

Economic Profitability of Tilapia Production in Malawi and China

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Abstract

This study was conducted to analyse the economic profitability of tilapia farming in Malawi and China, using data from 20 farmers both in Malawi and Guangxi Province, People's Republic of China. Application of enterprise budget for profitability analysis showed that profits for tilapia were significantly different ($p \leq 0.05$) between the two countries with Malawi registering a bigger benefit-cost ratio of 1.61 than 1.20 for China. However, 3 farms in Malawi posted losses during the production cycle. Breakeven price was \$2.00 for Malawi against \$1.26 for China. Sensitivity analysis was conducted to evaluate the influence of changes in price, feed, labour and fixed cost on net profit. Holding all conditions constant, sensitive coefficient for price was relatively high for Malawian farms at 2.63 followed by feed, labour and fixed cost at -0.70, -0.36 and -0.32 respectively. Similarly for China, price showed the highest elasticity of 5.96 compared to -3.65, -0.67, -0.27 of feed, fixed cost and labour respectively. For the farms that did not make profits, application of the shutdown rule indicated that the farms were making surplus gross margins hence could continue operating (Price \geq Average Variable Cost; and Revenue \geq Total Variable Cost). The present study has demonstrated that differences in input intensification result in different gross revenues since yield is a function of stocking density, feed input, labour and other production inputs. Irrespective of the intensity of input use, farmers still make profits, thus tilapia production is a viable enterprise in both countries.

Keywords: Profitability; Sensitivity analysis; Shutdown rule; Tilapia; Benefit-cost ratio; Elasticity

Introduction

Both Malawian and Chinese tilapia culture started in mid-1950, with the establishment of Domasi Experimental Fish Farm, now National Aquaculture Centre (NAC) in Zomba District, Malawi in 1957 to breed *T. rendalli* and *O. shiranus* [1], and the introduction to China of *O. mossambicus* from Vietnam in 1956 [2]. Malawi has since struggled to commercialize its aquaculture due to lack of high production technologies, poor quality feed where most farmers use maize bran, and use of a genetically inferior species that is harvested below 100 g of individual body weight. On the other hand, China's tilapia industry developed rapidly since the early 1980 referred by Sustainable Fisheries Partnership [3], to the extent where tilapia export volume and value are now the highest in the world, and thus the tilapia aquaculture industry is a major sector of China's fisheries [4]. Environmental and climatic conditions for both Malawi and China are suitable for the growth of tilapia. As a tropical species, tilapia is farmed across the whole country in Malawi, while it is concentrated along South China regions that include Hainan, Guangdong, Guangxi, Fujian, and Yunnan provinces, with a potential for 2 production cycles annually. Total pond area dedicated for tilapia production in 2014 was 245 ha for Malawi [5] and 111,000 ha for China [4].

Tilapia production is however affected by a number of factors, such as growth potential of candidate species, stocking density referred by Kpundeh [6], production technologies referred by Dey, et al., [7] farming or culture systems like pond, cage and tank referred by Decline, El-Sayed, Kapinga, Mlaponi, Kasozi, [8-10] and level of farming based on input intensification referred by Rakocy [11] i.e., extensive, semi intensive and intensive.

In China, low local demand for tilapia has a negative effect on production [12], unlike in Malawi where high demand can be used as an opportunity to spur increased production. However, both countries are faced with a common problem of high production costs due to high cost of inputs i.e., feed, as the farming communities have little

information on the economic performance of their industries. Lai and Yang [12], attributed lack of knowledge and commercial organization among tilapia producers to be a contributing factor in preventing them from obtaining competitive prices for their products, hence suffer from the manipulation of wholesalers who set standard prices for 300-500g fish and refuse to pay extra for larger sizes. According to Engle [13], efficient management of a farm can make the difference between profits and losses especially in years with unfavorable prices and costs. Profit is a financial benefit that is realized when the amount of revenue gained from a business activity exceeds the expenses, costs and taxes needed to sustain the activity [14]. Therefore, farm management involves more than just taking care of the biological processes; it includes paying close attention to economic and financial measures of the farm business through financial analysis which is essential to the success of the business [13]. By virtue of the powerful tools at its disposal, economic analysis has an important role to play in assessing the resource use efficiency among different and often competing uses [15]. In its broadest sense, economic analysis is also a means by which policy-makers can receive guidance on the use of resources in order to promote the greatest return for the society as a whole. In other words, economic analysis is part of the policy evolution process that allows stakeholders to evaluate alternatives and so reach priorities for development action, which according to Neiland, Shaw and Bailly [16], will be influenced to a greater or lesser degree by political priorities.

At the moment, there is limited information about the economic performance of tilapia farming in China and Malawi. In the present

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study, economic profitability of tilapia farming was estimated for small-scale farmers who according to Nha [17], are those farmers with tilapia farms <1 ha) in Guangxi Province, China, as well as the small-scale semi-commercial farmers (those using commercial feed under semi-intensive production system, having farms <1 ha) in Malawi. According to Barry, Ellinger, Baker, Hopkins [18] and Engle [13], this is an important step for the successful implementation of any farm enterprise. The study compared the economic performance of tilapia culture of these two countries in order to see if there are differences in profitability of the enterprises based on profitability ratios, as well as the effect of changes in prices and costs on profitability.

Materials and Methods

Study areas

This study was conducted in Malawi and China. Malawi has three seasons, viz: the dry season running from August to October, the rainy season which stretches from November to April and the cool season which runs from May to July. The country's temperature and rainfall is mainly influenced by the lake and altitude which varies from 37 m in the Shire Valley Region, to 3050 m in the Mulanje Mountain area. Annual rainfall is between 635 mm and 3050 mm. Although rainfall varies, most parts of the country receive enough rain for dry land farming (except during periods of drought). The study was rather conducted in all the three administrative regions of: North, Centre and South. Farmers were sampled from the following districts: Nkhatabay, Mzimba and Rumphu in the North, Lilongwe and Mchinji in the Centre and Zomba, Mangochi, Thyolo, Mulanje and Chikwawa in the South.

In China, the study was conducted in Guangxi Province. The Province is located in a sub-tropical region, where tilapia can be cultured and supplied all year round due to warm climate and rich rainfall [19]. Other advantages for tilapia culture in the province include: relatively long history of tilapia culture, good tilapia selection programs, well-developed large-scale tilapia hatcheries, well-trained research scientists and extension workers [12]. In addition, the province has tilapia processing factories that have been authorized by Hazard Analysis of Critical Control Points (HACCP) and acquired accreditation for producing export quality products intended for the European Union (EU), USA and Japan markets, and this has also fostered the further expansion of tilapia culture in the province [12]. In 2014, the tilapia farming area in Guangxi comprised about 23,000 ha [4]. According to the China Fisheries Yearbook 2013-2014, tilapia production in Guangxi has increased by 10% on average between 2004 and 2013 against China's 7.16%, while contributing an average of 16% to the total tilapia output.

Data collection

To generate economic data for Malawi, the study targeted 20 (almost all of the 23) small-scale semi-commercial fish farmers located in all the three regions of the country. The farmers were interviewed between December 2016 and February 2017 through administration of a structured questionnaire. Data and information collected included: pond sizes, inputs (seed, feed, manure, drugs and labour), and number of ponds owned, production levels and pricing (farm gate prices, factors affecting pricing). Oral informed consent was obtained from each study participant before commencement of the interview, as the enumerator briefly explained the purpose of the study, the risks and benefits of participation in the study, and conditions of confidentiality. As reported by Ahmed, Young, Dey, Muir [20], participatory, qualitative, and quantitative methods were combined in the primary data collection.

For China, secondary data from Guangxi Province, which was collected in 2014, was used. A random sampling survey was employed to identify the target farmers and data was collected through administration of structured questionnaires by a team of enumerators. Data exploration was therefore done to screen and organize the secondary data for identification of 20 tilapia farmers to be part of the present study. Among the factors considered in the data exploration were identifying those farmers that had all of the above mentioned study parameters for inputs, output and marketing data. However Chinese farmers did not have data on manure for pond fertilisation, but inversely they had electricity as an input of production.

Data analysis

In any enterprise, the understanding of costs and benefits is an important prerequisite for policy formulations aimed at improving productivity levels. In the present study, production costs included inputs associated with production such as feed, seed, manure, drugs and labour. Profitability analysis involves examining the relationship between revenues, costs, and profits and requires an understanding of selling prices and the behaviour of the activity cost drivers. The study used profitability analysis, sensitivity analysis and shutdown rule at farm level, comparing them by farm and by countries.

Profitability analysis was performed with an aim of determining the economic profitability of tilapia production. The economic profitability analyses involved the use of enterprise budget to calculate revenues (R), total cost (TC), fixed cost (FC), total variable cost (TVC), average variable cost (AVC), total profit (TP), profit margin (PM), benefit-cost ratio (BCR), break-even price (BEP), and break-even production (BEPr), using the following formulas:

$$R = P \times Q$$

Where P is selling price of fish per kg, Q is yield or quantity of output in kg

$$TC = TVC + FC$$

$$AVC = TVC / Q$$

$$TP = Q \times (P - AVC) - FC$$

$$PM = TP / TC$$

$$BCR = R / TC$$

$$BEP = AVC + (FC / Q)$$

$$BEPr = FC / (P - TVC / Q)$$

Benefit-cost ratio is one of the most common indicators normally used in capital budgeting to determine the financial desirability of an investment [21]. Calculating a BCR helps investors in assessing the certainty of how promising or successful an aquaculture enterprise might be. An investment is therefore profitable if the BCR is greater than 1 [22]. Other important profitability indices are break-even price and break-even production. According to Engle and Neira [23], these indices indicate profitability of an operation as long as the price and production obtained are above the break-even price and break-even production.

According to Nyekanyeka [24], estimation of economic returns play a very important role in influencing farmers' choice to adopt a new technology and consequently influences their resource management decisions. While cost and return analysis measures the success and failure of farm business [25], estimation of the production function identify inputs that influence yield and show the efficiency of input

use [26]. To assess management of inputs and how the enterprise can respond to uncertainties in key inputs, sensitivity analysis for the two industries was conducted. [27-29] Saltelli, Ratto, Andres, Campolongo, Cariboni, et al., defines sensitivity analysis as how the uncertainty in the output of a model can be apportioned to different sources of uncertainty in the model input. In this study, tilapia farm gate price, major variable cost (feed), and fixed costs were chosen as parameters to be factored in sensitivity analysis to know their impact on net profit of tilapia farming. Sensitivity analysis was therefore calculated using the formula:

$$\alpha = (\Delta NP / NP) / \Delta X / X$$

Where α is sensitivity coefficient, $\Delta NP / NP$ is the change in net profit due to changes in the uncertainty parameter, $\Delta X / X$ is the ratio of the changing influence factors.

The goal of any enterprise is to maximize profits or minimize losses. As Perloff [30] observes, an enterprise can achieve this goal by following two rules. Firstly the enterprise should operate, if at all at the level of output where marginal revenue equals marginal cost. Secondly, the enterprise should shut down rather than operate if it can reduce losses by doing so. The general rule is that, an enterprise must have revenue $R \geq TC$, in order to avoid losses. Thus, an enterprise will find it more profitable to operate so long as the market price $P \geq AVC$ [31]. In simple terms, the rule is that to produce in the short run an enterprise must earn sufficient revenue to cover its variable costs [32]. The rationale behind this rule is that, by shutting down, an enterprise avoids all variable costs [33]. Because the enterprise still has to pay fixed costs regardless of whether an enterprise operates or not [33], they must not be considered in deciding whether to produce or shut down. In the present study, the shutdown rule was therefore applied to determine if farms that made losses needed to shut down or there was potential for fixed cost recovery so that they should continue operating.

Result

Profitability of tilapia production farms

Economic variables and performance parameters for the two tilapia producing countries are presented in Table 1. Among the input variables of tilapia farming, feed accounted for 73.53% and 42.70% of total production cost for the Chinese and Malawian tilapia farms respectively, followed by labour 5.36% and 22.33% with seed contributing a significant 4.74% and 9.96%. Results of the economic variables were used to analyse economic profitability of the different tilapia farms on a per hectare basis. Based on the calculated TC, R and TP, economic performance indices such as PM and BCR for Malawi and China tilapia farms were estimated. Enterprise budgets for tilapia farms in the two tilapia farming countries are presented in Table 1. The results from the present study shows that TC, R, PM, BCR, BEP and BEPr were different between the two tilapia farming countries, with TC, TVC, FC, R and BEPr higher in China, while Malawi registered higher TP, BCR and BEP. Average stocking density, yield and price of fish were also different, with stocking density and fish price higher in Malawi compared to China and yield been higher in China than Malawi.

Sensitivity analysis

In the present study, sensitivity analysis was conducted to evaluate the influence of changes in price, feed, labour and fixed cost on net profit. Table 2 shows net profit sensitivity analysis results for major inputs and price for tilapia farms in Malawi and China. *Ceteris paribus*, sensitive coefficient for price was relatively high for Malawian farms

followed by feed, labour and fixed cost. Similarly, for China, sensitivity for price was the highest compared to feed, fixed cost and labour.

Shutdown rule of non-profit farms

Economic performance results of some farms that posted losses in Malawi are presented in Table 3. The principle of shutdown rule was applied on these farms to determine whether the farms were making enough revenue to continue production or less revenue to be temporarily shut down in order to avoid posting further losses. Based on the $P=AVC$ and $R=TVC$ relationship, it was observed that positive gross margin was realised from the farms ($P \geq AVC$) and ($R \geq TVC$).

Discussion

The rationale behind the analysis of profitability indices like BCR and PM in any business enterprise is to have a clear picture of the economic strength and/or weakness of the business. In aquaculture development, these indices suggest whether promotion and support of the industry can be vital for livelihood improvement of the players. In the present study, the cumulative cost of feed, labour and pond construction accounted for 81.87% of the total cost of production in Malawi. For China, feed, rent and labour accounted for a combined 83.63% of the total cost of production, which was a similar trend to earlier findings [34,35] on cobia in Brazil; [4] on Tilapia in China, however Alam and Yin, Wang, Zhou, Wang, Li, et al., [36,37] found different results in their respective studies on *Pangasius hypophthalmus* in Bangladesh and Crucian carp in China. Feed was actually the highest contributor to total cost, and this high cost of feed in both countries, can be attributed to the recent global economic condition which has impacted on production costs of most enterprises. Liping [38], also observed that the costs for labour, feed, chemicals and infrastructure have been reported to have greatly increased in recent years. Results of the present study on enterprise budget indicate that majority of the farmers had a benefit-cost ration of >1 . This shows that tilapia production is profitable according to the level of investment and variable cost minimization. This result is in agreement with the findings by Elhendy and Alzoom [39] on Tilapia in Saudi Arabia; Yesuf, Ashiru, Adewuyi, Ajao, Olagunju, et al., [40-42] on catfish in Nigeria; [43] El-Naggar in Egypt; Kudi, Bako, Atala, Adewuyi, Phillip, et al., [44,45] in Nigeria; Kassali, Baruwa, Mariama [46] in Niger, who also indicated that fish production was highly profitable. China tilapia industry experience high production due to high growth rate of their species, but rather high production costs due to high feed input limit the industry's profit margin per hectare when compared head-to-head with the Malawian industry where most farmers harvest <100 g table size tilapia. The most important driver of profitability for Malawi is low production cost due to less feed input emanating from the semi-intensive nature of the production system where fertilizers and manure are used to boost primary productivity which is in line with the finding of Elhendy and Alzoom, El-Naggar et al., and Kudi et al. [39,43,44]. Apart from effects of high feed cost, profit margin in Chinese tilapia industry is also marginalized by high production cost due to intensive inputs i.e., mechanization with aerators, water pumps, feeders as well as electricity and rent, unlike in Malawi where most ponds are filled and drained by gravity with per unit production so low that it does not demand the use of aerators. This observation is in line with the concept of Engle [13] who stated that lower production costs can yield higher profits. High profit margins for tilapia farmers in Malawi can also be attributed to high farm gate price of tilapia which is almost double that of China. This can be a result of the tilapia production chain for Malawi which runs from input suppliers through production to consumption

Parameters	Malawi	%	China	Production
Production parameters				
Stocking density	60000	--	24187	--
Feed conversion rate	1.32 ± 0.56	--	1.37 ± 0.19	--
Harvest size (g)	69.21 ± 31.81	--	615.19 ± 75.39	--
Production (kg/ha)	4152.60 ± 1908.68	--	14651.37 ± 1751.22	--
Average price (\$/kg)	3.23 ± 0.59	--	1.51 ± 0.15	--
Culture duration (months)	6	--	6	--
Variable costs				
Seed	828.21 ± 0.00	9.96	874.01 ± 555.02	4.74
Feed	3549.74 ± 978.79	42.70	13549.16 ± 2346.85	73.53
Manure	188.55 ± 119.30	2.27	--	--
Drugs	241.28 ± 57.05	2.90	327.63 ± 242.37	1.78
Electricity	--	--	192.03 ± 50.68	1.04
Labour	1856.32 ± 814.55	22.33	987.54 ± 418.24	5.36
Total	6664.11 ± 1649.38	--	15930.37 ± 2423.93	--
Fixed cost				
Equipment	248.87 ± 8.31	2.99	126.04 ± 125.41	0.68
Rent	--	--	1930.56 ± 545.68	10.48
Pond construction	1399.64 ± 957.13	16.84	440.22 ± 218.29	2.39
Total	1648.51 ± 957.16	--	2496.82 ± 570.53	--
Total costs	8312.62 ± 2028.86	100	18427.19 ± 2536.27	100
Revenue (\$/ha)	13413.05 ± 5831.79	--	22141.81 ± 2278.65	--
Total profit (\$/ha)	5100.43 ± 4755.79	--	3714.61 ± 1640.66	--
Profit margin	61.36%	--	20.16%	--
Benefit-cost ratio	*1.61 ± 0.59	--	1.20 ± 0.10	--
Break-even price (\$/kg)	2.00 ± 0.86	--	1.26 ± 0.14	--
Break-even production (kg/ha)	1014.32 ± 909.24	--	5889.44 ± 3153.58	--

Note: 1. Data is expressed as mean ± standard deviation (M ± SD), n=20; 2. Values with*are significantly different α =0.05; 3. All costs are expressed in \$, where \$1 = K724.45 (Malawian Kwacha)=6.67 ¥ (Chinese Yuan).

Table 1: Costs and profitability of tilapia per production cycle for Malawi and China.

Farms location	Price	Feed	Labour	Fixed cost
Malawi	2.63	-0.70	-0.36	-0.32
China	5.96	-3.65	-0.27	-0.67

Table 2: Sensitivity coefficients of net profit for tilapia farms in Malawi and China.

Farm	Yield	P	R	TC	TVC	AVC	BCR	P-AVC	R-TVC
1	2520.00	2.76	6957.00	7292.43	6007.32	2.38	0.95	0.38	949.69
2	1860.00	4.14	7702.39	8464.35	6142.59	3.30	0.91	0.84	1559.80
3	2196.00	3.45	7578.16	7618.78	7024.05	3.20	0.99	0.25	554.11

Note: where P is price, R is revenue, TC is total cost, TVC is total variable cost, AVC is average variable cost, BCR is benefit cost ratio.

Table 3: Economic performance of non-profitable farms in Malawi per production cycle in \$/ha.

level with isolated cases through traders at the domestic market, hence giving farmers a better farm gate price unlike the Chinese chain in which producers channel their produce through fish collectors, processors and traders en route to the consumers. As the chain grows longer, farm gate prices become low, so as to give players at each level a fair cost price in order to make considerable profits that do not have a huge economic bearing on the consumer. However, it has been a general observation that income was generated by farmers no matter how small or big the farm or ponds were which agrees with earlier observations by De Bezerra, Domingues, Maia Filho, Rombenso, Hamilton, et al., [35] and Zhang, Zhang, Li, Yang, Yuan, et al. [47]. In general, the increase in tilapia production for China is being attributed to wider acceptance of the species at the international market [19], owing to the fact that, the local market is less rewarding and yet developing [48].

Sensitivity analysis results show that the net profit of tilapia is

very flexible to changes in price, feed, labour, and fixed cost, where an increase in farm gate price by 1%, is expected to result in increased net profit of 5.96 and 2.63% for China and Malawi respectively, while a similar increase in feed, labour and fixed costs, can result in a decrease in net profit by 3.65, 0.27, 0.67 and 0.70, 0.36, 0.32% for China and Malawi respectively. Similarly, a decrease in farm gate price will result in decreased net profit, while a decrease in feed, labour and fixed cost will conversely result in respective increase in net profit by the same margin. This result is similar to earlier findings by Kam, Leunga, Ostrowski [49] on Pacific threadfin in Hawaii; Ruiz [50] in Ecuador; Yuan [4] on tilapia in China. Individually, farm gate price had the most predominant elasticity which was in agreement with Liu and Sumaila [51] and Yuan [4] who found similar results in their respective studies. The results show that the Chinese industry is more sensitive and volatile to market changes, hence has the weakest ability to resist market risks, which is a result of high production cost that is

compounded by a low farm gate price. In terms of productivity, both countries had good feed conversion ratios (FCR) of <1.5 (Table 1), which reflected on feed processing technique [52], feed ingredients, different brands, and favorable climatic conditions. For Malawi, FCR was characteristically low due to low feed input as well as use of feeding trays that facilitated full ingestion of the feed by fish, since the sampled farmers use sinking pellets. Use of commercial fish feed has however increased yield per ha from a range between 500-2316 kg referred by Chimatiro and Chirwa [53] to 4152.60 kg. The results also show that about 15% of tilapia farmers in Malawi did not make profit. However, application of the shutdown rule on non-profitable farms in Malawi show that the farmers made enough revenue to cover variable cost with a little surplus ($P \geq AVC$). This was a positive development in the short term hence the farms can continue with production, so as to offset fixed costs.

Conclusion and Recommendation

Results of economic analysis of an aquaculture enterprise must be profitable if any meaningful development is to be registered for continued investment to warrant that fish farmers stay in business. The present study has demonstrated that variations in input intensity result in different gross revenues since yield is a function of stocking density, feed input, labour and other production inputs. Irrespective of the intensity of input use, farmers still make profits. The fact that Malawian tilapia fetch considerable higher farm gate prices, gives Malawian farmers especially those small-scale farmers that use maize bran as feed input, an opportunity to intensify their production by increasing feed and stocking density (as most subsistent farmers stock 1-2 fish per m^2) since they demonstrated to be the drivers of production. This can have a positive influence on yield which will however not guarantee a corresponding improvement in the profit margin, but rather increase fish production from aquaculture. To enhance productivity, Government and its development partners need to make deliberate efforts to help farmers with subsidized inputs especially feed and quality seed. With the farmers harvesting <100 g fish, there is need to critically look at ways of coming up with a fast growing candidate species. Malawian researchers also need to look at farming models that can best utilize the current species to its best potential. The understanding of costs and benefits is also an important pre-requisite for policy formulations aimed at improving productivity levels. For Chinese farmers, improving the quality of tilapia products from aquaculture so as to fetch good markets is one way of improving the profit margin. However, based on the sensitivity analysis results, there is too much investment on feed which tax on the benefits, hence finding better ways of reducing feed input without compromising production and profits can help boost the Chinese tilapia industry. The study has demonstrated that a 5% decrease in feed cost will result in 18.24% and 3.48% increase in total profit for China and Malawi tilapia farms respectively.

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Conflict of interest

The authors declare that they have no conflict of interest.

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