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Economics of freshwater Mud Eel fattening (*Monopterus cuchia)* in polyculture system: a case study from Nilphamari, Bangladesh

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Abstract. The present study was carried out to analyze the cost and returns as well as to determine the effect of variable inputs on outputs of *Monopterus cuchia* fattening in polyculture systems. A total of 60 *Cuchia* farmers were selected from Saidpur upazila in the Nilphamari District. Data were collected through face-to-face interviews from September 2018-April 2019. Average stocking density (no/acre) for *M. cuchia, Heteropneustes fossilis, Clarias batrachus and Oreochromis niloticus* were 2288±228, 2066±144, 1883±197 and 4842±715, respectively. The average production of Cuchia, shing, magur and tilapia were 979.17±128.65, 368.33±66.36, 330±51.42 and 1027.5±118.76 kg per acre, respectively. The total variable cost was BDT 191,225.9±96565.7 per acre whereas total fixed cost was BDT 85,731.45±6276.64 per acre. In the total variable cost, percentages of labor, feed, fertilization, liming, stocking and other cost were 12.01%, 36.01%, 0.38%, 1.47%, 14.55% and 6.59%, respectively. This study also revealed that per acre gross revenue and net return were BDT 452,025.58±35829 and 173,907.72±24560 respectively. The benefit cost ratio (BCR) value in *Cuchia* polyculture farming was 1.65. Based on the Cobb-Douglas production function model, fingerling cost and feed cost were significant of Cuchia fattening in polyculture system. The production function analysis also reveals positive effects of different variable costs indicating enough scope to increase production and income from *Cuchia* fattening in polyculture system with a reduction in production costs and increased market price
Keywords: *Monopterus cuchia*, Fattening, Polyculture

Introduction

Freshwater mud eel or swamp eel, *Monopterus cuchia,* also known as *Cuchia or Kucha.* It belongs to the family Synbranchidae of the order Synbranchiformes and commonly occurs in the freshwater of Bangladesh, Pakistan, Nepal, Myanmar and India (Talwar and Jhingran 1991). The mud eel (*M. cuchia*) is a carnivorous, nocturnal species and very tasty, nutritionally rich with medicinal value and highly priced in the other foreign markets (Miah *et al.* 2015). The average protein content of eel flesh is 14g/100g and the caloric value of eel flesh is as high as 303 Kcal/100g compared to 110 Kcal/100g in other average fishes (Nasar 1997). This fish can play a unique role in the socio-economic welfare of the area which will be the potential to develop an extension of the fishery. Considering its importance research on genetic diversity, present status and population of mud eel have been conducted in Bangladesh (Devi *et al.* 2017; Chakrabarty 2018). Researchers also focused on breeding biology and induced breeding status of freshwater mud eel (Miah *et al.* 2015). Moreover, the effect of stocking density on survival, growth and production of mud eel under semi-intensive pond aquaculture (Chakraborty *et al.* 2018); growth performance in different ditches conditions (Hosen *et al.* 2019); and yield performance of sustainable aquaculture of *Monopterus cuchia* have also been observed by Chakraborty *et al.* (2017). In addition, researches on the morphological characterization of two freshwater eels *Monopterus cuchia* and *Ophisternon bengalense* were conducted by Roy *et al.*

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(2016). Furthermore, Sharmin *et al.* (2017) reported the marketing system and export potentiality of freshwater mud eel in some selected northwest regions of Bangladesh. However, most of the researches mostly concerned on production, growth rate and culture suitability of *Cuchia* but little is known about the economic and technical analysis on *Cuchia* under polyculture level in Bangladesh. Though, it is very much essential to know the production cost and performance for the management and development of *Cuchia* polyculture. Besides, identification of the main cost items as well as the effect of variable inputs on outputs in *Cuchia* polyculture system is undoubtedly obligatory, where efficiencies and profitability are based on. In view of the above perspectives, this study aimed to evaluate the potential highness of *Cuchia* polyculture with fishes and extract the relation between variable inputs with economic returns.

Materials and Methods

Data collection: Data were collected by using a structured interview schedule from the *Cuchia* farmers of Saidpur upazila at Nilphamari district where most of the *Cuchia* farming is going on. During the first phase of the research work, a simple random sampling was conducted to assess the cost and return from tilapia monoculture and tilapia culture with carps. A total of 60 farmers were selected purposively for a better understanding of cost and return from *Cuchia* farming. The survey was carried out for a period of 8 months from September 2018 to April 2019. Draft survey schedule was prepared and it was pre-tested by interviewing a few farmers of the study area through face-to-face interviews. After pre-testing, a set of final survey schedules was developed and the schedule was elaborated to include all types of questions relating to the *Cuchia* poly farming system. Secondary data was collected from various sources viz. district Fisheries officer, Upazila Fisheries Officer and NGO worker, various books, reports, thesis papers journals. Finally, the Crosscheck interviews were conducted with key informants such as Upazila fisheries.

Analytical technique: Data were analyzed to achieve the objectives of the study. In the present study, some tabular analysis and descriptive statistics (sum, average, percentage, ratio etc.) were used for different cost and return analysis.

Tabular analysis: Cost and return analysis were performed on both variable and total cost bases. To assess the profitability a simple tabular analysis was performed according to the profit (Π) equations:

$$\Pi i = \sum_{i=1}^{n} Qi\ P - TC$$

$$= \sum_{i=1}^{n} Qi\ Pi - (VC + FC)$$

Where, $i = 1, 2, 3, \ldots n$

Πi = profit from i^{th} *Cuchia* production (BDT. per acre per production period)

Qi = Quantity of the i^{th} product;

Pi = Average price of the i^{th} product

TC = Total Cost;

VC = Variable Cost; FC = Fixed Cost

Cost-benefit analysis: Several variable costs like stocking cost, liming cost, fertilizers and chemical cost, labor and marketing cost were estimated during the period of farming. There were some fixed costs such as land rent and pond preparation as well. In addition, Interest on Operating Cost (IOC) was calculated by taking into account the variable cost in this study. The standard formula for calculation of interest on operating capital is as follows:
Interest on Operating Capital = Al.i.t (Miah 1988)
Where,
Al = Total investment/2
i = interest which is 10% per year
t = time duration of the culture period

Gross return: Gross return was calculated by simply multiplying the total volume of output with per unit of price at harvesting period (Dilon and Hardaker 1993).

Gross Margin: Gross margin calculation was done to have an estimate of the difference between total return and total variable costs.
GM = TR-TVC

Net return/Margin: Net return was calculated by deducting total costs (variable and fixed) from gross return (Total return).
NM = TR-TC

Benefit-cost ratio: Benefit-cost ratio (BCR) or profitability index was deliberated following the equations in bellow:
BCR = GR/TC
Where,
BCR=Benefit cost ratio
GR=Gross return
TC=total cost

Models for economic analysis: The Cobb-Douglas function model (Ahmed *et al.* 2008) of the following form was used for the analysis:

$$\text{Log } Y = \log a + b_1 \log X_1 + b_2 \log X_2 + b_3 \log X_3 + b_4 \log X_4 + b_5 \log X_5 + b_6 \log X_6 + \text{Log } U_i$$

Where,
Y = Gross revenue (BDT./ac/year),
a = Constant parameter in the equation, mathematically interpreted as the intercept,
X_1 = preparation cost (BDT./ac/year),
X_2 = Fingerling cost (BDT./ac/year),
X_3 = lime cost (BDT./ac/year),
X_4 = Fertilizer cost (BDT./ac/year),
X_5 = Feed cost (BDT./ac/year),
X_6 = Labor cost (BDT./ac/year),
b_1-b_6 = Coefficient of the relevant variable,
U_i = Random error or disturbance term, i = 1, 2, 3 ….. n

Data analysis: Data from questionnaire interviews were coded and entered into a database system using Microsoft Excel software. Qualitative data were converted into quantitative numbers if required after processing. Primary analysis (descriptive, graphs, pivot tables etc.) was carried out using Microsoft Excel. Economic analysis was conducted by using STATA 13 software to determine production costs and returns.

Results

Assessment of fattening practice with production: Though farm size or pond size was an important factor for *Cuchia* fattening in the polyculture system, the contacted farmers in the surveyed area have been reported to conduct the farming in a small area that was one decimal. *Cuchia* fattening or farming mostly depends on the natural source. It was observed from the survey, only 18.33% of the farmers collected fingerlings from nature while the remaining farmers collected fingerlings from the hatchery. Farmers stocked *Heteropneustes fossilis* (shing), *Clarias batrachu* (magur) and *Oreochromis niloticus* (tilapia) with *Cuchia* to get extra profitable production. Table I is showing the average stocking density (no/acre) with size and production in the fattening of *Cuchia* and other fish fingerlings. According to the survey, all of the *Cuchia* fatteners in Nilphamari district used lime during the culture period to keep the water quality in good condition. The entire *Cuchia* farmer used lime and cow-dung as organic fertilizer during their culture period. The survey also revealed that farmers used commercial diet like mega and nourish feed. The average production of *Cuchia* was recorded as 979.17 kg/acre/year. However, the average production of shing was 368.33 kg/acre/year, magur was 330 kg/acre/year and that of *tilapia* was 1027.5 kg/acre/year (Table I).

Table I: Average stocking density (no/acre) according to the size of *Cuchia* and other fish fingerlings

Name of species	Average size of Cuchia and other fish fingerling (inch)	Mean stocking density (no/acre) of all *Cuchia* and fish fry (Mean±SD)	Average Production (kg/acre/year) (Mean±SD)
	11.56	2288.33 ± 228.55	979.17 ± 128
Shing	2.42	2066.67 ± 144	368.33 ± 66
Magur	2.47	1883.33 ± 197	330 ± 51
	1.37	4841.67± 715	1027.5± 118

Variable cost: Among different costs, the feed cost was found as a principal cost item (BD Tk. 99763 ±18637 per acre) for mud eel fattening covering more than 36% of the total variable cost. On the other hand, the average stocking cost was BD Tk. 35661 ±2476 per acre (Fig. 1). This survey also revealed that the average labor cost was BD Tk. 28,757 ±3191 per acre. Minimal costs for fertilizers and lime were reported for fattening of eel in the surveyed area as BD Tk. 905 ±158 per acre and BD Tk. 4083 ±719 per acre, respectively. The harvesting costs were also counted as variable cost that was BD Tk. 18,316.67 ±5067 per acre.

Fixed cost: The average pond preparation cost was BD Tk. 18357 ±5452 per acre which is 20% of total cost. The average land rental expenditure was 7% and the cost was BD Tk. 6833±1107 per acre. While the average interest on operating capital was BD Tk. 68068±11054 per acre for Cuchia polyculture which is 73% of total fixed cost.

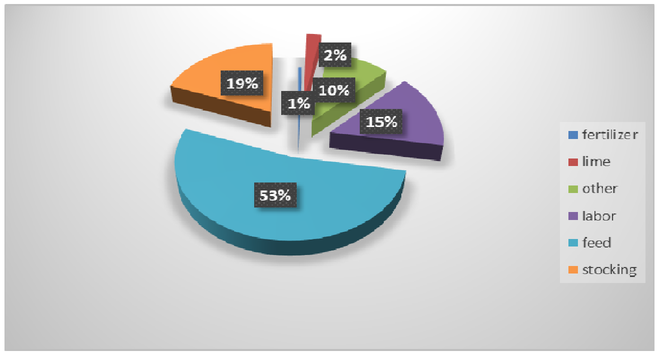

Fig. 1: Percentages of different variable costs in Cuchia polyculture.

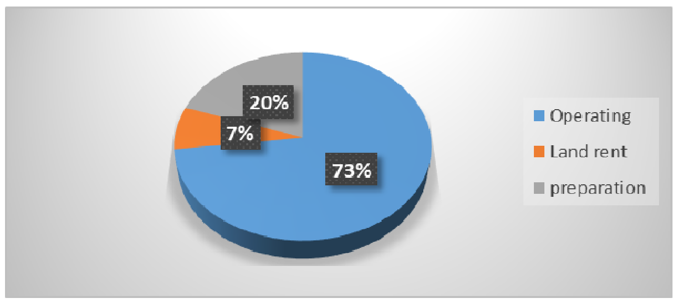

Fig. 2: Percentages of different fixed costs in Cuchia polyculture.

Economic output: The average gross revenue (GR) from *Cuchia* poly farming was BD Tk. 4, 52,025±35829 per acre per year. The average contribution of Cuchia, shing, magur and tilapia were in gross revenue were BD Tk. 1,77,258±24000, 93,477±15796, 95,724±14800 and 85,565±14692 per acre per year, respectively (Table II). The average net return (NR) from *Cuchia* polyculture was BD Tk. 173907 per acre per year and that of the benefit-cost ratio (BCR) from *Cuchia* culture was 1.65 per acre per year (Table II).

Table II: Economic indicators of *Cuchia* polyculture (BDT/acre/year)

Economic indicators	Amount (BDT/ acre/year) (Mean±SD)
Total variable cost (TVC) (BDT/acre/year)	1,91,225 ±96565
Total fixed cost (FC) (BDT/acre/year)	85,731±6276
Total cost (TVC+FC) (BDT/acre/year)	2,78,117±11269
Gross revenue (GR) (Tk /acre/year)	
Cuchia	1,77,258±24000
Shing	93,477±15796
Magur	95,724±14800
Tilapia	85,565±14692
Total GR	4,52,025±35829
Net return (NR = GR - TC) (Tk /acre/year)	1,73,907±24,560
Benefit-cost ratio (BCR = GR/TC)	1.65

Factors affecting Cuchia production in polyculture: The coefficient of preparation, lime, fertilizers and labor cost were positive but not statistically significant. It implied that as other factors remained constant a 1 percent increase of the specific cost would increase the revenue by 0.15, 0.11, 0.01 and 0.09 percent, respectively for *Cuchia* production (Table III). Likewise, the coefficient of fingerling cost was positive and statistically significant ($p<0.01$), thus connoted a 1 percent increase in fingerling cost with regarding other factors remained steady would raise the revenue by 0.11 percent for *Cuchia* production. Whereas, the coefficient of feed cost showed negative sign and statistically significant ($p<0.1$), denoted 0.04% decrease of revenue with 1 percent uplift of feed cost as other factors remained firm (Table III).

Coefficient of multiple determinations (R^2): The coefficient of multiple determinations (R^2) of Cuchia production was 0.16, expected that about 16 percent of variations in revenue of Cuchia production have been considered as the explanatory variables included in the model (Table III). The measure of the overall fit of the estimated regression, F-value of Cuchia production was significant at 1 percent level, indicated the inclusion of the variables as important for explaining the variation in revenue of Cuchia production.

Table III: Estimated values of coefficients and related statistics of the Cobb-Douglas production function model

Explanatory variables	Coefficient	t-value	P>|t|
Intercept	9.86	5.02	0.000
Preparation cost(X_1)	0.15	1.40	0.169
Fingerling cost (X_2)	0.11	3.61	0.001
Lime cost (X_3)	0.11	1.35	0.182
Fertilizer cost (X_4)	0.01	0.08	0.936
Feed cost (X_5)	-0.04	-1.73	0.089
Labor cost (X_6)	0.09	0.60	0.550
R^2	0.16		
F-value	4.54		

Discussion

Among different fixed costs; the average land rental value, pond preparation cost and interest on operating capital were found comparatively higher than the finding of Chakraborty *et al.* (2017). Land rent could be varied with the time, geographical location and size. Moreover, preparation cost was varied by different technology used during preparation. On the other hand, the interest rate was subjective with the culture duration and variable cost.

Whereas from the variable cost analysis, it was observed that total variable cost was comparatively higher than different studies (Chakraborty *et al.* 2018; Chakraborty *et al.* 2017) that comprised more than 70% of the total cost. As it depended on different cost items such as feed, lime, fertilizer etc. Among them, feeding cost was found the major variable cost (53%) followed by stocking cost (19%) in the present observation. Chakraborty *et al.* (2017) showed that the average stocking cost was BDT 28300, 33400 and 29500 in each ditch for 8 months. In another cost analysis, Chakraborty *et al.* (2018) recorded the average stocking cost was BDT 45024.29, 50500 and 60000 per acre and feed costs were BDT 69425.10, 78056.68 and

76307.69 per acre for 8 months, respectively. The observed higher stocking and feeding cost might be associated with the higher stocking density, price variation according to locality, availability of mud eel, application type of feed and improper feeding rate by the farmers as well. However, the lime and fertilization cost in the present survey was found comparatively similar to the observation of Chakraborty *et al.* (2018).

Another important variable cost item is the labor which constituted 12% of the total variable cost in the present survey. Chakraborty *et al.* (2018) showed that labor cost was 19433.3 TK per acre for 8 months. Chakraborty *et al.* (2017) also estimated that labor cost was 21234.34 TK/ditch/240 days. Compared with Chakraborty *et al.* (2017) and Chakraborty *et al.* (2018), labor cost from the present study was found higher which might be associated with the farming duration, size of the pond and increased labor wages with time.

The total fixed cost of this present study was found BDT 85731.45$\pm$6276.64 per acre for 12 months. Chakraborty *et al.* (2018) showed that total fixed costs were 85443 TK, 70826 TK and 73208 TK per acre for 8 months. Fixed cost depended on preparation, land rent, interest on operating cost etc. the fixed cost was found dissimilar with Chakraborty *et al.* (2018) due to higher land rent and IOC in polyculture system as well as culture duration.

Likewise the fixed and variable cost, the total cost in the present study was also revealed higher compared with other studies (Ferdoushi *et al.* 2019; Chakraborty *et al.* 2018; Chakraborty *et al.* 2017) due to their focus on short duration monoculture system related variable cost and the fixed cost. In addition, Chakraborty *et al.* (2018) estimated that the highest net benefit was BDT 109444.94, 157924 and 168252 per acre for 8 months. Yields obtained by polyculture are usually much higher than those obtained by monoculture, especially if the right species have been chosen. From Rahman *et al.* (2012), it was found that the net profit was dissimilar in the case of tilapia farming. Other benefits also may be gained by polyculture, as, for example, quite often the ecological conditions in a pond are improved by polyculture (Ibrahim and Naggar, 2010). In the present study, some high valued fish like *shing* and *magur* were also stocked align with *Cuchia*, which triggered the net return than Chakraborty *et al.* (2018) and augmented higher average net return from *Cuchia* polyculture system.

The benefit-cost ratio (BCR) or profitability index of 1.0 means that the operation is at a break-even position (Ahmed *et al.* 2008). The benefit-cost ratio of the present study was 1.65 per acre per year indicated the turnover of Tk 1.65 per from investment of Tk 1. Chakraborty *et al.* (2018) showed BCR of 1.56 and 1.60 from their experiment. Meanwhile, the present study observed higher BCR than the above study. Whereas, the benefit-cost ratio of 1.82 and 1.62 (Emokaro *et al.* 2010; Adebayo *et al.* 2013) was higher in case of catfish culture. Khan *et al.* (2008) stated that minimization of production cost increased the revenue and promoted the benefit cost ratio.

The Cobb-Douglas function model from this present study demonstrated that the included variables were responsible for *Cuchia* production as well as income in polyculture systems. There was a positive effect of these factors in the polyculture system and there was enough scope to increase the production and income from *Cuchia* fattening in the polyculture system.

The findings of this study suggest Cuchia fattening in polyculture as a profitable venture. Cuchia farming might directly increase the income whereas indirectly improve the socio-economic conditions and livelihoods. Present findings also suggested the improving of feed formulation and feeding practices to reduce production costs. Findings also revealed that the principal factors to increase profit are through the reduction in variable costs, increased production per unit of the pond, and increased price per quantity of *Cuchia* by aiming at higher-value production. However, the study recommended that the establishment of *Cuchia* hatcheries for adequate and quality supply of seed as quality seed can increases the survival and hence profit margins.

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