Maejo International Journal of Energy and Environmental Communication

Journal homepage: https://ph02.tci-thaijo.org/index.php/MIJEEC

ARTICLE

A cost and benefit analysis of Nile tilapia culture in biofloc technology, the environmental friendly system: the case of selected farm in Chiang Mai, Thailand

Sudaporn Tongsiri, Nongnaphat Somkane, Udomluk Sompong, Daracha Thiammueang*

Faculty of Fisheries and Aquatic Resources, Maejo University, Chiang Mai, 50290 Thailand

ARTICLE INFO

Article history:
Received 14 Feburay 2020
Received in revised form
20 March 2020
Accepted 25 March 2020

Keywords:
Nile tilapia
Biofloc system
Environmental friendly system
Food safety
Chiang Mai province

ABSTRACT

This study aimed to investigate the cost and benefit as well as other economic analysis of Nile tilapia culture in the biofloc system. The data derived from the selected study area where was the initial farm rearing in biofloc system in Chiang Mai province, Thailand. The study revealed that the 50 fingerings m^{-3} were released in sphere-shape polyethylene ponds (9 m of diameter x 1.20 m height), and raised for 5 months to reach the harvest size (500-600 g). The fish yield was about 1,500 kg/pond or 25 kg m^{-3}. Total production cost was 101,988 Baht, divided into total fixed cost 13,656 Baht/pond (13.39%) and total variable cost 88,333 Baht/pond (86.61%). Fish feed cost was the highest at price (58.34%). The fish price was determined at 85 Baht/kg, 15% increasing from Nile tilapia common culture. Because they were cultured in the chemical and antibiotic-free system that produced the income to 121,125 Baht/pond and would receive net profit at 19,137 Baht/pond on average from 1,425 kg/pond with 95% of survival rate. Total income was 484,500 Baht/crop and total net profit was 76,549 Baht/crop. In other words, the net profit per kg was 13 Baht. The benefit and cost ratio (B/C ratio) was 1.19, and the net present value (NPV) assessment was 1.43 million Baht, which means worthiness to invest. The expected returns of this project or Internal rate of return; IRR was 45%, which was a greater ratio than the minimum expected returns (15% of the interest rate of return calculation). The payback period was 7.14 years, which indicated that the investors had to run this business for 7 years and one and a half months to recover their investment money. Consequently, the business has a favorable prospect, and the biofloc system for the culture of tilapia is applicable for fish farmers.

1. Introduction

Nile tilapia is an important aquatic animal species in terms of economic and domestic consumption in Thailand and has been widely cultured over 40 years. Thailand is one of the top 10 global tilapia producers that has contributed production to the world. In the year 2018, 8,344.20 Tonnes of Nile tilapia and its processed products were exported, accounting for 299.70 million Baht or 9.67 million USD (Noorit, 2018). There are many patterns of Nile tilapia culture, such as in an earthen pond, cage, or concrete pond. Each pattern has been evolved in order to develop and tried to solve the former patterns. For example, intensive culture was developed because more production per area is needed. However, a high density of cultured organisms could create various problems; for instance, waste treatment, environmental degradation, fish stress and health must take into consideration. Also, fish diseases spread quickly. As a result, the sustainable Biofloc technology was created

* Corresponding author.
E-mail address: daracha@mju.ac.th (Daracha Thiammueang)

to solve this problem by improving water quality through the addition of extra carbon to the aquaculture system, through an external carbon source or elevated carbon content of the feed (Crab et al., 2012). Biofloc technology is based on pond management using minimal water exchange and subsequent development of dense microbial populations.

The microbes are managed through the adjustment of the carbon:nitrogen (C:N) ratio to control inorganic nitrogen concentrations in the water (Avnimelech, 2011). The biofloc system was considered a sustainable and environmentally friendly aquaculture system since nutrients could be continuously recycled and reused. The biofloc has two major roles, including the maintenance of water quality by uptaking of nitrogen compounds generating *"in situ"* microbial protein and the increased culture feasibility by reducing feed conversion ratio or a decreasing of feed costs (Emerenciano et al., 2013). Nowadays, biofloc technology in aquaculture in Thailand has not been used widely, only found in some commercial shrimp farms because some other farmers have not been assured in the effectiveness of the microorganism uptaking mechanism (Kaenthong, 2019).

The selected study site name "King Fish Group" located in San Pa Tong District, Chiang Mai province, was the initial fish farm in Thailand, which has applied biofloc technology to Nile Tilapia culture since 2015. The farm owner intended to develop Nile Tilapia culture toward premium graded fish for exports, especially cultured in the organic system. Moreover, they aimed to be the role model fish farming with biofloc technology. This study purposed to investigate the cost and benefit, also other economic analyses such as payback period, net present value and internal rate of returns. The results of this could be used as a guideline for farmers or investors who were interested in this tilapia production business.

2. Methodology

The methodology adopted in this study is illustrated in Fig. 1. This study performed the cost and benefit analysis of Nile tilapia culture using biofloc technology, the environmentally-friendly system at "King Fish Group" fish farm.

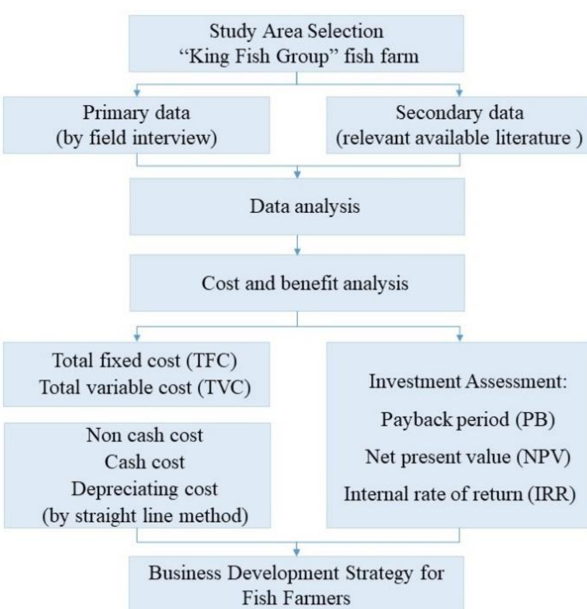

Fig. 1. A flowchart of the methodology.

The farm was located in Tungtom subdistrict, San Pa Tong District, Chiang Mai Province, Thailand. This farm has run the business on fish culture for many years and was the initial farm which has been applied the biofloc technology into their fish culture.

This study was done based on data and information on aquaculture management and production from the "King Fish Group" fish farm in Tungtom subdistrict study area, San Pa Tong District, Chiang Mai Province, Thailand. The primary data collection process was structured by an interview survey from a purposive-selection study area that was undertaken in this study. Therefore, data collected comprising primary and secondary data. Primary data obtained from farm owners by interview and questionnaires as well as direct observation related to the culture system, tilapia production, operational cost, profit, distribution and marketing. However, secondary data in the forms of the annual report, literature review from textbooks, academic papers and the statistics and other document related. Furthermore, the secondary data procedure obtained from the also were used. In addition, the fisheries office, through its extension staff, offer support to ensure that all the farmers follow similar aquaculture production practices throughout the region.

Cost and benefit investigation method was adopted from Charoenjiratrakul (1994)'s cost and benefit analysis method. Several essential factors were studied including total fixed cost (TFC), total variable cost (TVC). Besides the cost was divided into non cash cost, cash cost and the depreciating cost was calculated as straight line method. Moreover, the investment assessment was estimated. It including payback period (PB), net present value (NPV) and the internal rate of return (IRR) was analyzed.

3. Results and Discussion

3.1. Nile tilapia culture in biofloc system in the study area

From the interview, we found that there were 13 ponds in the 1.20 hectares (or 11,200 m^2 or 7 Rai in Thai measurement) area of this farm, including the 9 large sphere-shaped Polyethylene ponds (15 m of diameter x 1.20 m.) and 4 small sphere-shaped Polyethylene ponds (9 m of diameter x 1.20 m). Only 4 small ponds were raised for this study. The stocking density was 50 fingerlings m^{-3}, the initial size of fish (100 g/fingerling) were stocked and raised for 5 months to the market size about 500-600 g. The production from a big pond was about 6,000-7,000 kg and was 1,500 kg for a small pond. This fish production was sold in two ways, including; at the gate-pond (30%) and at the market (70%) in Lamphun and Chiang Mai provinces at a price 70 and 75 Baht/kg, respectively.

However, in this study, the organic culture system was applied to investigate how adequate and worthiness of this pattern to produce the premium grade of Nile tilapia for exports and domestic consumption for the consumers who realize in their health and desire good, safety, and non-toxic products. The result stated that there was a struggle in the process from good aquaculture practice (GAP) towards organic standard certified to follow the Organic Agriculture Certification Thailand (ACT), which gained legal status with the registration of Foundation of Organic Agriculture Certification Thailand or IFOAM.

The limitation was the too high densities are not acceptable because it possibly causes the fish stress and injury in the pond. The stock density has been controlled to not over 1,800 kg/Rai or 1,125 g m^{-2} for Nile tilapia culture in the pond (Organic Agriculture Certification Thailand, 2020). In other word, in case of to raise to marketable size (500 g.), the stock density must be only 2 fish m^{-2}. That was impossible in a commercial way to raise in an organic system and receive the fish product only 67.50 kg in 60 m^3 pond. Then, the benefit and cost estimation would be found that it was a considerable loss. So changing from an organic culture system to a food safety system was the preferable way in terms of investment worthiness. The Nile tilapia culture in biofloc system for safety food in this study means raising organic fingerlings in the chemicals and antibiotics-free system with the organic fish feeding.

3.2. Benefit and cost analysis of Nile tilapia culture in biofloc system

This benefit and cost analyzed based on four 9-m diameter sphere shape ponds x 1.20 m height, 60 m^3 water volume. Total production cost was 101,988 Baht, divided into total fixed cost 13,656 Baht/pond (13.39% of total production cost) and total variable cost 88,333 Baht/pond (86.61% of total production cost) (Fig. 2). Fish feed cost was the highest cost (58.34%), which similarly to other traditional cultures, but the number of feeding cost ratios on the biofloc system was less than others, 58%. In contrast, the fish feed cost of Nile tilapia cage culture in Moon river in Ubonrachthani province, in the Tapee river, Suratthani province was 76.30 and 74.80%, respectively (Suparat, 2001; Komanpririn, and Charernjiratragul, 2008). The fingerlings cost was 14.71% and the feeding ratio was 3% of fish weight (Fig. 2 and 3).

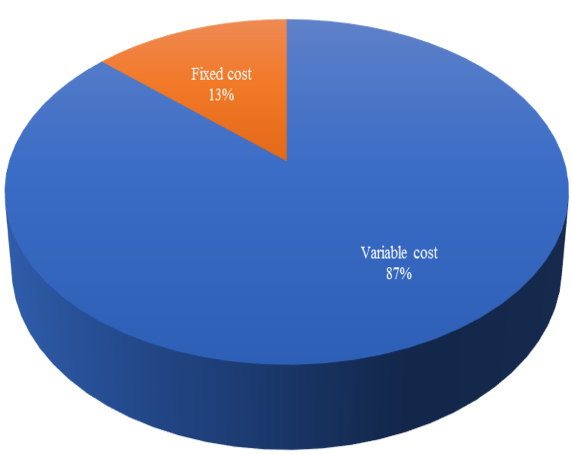

Fig. 2. Fixed cost and variable cost in Nile tilapia culture in biofloc system.

In this study, the organic 100 g-size of fingerlings were released in a biofloc pond, which generated a relatively higher cost but greater survival rate and more shortened time than a smaller size of fingerling. Stock density was 50 fingerlings m^{-3} or 3,000 fingerlings 60 m^{-3} water volume. Feeding cost in biofloc system was less percentage than the ones applying for cage or earthen pond culture because there was a minimize water exchange and water usage through maintaining adequate water quality in a biofloc system while producing low-cost biofloc rich in protein, which in turn can serve as a feed for aquatic organisms (Crab et al., 2010).

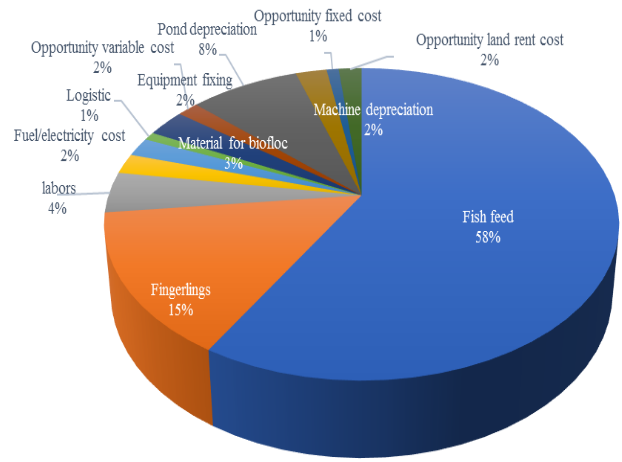

Fig. 3. Details of cost in Nile tilapia culture in biofloc system.

Fish production from non-chemical and non-antibiotic culture could be sold at a higher price. Thiammueang (2019) studied on the consumer's attitude in safety and organic fish in Chiangmai province and found that more than a half of the sample of consumers (65%) has the willingness to pay a higher price for organic fish but not over 20% compare with fish price from the common system since the consumer could afford for premium goods and for their better health. They would like to avoid consuming chemical residue products.

In this study, the fish price was determined at 85 Baht/kg, a 15% increasing from Nile tilapia common culture that produced the income to 121,125 Baht/pond and minus all the costs a farmer would receive net profit at 19,137/pond in average from 1,425 kg/pond with 95% survival rate. So after 5 months of the culture period, the farmer would gain a total income of 484,500 Baht/crop and a total net profit was 76,549 Baht/crop. In other words, the net profit per kg was 13 Baht. The benefit and cost ratio (B/C ratio) was 1.19 and the net present value (NPV) assessment was 1.43 million Baht.

This NPV was the positive indicated that the Nile tilapia culture in biofloc system investment was worthiness. If the NPV is minus means that the business is not worthiness. The expected returns of this project or Internal rate of return; IRR was 45%, which was a greater ratio than the minimum expected returns (15% of the interest rate of return calculation). The payback period was 7.14 years, which indicated that the investors had to run this business for 7 years and one and a half month, they would recover their investment money (Table 1).

From the worthiness of investment in this Nile tilapia culture in biofloc system analysis, all of the value of net profit, benefit and cost ratio, NPV, IRR were positive value but the payback period was over 7 years that because at the initial investment, especially, the pond frame which made by steel bar and modeled the pond with high-quality polyethylene. In case of cost reduction, the farmer could apply a fiberglass pond or other kinds of the pond, which is lower cost instead of a PE pond.

Table 1
Cost and benefits structure of Nile tilapia culture in biofloc system.

Cost type	Cash cost	Non-cash cost	Total	Percentage
Variable cost	86,718	1,615	88,333	86.61
- Fish feed	59,500	-	59,500	58.34
- Fingerlings	15,000	-	15,000	14.71
- labors	4,308	-	4,308	4.22
- Fuel/electricity cost	2,127	-	2,127	2.09
- Equipment fixing	2,000	-	2,000	1.96
- Logistic	880	-	880	0.86
- Materials for biofloc	2,903	-	2,903	2.85
- Opportunity variable cost	-	1615	1,615	1.58
Fixed cost	10,990	2,666	13,656	13.39
- Pond depreciation	8,360	-	8,360	8.20
- Machine depreciation	2,380	-	2,380	2.33
- Opportunity fixed cost	-	916	916	0.90
- Opportunity land rent cost	-	1,750	1,750	1.72
Total cost	101,988			100
Average production (kg/pond)	1,425			
Fish price (Baht/kg)	85			
Benefit (Baht/pond)	121,125			
Number of ponds	4			
Net profit (Baht/pond)	19,137			
Total benefit (Baht/crop)	484,500			
Net profit (Baht/crop)	76,549			
Net profit per kg (Baht)	13			
Benefit/cost ratio	1.19			
Net present value, NPV (Baht)	1,426,302			
Internal rate of returns (IRR)	45%			
Payback period (years)	7.14			

4. Conclusion and suggestions

Biofloc technology is the new alternative techniques that have been applied to aquaculture, replacing a conventional culture system such as an earthen pond or cage culture. It is able to produce more production due to a higher stocking density. This biofloc system is more efficient and convenient for commercial farming. However, too much stock density is prohibited in an organic system raising following the standard of Organic Agriculture Certification Thailand to avoid the fish stress and injury. These showed that rearing with biofloc technology in standard organic system was unlikely suitable in a commercial way. From this benefit and cost study, we found that feeding cost was the highest ratio. However, the feeding cost from the biofloc system was less ration than the traditional cultures since biofloc has been showed an adequate protein, lipid, carbohydrate and ash content of biofloc could be used as a fish feed. Meanwhile, increasing water turbidity was the disadvantage of the biofloc system, so sediment disposing of was frequently needed. Nowadays, it can be seen that the consumer's behavior in food and beverages had changed in terms of personal satisfaction, taste and awareness in their society because they realized about sustainable environmental and their health (DITP, 2018). Therefore, to encourage a fish culture in the biofloc system was another way for farmers in order to produce the chemical and antibiotic-free fish to the market transform to the consumer demands.

Nomenclature and abbreviation	
GAP	Good Aquaculture Practice
TFC	Total Fixed Cost
TVC	Total Variable Cost
PB	Payback Period
NPV	Net Present Value
IRR	Internal Rate of Return
ACT	Organic Agriculture Certification Thailand
DITP	Department of International Trade Promotion
IFOAM	International Federation of Organic Agriculture Movements

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

The authors acknowledge the funding support gratefully from Agriculture Research Development Agency (Public Organization) under the project "Upgrading tilapia production from biofloc system to premium organic product under food valley industry" in 2017. Also, we would like to thank the selected study farm "King Fish" Farm owner and other key informants for their information.

References

Avnimelech, Y. 2011. Tilapia production using biofloc technology (BFT). In Proc 9th Int Symp on Tilapia in Aquaculture pp. 362-366.

Charoenjiratrakul, S. 1994. Production economics and agricultural management, agricultural economics and natural resources, Prince of Songkla University, Songkla, Thailand.

Chutjareyaves, S. 2001. Cost and return on investment of hormone sex-reversal male tilapia culture in cage in Mun river, Ubon Ratchathani province, Proceedings of the 39th Kasetsart University Annual Conference: Fisheries, Agro-Industry, Kasetsart University pp. 220-227.

Crab, R., Defoirdt, T., Bossier, P., & Verstraete, W. 2012. Biofloc technology in aquaculture: beneficial effects and future challenges. Aquaculture 356, 351-356.

Crab, R., Chielens, B., Wille, M., Bossier, P., & Verstraete, W. 2010. The effect of different carbon sources on the nutritional value of bioflocs, a feed for Macrobrachium rosenbergii postlarvae. Aquaculture Research 41(4), 559-567.

Department of International Trade Promotion. 2018. Trend of Food Market in 2018, https://bit.ly/31Rpg3f, 15 Mar 2020.

Emerenciano, M., Gaxiola, G., & Cuzon, G. 2013. Biofloc technology (BFT): a review for aquaculture application and animal food industry. Biomass now-cultivation and utilization, 301-328.

Kaenthong, A. 2019. Biofloc and Aquaculture. http://www.nicaonline.com/web/index.php/2016-08-30-02-19-31/2016-08-30-14-15-11/797-biofloc-3, 6 Mar 2020

Komanpririn, K., & Charernjiratragul, S. 2008. Costs and returns of Nile tilapia cage culture in Tapee River, Suratthani Province, Proceedings of Department of Fisheries Annual Conference in 2008. Bangkok. 18-20 August, 2008, 197-208.

Noorit, K. 2018. Nile Tilapia production and Marketing in 2018, https://www.fisheries.go.th/strategy/UserFiles/files/Q3%2061.pdf, 24 March 2020.

Organic Agriculture Certification Thailand (ACT). 2020. Organic standards, http://www.actorganic-cert.or.th/download/organic-standards.

Thiammueang, D. 2019. Consumer's Behavior on Consumption in Safety and Organic Aquatic Animal: Case Study in Chiangmai Province. Research Report. Maejo University, Thailand.