their survival and growth.[6]

From the smoltification stage (approximately 100 grams) until the end of the growing period, the acceptable mortality rate is up to 15%.

Mortality rates are an important aspect of important in fish farming because they can affect profitability and sustainability. High mortality rates can lead to economic losses. It is essential to identify the causes of mortality and take measures to minimize them.

The high mortality rate during the egg to first egg-to-first feeding stage is due to the delicate and vulnerable nature of fish during this time. They are more susceptible to disease, stress, and inadequate nutrition. Therefore, it is crucial to provide appropriate and timely care during this period, such as monitoring water quality, and feeding.

The acceptable mortality rate during the growing period from smoltification to harvest is up to 15%. This rate is considered reasonable due to factors such as fish health, genetics, environmental conditions, and management practices. However, fish farmers should aim to reduce mortality rates as much as possible to maximize profitability and sustainability. This can be achieved by ensuring optimal water quality, providing a balanced and nutritious diet, implementing effective disease management practices, and maintaining good farm management practices.

The FCR or feed conversion ratio is another important parameter to consider as it represents the amount of feed required to produce one kilogram of fish. The lower the FCR, the better is the efficiency of the production process.

The FCR can vary depending on the size of the fish being raised. For example, for small fish weighing up to 30 grams, the FCR is around 0.8 x, but this requires the use of expensive starter feed. As the fish grow larger, the FCR increases. The standard FCR for the entire growth period of the fish is around 1.2 x. This means that for every 1 kilogram of body mass gained by the fish, 1.2 kilograms of feed are consumed. It is important to optimize the FCR to minimize the cost of feed and maximize the profitability of the fish farming operation. This can be achieved through careful selection of feed ingredients and feeding strategies, as well as monitoring the growth and health of the fish to ensure that they are consuming the optimal amount of feed.

Main operational cost components

The main operational cost components of a Salmon RAS project include eggs, feed, labor, energy, and financing costs like interest on loans. Analyzing these costs is critical to understanding the financial feasibility of the project.

The process of fish farming on a fish farm involves a conveyor system with monthly egg imports and monthly harvests. Ideally, the fish farm would obtain eggs from a brood stock that is also raised on the farm, but such farms are rare worldwide.

Feed is the main component of the cost of production. Feed accounts for about 60% of operational costs in an ideal fish farm. In an ideal fish farm, feed accounts for about 60% of operational costs. However, in reality, unforeseen circumstances can reduce feed costs to around 50-55% of operational costs.

Personnel costs are the second largest expense in the cost of production. In modern fish farms, the staff is divided into an engineering team and fish farmers who monitor the fish and control the growth process.

Infrastructure costs such as electricity for running the farm and cooling the water come next in terms of expenses.

Price premium for local production

The demand for locally produced food has been growing in recent years, and Salmon RAS projects can leverage this trend. In a case study by Atlantic Sapphire, a US-based Salmon RAS farm, the company was able to charge a premium for its locally grown fish, which helped to boost the revenue and profitability of the project.

The retail price of salmon varies depending on the region and the type of salmon being sold. In the USA, the average retail price for salmon is around USD 18-23 per kilogram, or USD 8.2-10 per pound.

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However, for Atlantic Sapphire salmon sold in their home market of Florida, the price is significantly higher, at around USD 28-35 per kilogram or USD 12.7-15.9 per pound. This represents a price premium of 20-50% over the average retail price of salmon in the USA. The company markets their salmon as a premium, sustainable, and locally-produced product, which appeals to consumers who are willing to pay a higher price for high-quality, environmentally-friendly food.

Common design mistakes

Designing a Salmon RAS farm is a complex process that involves multiple factors. One of the key considerations is water flow, which is crucial for maintaining the health and growth of the fish. Insufficient water flow can lead to a build-up of waste, which can harm the fish and affect harming the fish and affect the water quality. Therefore, it is important to ensure that the water flow rate is sufficient to keep the water clean and maintain optimal conditions for the fish.[7]

Another important factor in designing a RAS farm is filtration. Inadequate biofiltration can lead to a build-up of ammonia and nitrite, which can be harmful to the fish. Proper biofiltration involves providing sufficient surface area for beneficial bacteria to grow and convert waste into less harmful compounds. If the biofiltration system is not properly designed, it can lead to poor water quality and increased mortality rates among the fish.

The temperature control system is also an important consideration when designing a RAS farm. Salmon requires specific water temperatures for optimal growth, and the temperature needs to be carefully controlled to prevent stress and disease. Inadequate temperature control can result in slower growth rates, reduced feed conversion rates, and increased mortality. Under sizing chillers is a common mistake in RAS farm design. The chiller is responsible for maintaining the water temperature, and if it is undersized, it will struggle to maintain the desired temperature in the system. This can lead to increased stress and disease among the fish, reduced growth rates, and higher energy costs.

Installing too many pumps is another common design mistake that can impact the efficiency of the production process and increase operational costs. More pumps require more energy to operate, which can increase the cost of electricity. It is important to ensure that the number and size of pumps are appropriate for the system, and that they are properly located and configured to ensure efficient water flow.

Here are some common design mistakes in the RAS farm

a) Insufficient biosecurity measures: RAS farms require strict biosecurity measures to prevent disease outbreaks, but some designs may not incorporate proper quarantine areas or waste treatment systems, leading to contamination and disease spread.

b) Poor planning and layout: Inadequate planning and poor layout can lead to inefficient use of space, poor flow of water, and difficulty in maintenance and monitoring of the system.

c) Overcrowding: Overcrowding of fish tanks can cause stress and poor water quality, leading to lower growth rates, higher mortality rates, and increased disease risk.

d) Inadequate water treatment systems: RAS farms rely on efficient water treatment systems to maintain water quality, but some designs may not incorporate sufficient filtration or aeration systems, leading to poor water quality and decreased fish health.

e) Inadequate oxygenation: Oxygen is essential for the survival and growth of fish, and inadequate oxygenation can lead to low growth rates and increased mortality.

f) Poor tank design: Tank design is crucial in ensuring optimal fish growth and health. Poorly designed tanks can result in poor water flow, uneven oxygen levels, and increased waste accumulation.

g) Inefficient energy use: RAS farms require significant amounts of energy to operate, but some designs may not incorporate energy-efficient technologies, leading to high energy costs and negative environmental impacts.

h) Lack of automation and monitoring systems: RAS farms require constant monitoring and adjustments to maintain optimal conditions for fish growth. Lack A lack of automation and monitoring systems can lead to inefficient operations and decreased fish health.

i) Inadequate backup systems: RAS farms require backup systems to maintain optimal conditions during power outages or equipment failures. Failure to incorporate backup systems can lead to significant losses in fish stocks and decreased profitability.

j) Poor management practices: Poor management practices like overfeeding, improper stocking densities, and inadequate cleaning can lead to poor water quality and increased disease risk. Proper management practices are essential for the success of RAS farming.

In summary, designing a Salmon RAS farm requires careful consideration of multiple factors. Common design mistakes such as undersized chillers, inadequate biofiltration, and installing too many pumps can negatively impact the efficiency of the production process and increase operational costs. Proper design and implementation can ensure optimal conditions for the fish, leading to improved growth rates, feed conversion rates, and overall profitability.

Payback period and profitability

The payback period of a Salmon RAS project depends on various factors like the size of the farm, production volumes, and market demand. On average, the payback period can range from 7 to 10 years. This period is influenced by the length of the construction process. Current market prices also have a direct impact on the profitability of the project. Factors such as the cost of feed and energy can greatly affect profitability. Efficient design and management of resources can help to reduce costs and shorten the payback period. Despite the lengthy payback period, RAS farms can offer long-term benefits such as sustainable production, reduced environmental impact, and stable revenue streams.

If the project is well-designed, and the production process is optimized, the profitability can be attractive, with the IRR of the projects ranging from 20% to 30%.

Financing conditions also affect the profitability of projects. With current interest rates, the additional burden of interest payments is quite high, which requires additional efforts. Attracting financing is an important task for the success of the farms. In the US market, various sources of financing are available, such as loans and venture capital. It's important for salmon RAS farm owners to carefully evaluate their financing options and choose the one that best suits their needs and goals.[7]

A successful farm farms must not only have an efficient design but also manage the project's finances and resources with optimal

profitability. Therefore, when developing a project, all aspects must be taken into account, including financing conditions, to ensure successful and profitable farm operation.[8]

RAS farms are ESG compliant

RAS fish farms are considered ESG (Environmental, Social, and Governance) compliant due to their sustainable and responsible approach to fish farming. Firstly, RAS farms use recirculating systems that significantly reduce water consumption and waste discharge compared to traditional open-net farms. This leads to less environmental impact and pollution of water bodies.[9]

Secondly, RAS farms prioritize fish welfare, which means using advanced technology to maintain water quality, temperature, and oxygen levels to provide a comfortable environment for the fish. This approach to farming ensures the ethical treatment of fish and can contribute to the overall health of the ecosystem.

Thirdly, RAS farms are designed to minimize the use of chemicals and antibiotics, as well as the risk of disease outbreaks. This reduces the environmental impact of fish farming and provides healthier and more sustainable food for consumers.

Finally, RAS farms can also have a positive impact on local communities by creating jobs and supporting economic development. In addition, they can contribute to food security by providing a locally sourced and sustainable protein source. The main advantages of RAS in accordance with ESG principles are presented in Figure 1.

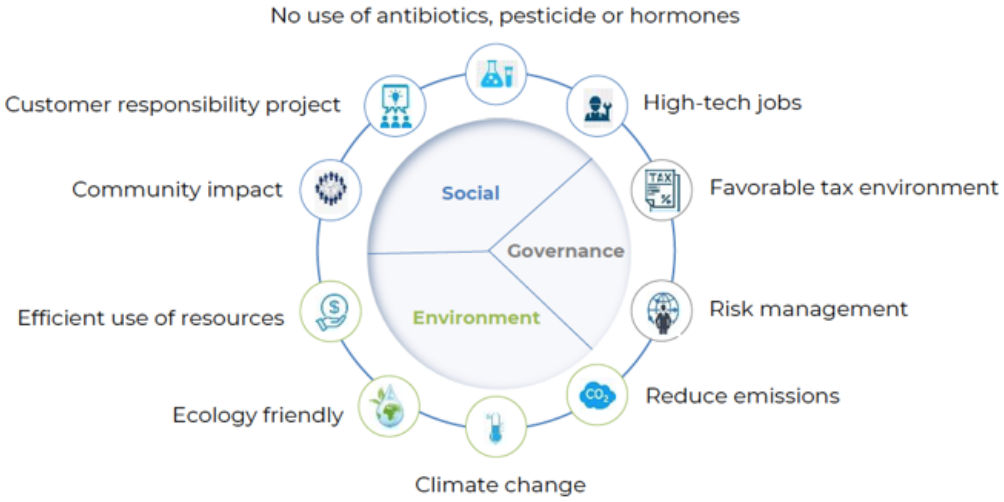

Figure 1 Compliance with ESG principles for RAS salmon farms.

Source: Author analysis.

Overall, RAS fish farms are ESG compliant due to their environmentally sustainable practices,[10] socially responsible approach to fish welfare, and governance structure that prioritizes responsible and ethical fish farming practices.

Conclusion

Salmon RAS farming offers an attractive opportunity for sustainable fish farming. However, careful analysis of key factors like growth rate, mortality, FCR, and cost components is critical to achieving success in this field. While the technology is promising and can lead to sustainable fish farming practices, it is important to consider the risks and capital investments required to implement such a project. It is also important to select the most cost-effective option for technological equipment and to carefully manage the farm. With proper planning and execution, Salmon RAS projects can provide significant returns on investment while also contributing to local food security and sustainable development.

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None

Conflicts of interest

The author declares no conflict of interest.

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