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IMPLEMENTATION OF GOOD FISH HATCHERY PRACTICES ON PRODUCTION PERFORMANCE AND FINANCIAL FEASIBILITY OF NILE TILAPIA HATCHERIES

PENERAPAN CARA PEMBENIHAN IKAN YANG BAIK TERHADAP KINERJA PRODUKSI DAN KELAYAKAN FINANSIAL PEMBENIHAN IKAN NILA

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ABSTRACT

Procedures of good fish hatchery practices (GFHP) are regulatory standards to ensure biosecurity, product traceability, and sustainability of hatchery operations in producing high-quality fish fries. The implementation of these practices determines not only the technical aspects of production but also some financial consequences for aquaculture practitioners. This study aims to evaluate the production performance and financial performance of the Nile tilapia (*Oreochromis niloticus*) implementing GFHP in Kutasirna Village, Cisaat District, Sukabumi Regency, West Java, Indonesia. Non-experimental methodology was applied to compare the business performances before and after the implementation of GFHP. Data were collected from direct observation and information from interviews with a group of 8 fish farmers in the village. Production performance and financial performance were improved after GFHP was implemented by the group. The fry production increased by approximately 110% and the net benefit–cost (net B/C) ratio increased by 73%. The financial parameters indicate reasonable stability to a higher feed price and a lower selling price of the fry. This study shows a strong indication of positive outcomes from the implementation of GFHP, i.e. continuous supplies of good quality fry for tilapia production.

Keywords: net B/C, NPV, profitability, R/C ratio, sensitivity analysis

ABSTRAK

Prosedur cara pembenihan ikan yang baik (CPIB) merupakan standar nasional untuk menjamin biosekuriti, ketertelusuran produk, dan keberlanjutan kegiatan pembenihan dalam menghasilkan benih ikan berkualitas tinggi. Penerapan prosedur ini tidak hanya menentukan aspek teknis produksi, tetapi juga memberikan konsekuensi finansial bagi pelaku usaha akuakultur. Penelitian ini bertujuan mengkaji kinerja produksi dan kinerja finansial usaha pembenihan ikan nila (*Oreochromis niloticus*) yang menerapkan CPIB di Desa Kutasirna, Kecamatan Cisaat, Kabupaten Sukabumi, Jawa Barat, Indonesia. Metode non-eksperimental diterapkan untuk membandingkan kinerja usaha sebelum dan sesudah penerapan CPIB. Data dikumpulkan melalui observasi langsung dan wawancara terhadap kelompok yang terdiri atas delapan pembudidaya ikan di desa tersebut. Kinerja produksi dan kinerja finansial mengalami peningkatan setelah CPIB diterapkan oleh kelompok pembudidaya. Produksi benih meningkat sekitar 110% dan rasio net benefit-cost (net B/C) meningkat sebesar 73%. Parameter finansial menunjukkan stabilitas yang cukup baik terhadap kenaikan harga pakan dan penurunan harga jual benih. Hasil penelitian menunjukkan indikasi kuat bahwa penerapan CPIB memberikan dampak positif, yaitu tersedianya pasokan benih nila berkualitas secara berkelanjutan.

Kata kunci: analisis sensitivitas, net B/C, NPV, profitabilitas, rasio R/C

INTRODUCTION

Nila tilapia (*Oreochromis niloticus*), native to Africa and the Middle East, is one of the most popular freshwater fishes cultured in the world, especially in Asian and African countries (Prabu *et al.* 2019). The wide geographical extent of the tilapia aquaculture is due to its biological characteristics. The fish can tolerate low oxygen levels and a wide range of salinity concentrations (Prabu *et al.* 2019; Munguti *et al.* 2022). The fish can be cultured in extensive, semi-intensive, and intensive aquaculture systems, either monoculture or polyculture (Prabu *et al.* 2019; Arumugam *et al.* 2023). Tilapia can easily adapt to both natural and artificial feeds, with reasonable feed conversion rate and growth rate (Yosef 2009; Arumugam *et al.* 2023). The feeds can be improved by mixing locally produced fish meal with catfish meal (Surianti *et al.* 2025). The combination of common commercial pellets with biopellets resulted in higher growth and survival rates of tilapia (Hutagalung *et al.* 2024). Feeding efficiency can be improved by employing automatic feeder machines (Chaidir *et al.* 2025).

Tilapia is also known as aquatic poultry and its consumption levels have increased worldwide (Yosef 2009; Dickson *et al.* 2016; Prabu *et al.* 2019; El-Sayed and Fitzsimmons 2023). Big markets with stable market prices promote significant increase in its production from 1.1 million tons to 5.6 million tons, a fourfold increase over the past decade. Tilapia provides high-quality protein and helps meet global food demand and achieve the Sustainable Development Goals (SDGs) through aquaculture efforts (Dickson *et al.* 2016; Munguti *et al.* 2022; Arumugam *et al.* 2023; El-Sayed and Fitzsimmons 2023).

Indonesia is one of the world's largest tilapia producers, ranking second after China (El-Sayed and Fitzsimmons 2023). In 2023, Indonesia exported the fish of approximately 11,000 tons (9,7% world share), valued at approximately USD 82 million. The export of value increased by an average of nearly 7% per year from 2017 to 2023 (BPS 2024). The domestic production of tilapia increased by an average of 1.19% (from 2020 to 2024). However, the production remained below the annual target of 2,462,779 tons whereas the annual production was 1,380,359 tons. One of major factors contributing such gap is shortage in high-quality tilapia fry and broodstocks which are essentials to the tilapia production and business sustainability (DJPB 2025).

Government of Indonesia (i.e. Ministry of Fisheries and Marine Affairs) released important policies to promote the implementation of quality assurance and safety of fishery products. The Regulation of the Minister of Marine Affairs and Fisheries Number KEP.02/MEN/2007 concerning good aquaculture practices (GAP), which was later revised to the Regulation of the Minister of Marine Affairs and Fisheries Number 22 of 2024 concerning good fish hatchery practices, and the Regulation of the Minister of Marine Affairs and Fisheries Number 35/PERMEN-KP/2016 concerning good fish hatchery practices (GFHP) are adopted to promote certification of producers and their products.

Prior to the issuance of these regulations, standards in tilapia aquaculture business were not recognized in Indonesia. The quality of fry was not guaranteed, the quality and quantity of the products were inconsistent and unsustainable, and biosecurity protocols were not optimally implemented. Now, the business owners are currently encouraged to build business accountability and sustainability by applying procedures and techniques from seeding to rearing activities with references to the Indonesian national standard (SNI) and good fish hatchery practices (GFHP) (DJPB 2025).

Sufficient supplies of good quality fry play an important role in determining the performance of aquaculture business. The quality management and assurance of GAP and GFHP introduced by Government of Indonesia should stimulate business owners and operators to improve or acquire better knowledge, attitude, and skills that promote both quantity and quality of aquaculture practices and products. The outcomes of such management system should not be only impacts on technical aspects of the fry production (such as water management, feed management, fish health, and disease control) but financial implications. Some outcomes of quality management system in aquaculture have been reported from Indonesia and other countries. The implementation of good aquaculture practices (GAP) certification in hatcheries indicated some increase in fish production (Samah 2020), while the implementation of GFHP in shrimp hatcheries increased the production of fry by 19%–50% (Sau *et al.* 2017; Hartati *et al.* 2019). The implementation of best management practices (BMP) was reported successful in increasing the price of the cultured fish in Egypt, hence improved business revenue and profits by USD 18.9 million, or around 80% (Dickson *et al.* 2016). The implementation of BMPs also improved the water quality

(Frimpong *et al.* 2014) reduced environmental impacts by 22%, and increased profits in tilapia farming (Henriksson *et al.* 2017; Ali *et al.* 2020; Portinho *et al.* 2021).

Despite the increasing market demand for safe and certified aquaculture products, the adoption of good aquaculture practices (GAP) and good fish hatchery practices (GFHP) among aquaculture enterprises in Indonesia remains limited. The varying levels of adoption among farmers have contributed to disparities in technical efficiency and financial performance between certified and non-certified hatchery operations. However, empirical evidence demonstrating the economic and technical advantages of GFHP implementation in tilapia fry hatcheries is still scarce. This lack of information constrains government efforts to promote wider adoption of certified aquaculture practices among hatchery operators. Therefore, this study aims to assess the effects of GFHP implementation on technical performance, financial profitability, and business sustainability in tilapia fry hatchery enterprises.

METHODS

This research was conducted on hatcheries operated by a group of tilapia fish farmers in Kutasirna Village, Cisaat District, Sukabumi Regency, West Java (106° 52' 50" E and 06° 52' 55" S). Data collection and direct field observation was carried out from February 2023 to April 2023.

Data collection

Data were collected direct observation in the field and interviews with 8 tilapia fish farmers. Observation was carried out to record and assess all ongoing fish culture activities, starting from the preparation for broodstock spawning, the spawning process, fry maintenance, and finally fry harvest. Data types on the production performance were fish fecundity (the number of eggs produced by the female broodstock), fertilization rate (FR) (the number of eggs that were successfully fertilized), hatching rate (HR) (eggs that successfully hatched), survival rate (SR) (the number of live fish fry at the end of culture), and the number of fries produced. Data types on the financial performance were production costs and total revenue from the sale of the fry. Secondary data was obtained from the Central Statistics Agency (Statistics Indonesia-BPS), the Directorate General of Aquaculture (DJPB), and several related literatures, both in the form of published journals and other sources relevant to the research topic.

Production performance analysis

The production performance parameters of the hatcheries, such as fecundity, fertilization rate (FR), hatching rate (HR), survival rate (SR), and fry production were calculated with the following formulas:

$$FR\ (\%) = \frac{F}{T} \times 100$$

Description:
FR = Fertilization rate (%)
F = Fertilized eggs
T = Total eggs observed

$$HR\ (\%) = \frac{N_h}{N_f} \times 100$$

Description:
HR = Hatching rate (%)
N_h = Hatched eggs
N_f = Fertilized eggs

$$SR\ (\%) = \frac{N_t}{N_0} \times 100$$

Description:
SR = Survival rate (%)
N_t = Number of individuals alive at time t
N_0 = Initial number of individuals

Water quality

The water quality parameters (such as pH, temperature, and dissolved oxygen (DO) were measured using tool kits provided by the farmers; pH meter, thermometer, and DO were measured using a LUTRON DO-5510 meter.

Financial analysis

Financial parameters of the hatcheries (profitability, financial feasibility, and sensitivity analysis) were calculated on the basis of investment costs (I), fixed costs (FC), variable costs (VC), total costs (TC), and total revenue (TR). The business profitability was measured in terms of business profit (TR-TC), the revenue-to-cost ratio (R/C ratio) and payback period (PP); this analysis was carried out using Microsoft Excel with the following formulas:

$$R/C\ Ratio = \frac{TR}{TC}$$

Description:
R/C ratio = Revenue-cost ratio
TR = Total annual revenue
TC = Total annual cost

$$PP = \frac{I}{\pi}$$

Description:
PP = Payback period
I = Initial investment costs
π = Annual profit

The financial feasibility was measured in terms of cost-benefit analysis (CBA), including net present value (NPV), net benefit-cost ratio (net B/C), internal rate of return (IRR), and sensitivity analysis to changes in fish feed prices and decreases in fish selling prices. This analysis was carried out using the following formulas:

$$NPV = \sum_{t=5}^{n} \frac{(Bt - Ct)}{(1+i)^t}$$

$$Net\ ^{B}/_{C} = \frac{\sum_{t=5}^{n} \frac{Bt - Ct}{(1+i)^t}}{\sum_{t=5}^{n} \frac{Ct - Bt}{(1+i)^t}}$$

Description:
NPV = Net present value
Net B/C = Net benefit-cost Ratio
Bt = Business revenue in year t (IDR)
Ct = Business costs in period t (IDR)
t = Age of business activity (years)
n = Year (1–10)
i = Interest rate level (%)

$$IRR = i + \frac{NPV}{(NPV' - NPV")} \times (i' - i")$$

Description:
IRR = Internal rate of return
i' = Discount rate that produce NPV^{+} (%)
i" = Discount rate that produces NPV^{-} (%)
NPV' = NPV at interest rate i' (Rp)
NPV" = NPV at interest rate $i"$ (Rp)

This financial analysis applies the following assumptions:

1. The business life cycle is 10 years, based on the life time of the culture pond.
2. The discount rate (DR) is based on the interest rate published by BRI people's business credit (KUR) in 2025, i.e. 6%.
3. The tilapia broodstocks were 6 packages of GAP-certified broodstocks or a total of 2,400 broodstocks consisting of 1,800 females and 600 males.
4. Research data are obtained from all eight members of the tilapia farming group.
5. Comparative study on hatchery performances in two epidoses, before and after the implementation of GFHP.
6. A GFHP-hatchery is defined as a legal business (i.e. registered business), implementing bookkeeping, sufficient functional facilities and infrastructures, GFHP-certified broodstocks, implementing complete activities (from spawning, hatching, and larvae), implementing feed management and monitoring activities (seed quality, mortality, biosecurity, environment and waste, traceability, production efficiency, and economic value).
7. Sensitivity analysis was performed to lower selling price of fish fry and higher price of the feed.

RESULTS AND DISCUSSION

Production performance

The tilapia fry production activities include preparation of the rearing and spawning ponds, the spawning process, rearing the fry, and harvesting the fry. All activities take a total of 2 weeks to complete. The broodstock and spawning pond preparation procedures were generally similar in both GFHP and non-GFHP hatcheries, including pond drying, fertilization, water filling, and broodstock selection. However, GFHP hatcheries implemented more standardized operational procedures related to sanitation, water quality control, and broodstock management. These differences in production practices between GFHP and non-GFHP systems are presented in Table 1.

The spawning and broodstock management procedures are generally comparable between GFHP and non-GFHP hatcheries, including broodstock selection, spawning ratio, stocking density, and fry harvesting duration. Nevertheless, GFHP hatcheries implemented more standardized operational practices related to broodstock quality assurance, sanitation protocols, water quality monitoring, and production record management. Fry were harvested after 14–15 days, with an average production of approximately 216,000 fry per production cycle. The main differences between GFHP and non-GFHP production systems are summarized in Table 1.

Table 1. The production practices in the Tilapia hatcheries before and after the implementation of GFHP (Good Fish Hatchery Practices).

Aspects	Before GFHP	After GFHP
Legality and administration	There are no fish culture groups, and proper bookkeeping is lacking.	Fish culture groups exist and maintain good bookkeeping.
Facilities and infrastructure	Fish hatchery ponds are not zoned, and many still employ polyculture systems involving red tilapia, koi, and other fish.	Hatchery ponds for various fish species are separate. Zones have been created for each species.
Broodstock	The origin of the broodstock is uncontrolled, lacking certification, and the sizes are inconsistent.	Certified broodstock, with clear strains and sizes that meet SNI standards.
Spawning	The process is not standardized, and egg yields fluctuate.	Spawning according to standard operating procedures (SOP) results in greater efficiency and consistent success.
Hatching and larvae	Egg hatching is poor, and larvae are not uniform.	Egg hatching is good, larvae are more uniform, and ready for sale.
Feed and feed management	Feeding schedules are irregular, and feed amounts are uncontrolled.	Feeding is controlled.
Seed quality (SNI)	Seed are not uniform in size and are of poor quality.	Seedlings are relatively uniform and of improved quality.
Mortality	Mortality is around 20%, with survival rates around 80%.	Mortality is around 10%, with a survival rate of 90%.
Biosecurity	Equipment is mixed with other fish.	Equipment is separate and disinfected regularly.
Environment and waste	Waste is disposed of directly.	Waste is managed through settling tanks.
Traceability (recording)	Only sales records are kept.	Records are fairly complete (broodstock, spawning, hatching, water quality, mortality, and sales).
Production efficiency	Production is unstable and fluctuating.	Production is stable, more efficient and predictable.
Economic value	Profits fluctuate	Profits have increased due to improved efficiency and seed quality.

The broodstock implementation of GFHP has significantly impacted fish hatchery culture activities. The use of separate or unmixed facilities and infrastructure and implementation of controlled management of the fish fry production process increase the fry production. Almost all aspects of fry production are improved after the implementation of GFHP (Table 1).

The implementation of GFHP significantly enhanced the reproductive efficiency and fry production performance of tilapia hatcheries (Table 2). Fecundity increased from 1,500 to 2,600 eggs per female broodstock, resulting in an increase in total fecundity from 450,000 to 780,000 eggs per production cycle. Furthermore, improvements were observed in fertilization rate, hatching rate, and survival rate, which increased from 85.33% to 91.03%, 88.54% to 90.14%, and 79.41% to 88.59%, respectively. These improvements led to a substantial increase in fry production from 20 liters/cycle to 42 liters/cycle, ultimately increasing annual production from 480 liters/year to 1,008 liters/year, representing an increase of approximately 110%.

The significant improvements in fecundity, fertilization rate, hatching rate, and survival rate following GFHP implementation suggest that standardized hatchery management substantially enhanced reproductive efficiency and larval performance in tilapia hatcheries. Improved broodstock selection, controlled feeding regimes, better water quality management, and enhanced biosecurity protocols likely reduced physiological stress and minimized disease transmission during spawning and larval rearing. Consequently, these improvements contributed to higher fry production and more predictable production outcomes. Similar trends have been documented in previous studies evaluating the implementation of best management practices (BMP) in tilapia aquaculture systems, where standardized operational management improved reproductive success, fry survival, and overall production efficiency (Frimpong *et al.* 2014; Dickson *et al.* 2016; Ali *et al.* 2020).

Such improved production performance indicate potential increas in financial profits and the sustainability of the aquaculture business. The implementation of management practices can improve technical efficiency, lower production costs (Rahman *et al.* 2020), while the implementation of biosecurity can reduce disease incidence (Subasinghe *et al.* 2023), which ultimately improves financial viability indicators. The implementation of best aquaculture practices (BAP) also increases consumer preference for purchasing certified products because they produce better quality (Roheim *et al.* 2012). This re-confirms that the implementation of certification GFHP not only important for improving the technical aspects and business sustainability, but also provides financial benefits for aquaculture business actors.

Financial analysis

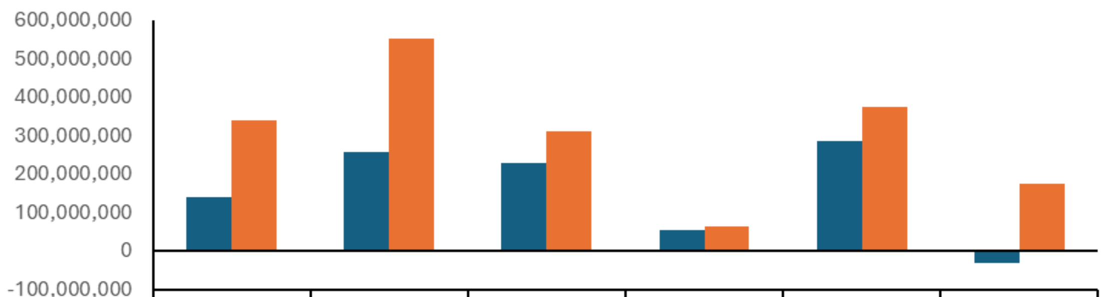
On one hand, the implementation of GFHP requires additional facilities and infrastructure, such as additional ponds for separate broodstock rearing and biosecurity equipment, such as water quality test kits, and other costs. Operational production costs also increased as farmers need to attend training program to improve skills and knowledge in managing the GFHP implementation. Other additional costs include medicines and feeds. The costs of running the hatchery for with and without GFHP implementation are presented in Figure 1.

On the other hand, the implementation of GFHP resulted in a significant increase in revenue by 114% (Figure 1). In line with this, the profit that previously experienced a loss, after the implementation of GFHP, became profitable. The R/C increased from 0.9 and 1.47 when GFHP is implemented. These parameters indicate that the implementation of GFHP increases the profitability of this hatchery.

Table 2. The production performance of the Tilapia hatcheries before and after the implementation of good fish hatchery practices (GFHP).

Parameters	Before GFHP	(%)	After GFHP	(%)
Fecundity (eggs/female broodstock)	1,500		2,600	
Number of female broodstock	300		300	
Total fecundity (eggs)	450,000		780,000	
Fertilization rate (FR, %))	384,000	85.33	71,000	91.03
Hatching rate (HR, %)	340,000	88.54	640,000	90.14
Survival rate (SR, %)	270,000	79.41	567,000	88.59
Fry production/cycle (liters)	20		42	
Production/year (liters)	480		1.008	

Note: 1 liter = 13,500 individuals.



	Invesment cost	Revenue	Variable cost	Fix cost	Total cost	Profil
Before CBIB	141,657,120	258,000,000	230,873,300	56,316,684	287,189,984	-29,189,984
After CBIB	338,760,560	552,000,000	311,077,440	65,164,644	376,242,084	175,757,916

Figure 1. Profitability analysis (in IDR) of tilapia fish fry culture for one year before and after the implementation of good fish hatchery practices (GFHP).

The implementation of GFHP significantly improved the financial feasibility of tilapia hatchery operations, as indicated by higher net present value (NPV), net benefit-cost ratio (net B/C), and internal rate of return (IRR), as well as a shorter payback period (PP) (Table 3). Over a 10-year operational period, the NPV increased substantially from IDR 55,376,698 (before GFHP implementation) to IDR 598,833,106 (after implementation), representing more than a tenfold increase. In addition, the net B/C ratio increased by 73%, indicating improved economic efficiency of the hatchery business. The IRR value after GFHP implementation was also considerably higher than the prevailing KUR (people's business credit) interest rate of 6%, suggesting that the investment is financially attractive and feasible. Furthermore, the implementation of GFHP reduced the payback period from 9.7 years to 3.3 years, demonstrating faster capital recovery and improved business profitability.

Table 3. Financial feasibility analysis of tilapia fish seed culture before and after the implementation of good fish hatchery practices (GFHP).

Financial Indicators	Before GFHP	After GFHP
NPV (IDR)	55,376,698	598,833,106
Net B/C	2.28	3.95
IRR (%)	14.84	40.00
PP (year)	9.7	3.3

Previous research on tilapia hatchery culture produced a net B/C value of 1.01, an IRR value of 8.95%, and a PP for 10 years (Nass *et al.* 2025), while the culture of fingerling-sized tilapia hatchery in the backyard aquaculture system produced a net B/C of 1.12, an IRR value of 21.7%, and a PP for 3 years (Dorantes-De-La-O and Maeda-Martínez 2023). Small-scale tilapia culture produced an IRR value of 18.40% (Castilho-Barros *et al.* 2020) and, in fish culture with fingerling-sized seeds, produced an IRR value of 7.1% and a PP for 6.8 years (Brande *et al.* 2023), and a net B/C value of 1.7 (Burad-Méndez *et al.* 2023). Compared with the results of several studies, tilapia fish culture in this group of farmers is very promising, both before and after the implementation of GFHP. This is indicated by a positive NPV value, a net B/C of more than one, and an IRR that exceeds the KUR interest rate. However, the values obtained with the implementation of GFHP results are higher, with an increase in net B/C after implementation of 73%, an increase in the IRR value of 170%, and a shorter return period for the investment invested after the implementation of GFHP.

Sensitivity analysis

The maximum limit for feed price increases to ensure the business remains viable in the long term is 54.64% (Table 4). The present study demonstrated that hatchery operations implementing GFHP could tolerate feed price increases of up to 54.64% while remaining economically viable, suggesting a relatively high level of financial resilience compared to previous studies. Burad-Méndez *et al.* (2023) reported that tilapia production systems remained feasible under a 20% increase in feed prices, whereas Diatin *et al.* (2017) also observed relatively low sensitivity of tilapia farming to feed cost fluctuations. The greater tolerance observed in this study may reflect the positive effects of GFHP implementation on operational efficiency, including improved feed management, enhanced survival rates, better broodstock and fry quality, and reduced production losses. These factors likely improved overall productivity and profitability, enabling hatchery enterprises to absorb higher feed costs. However, because feed remains a major operational expense in aquaculture, farmers should continue improving feeding efficiency through better feed formulations, optimized feeding schedules, and efficient feed management strategies to ensure long-term economic sustainability.

Table 4. Sensitivity analysis of tilapia hatchery business to changes in fry selling prices and feed prices.

Changes	Sensitivity Values (%)
Increase in feed prices	54.64
Decrease in seed prices	38.11

The tilapia fish hatchery culture business in the farmer group is not sensitive to decreases in selling prices or increases in feed prices. The maximum limit for decreasing the selling price of fries so that this business remains financially viable and continues to operate is 38.11%. The results of the study conducted by Burad-Méndez *et al.* (2023) show that a decrease in the selling price of tilapia by 20% still provides a positive value, meaning it is still feasible to run. Based on this, this tilapia fish hatchery culture business is not sensitive to decreases in selling prices. Thus, the increase in feed prices and the decrease in selling prices in the fish hatchery culture business in this group remain profitable and financially viable for 10 years.

CONCLUSION

The implementation of GFHP in tilapia fish hatchery culture resulted in a 110% increase in seed production value compared to before the implementation of GFHP. Financial performance showed an increase in profit and benefit value after the implementation of GFHP by 73%, and the investment payback period was shorter (3.3 years) compared to before the implementation of GFHP (9.7 years). This tilapia fish hatchery culture business is not sensitive to changes in increasing feed prices and decreasing selling prices of tilapia fish fry, so this business is worthy of long-term development in order to support sustainable fish culture.

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