



Economics and Determinants of Pangas catfish Production in India

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Abstract

The article models the structure of Pangas catfish (*Pangasius pangasius*) (Hamilton, 1822) production to present the determinants of production and estimate costs and return in *Pangasius* farming in India. Farm business analysis was performed for computing costs and return and for determining factors of production, Cobb-Douglas production function was estimated. Empirical findings indicate the *Pangasius* culture was profitable. Net income across all farms was ₹ 437528.9 ha⁻¹, which varied from ₹ 397469.7 ha⁻¹ on large farms to ₹ 588668.1 ha⁻¹ on small farms. The major determinants of *Pangasius* production were feed, seed, area, experience in *Pangasius* culture and days of culture. Coefficients indicate increase in production can be attained by increasing the inputs. The overall estimate of return to scale was larger than unity implies *Pangasius* production can be increased from scale economies. Efficient production practice, with low cost inputs, local seed availability, proper resource allocation and seeking guidance through PAD* for sound and competitive culture practice may ensure sustainable production in the country.

Keywords: *Pangasius*, farm-business analysis, Cobb-Douglas production function

Introduction

Aquaculture is one of the fastest growing sector in India which has grown at 6-7% per annum in recent past due to the species diversification (introduction of new species) and new culture system e.g. cage

culture (Ayyappan, 2012). Freshwater aquaculture in India contributes more than 95% of total aquaculture production; marine aquaculture is limited to few species and contributes lesser. Recently, catfish has started playing a very significant role in world aquaculture. *Pangasius*, a catfish with its qualities like fast growth, air breathing, tolerance to low dissolved oxygen and compatibility to polyculture has gained popularity in many Asian countries. It has been promoted in Bangladesh over the years to ensure food security and income generation for rural communities (Ahmed & Hasan, 2007). Keeping in view its attributes, *Pangasius* was introduced in India during 1995-96 from Thailand through Bangladesh (Ahmed, 2007; Rao, 2010). Culture of *Pangasius* spread very fast in India and the country emerged as one of the largest producers of pond-cultured *Pangasius* (Rao, 2010). Fish farmers of Andhra Pradesh have initiated the pond farming of *Pangasius* since the year 2004, with a view to diversify their carp-based aquaculture, and to harness its high yield potential for domestic as well as export market. Andhra Pradesh produced more than 0.5 million tonnes of *Pangasius* from 32000 ha of pond area, with productivity of 12.5 to 50 tonnes/ha/year during 2009 (Rao, 2010). The species is well established for culture in Krishna and West-Godavari districts of Andhra Pradesh.

The Government of India, through National Fisheries Development of Board (NFDB), Hyderabad is promoting cage-culture of *Pangasius* for quality production and has sanctioned a few projects for its promotion. On the other hand, local newspapers in Andhra Pradesh reported the price crash and declining profits in *Pangasius* culture, a cause of concern for policy makers (Anon, 2011). The price crash led to loss in *Pangasius* culture and many farmers thus, withdrew from its culture, which reduced a grave situation. However, due to lack of systematic studies on economics of *Pangasius* production, appropriate advisories are lacking on

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*PAD – *Pangasius* Farming Standards by Aquaculture Stewardship Council (ASC)

the part of decision makers to overcome these situations. Although there are a number of studies related to economics of carp culture and shrimp aquaculture (Jayaraman, 1997; Sharma & Leung, 2000a,b; Dey et al., 2005; Singh et al., 2009; Debnath et al., 2013). There is hardly any study available on economics and factors affecting production of *Pangasius* in India. Under this background, the study was conducted with following specific objectives in the state of Andhra Pradesh: (a) to estimate costs and return in *Pangasius* culture; (b) to determine the factors affecting *Pangasius* production and (c) to estimate the returns to scale and resource use efficiency in *Pangasius* production. The results of the study will help in taking policy decisions to improve *Pangasius* culture.

Materials and Methods

Andhra Pradesh (AP) has largest area under *Pangasius* culture in the country and hence it was selected for the study. Multistage stratified random sampling was used to select sample for the study. Two districts namely Krishna and West-Godavari from AP were selected on the basis of highest area under *Pangasius* culture. Similarly, two *mandals* Kaikaluru and Kalidindi from Krishna district and Mogalthru and Kallamandal from West-Godavari district were selected on the basis of their contribution to *Pangasius* culture in the *mandals*. A village from each of the selected *mandal* was selected based on area under *Pangasius* farming in the village. Achavaram from Kaikaluru, Korkollu from Kalidindi, Kalipatnam (W) from Mogalthru and Bondadalanka from Kallamandal were selected on the basis of abundance of *Pangasius* culture in the villages (Table 1).

From a prepared list of all the *Pangasius* farmers of selected villages, a sample of 30 farmers were selected randomly from each of the selected villages.

Thus a total of 120 fish farmers were selected for the study from four villages of the two districts in the state. The sample farmers were classified into two categories *i.e.* small farmers (having ponds area <4 ha) and large farmers (having pond area >4 ha) on the basis of their pond area. It was found that 63 farmers were small and 57 large. The data was collected during the year 2011-12 by personal interview method with the help of pre-tested interview schedule specially designed for the study.

Farm business analysis was performed to compute the economics of *Pangasius* culture. Total cost includes total variable cost (TVC) and total fixed cost (TFC). Wherein, total variable cost includes costs of all the inputs like fertilizers and chemicals, seed, feed, labour, charges paid for harvesting and interest on working capital. Total fixed cost (TFC) includes salary of permanent labour, interest on fixed capital, depreciation on fixed assets and its repair and maintenance.

The Cobb-Douglas (C-D) production function is able to handle multiple inputs in its generalized form and it can also handle autocorrelation, heteroscedasticity and multicollinearity (Murthy, 2002). Economists prefer Cobb-Douglas (C-D) production function over Constant Elasticity of Substitution (CES), because, when the function involves more than two inputs, it is difficult to use CES (Smith, 1982). Overall C-D production function has several advantages and most importantly its ease in estimation or use, good empirical fit across many data sets and extreme flexibility are discussed often (Miller, 2008). In aquaculture, C-D production function was used, while determining the input - output relationship and also the returns to scale in pond aquaculture in southern Ghana by Asamoah (2012) and in other places by Dey et al. (2000) and Bimbao et al. (2000). The functional form of CD model used for *Pangasius* culture in Andhra

Table 1. Sampling plan at farm level

Sl. No.	Districts	Mandals	Villages	Sample farmers		Total
				Small	Large	
1.	Krishna	Kaikaluru	Achavaram	18	12	30
		Kalidindi	Korkollu	16	14	30
2.	West-Godavari	Mogalthru	Kalipatanam	15	15	30
		Kallamandal	Bondadalanka	14	16	30
Total						120

Pradesh is specified below;

$$\ln Y = \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + \beta_7 \ln X_7 + \beta_8 \ln X_8 + \beta_9 \ln X_9 + \beta_{10} \ln X_{10} + \beta_{11} \ln X_{11} + \beta_{12} \ln X_{12} + \beta_{13} \ln X_{13} + E$$

Where, Y = fish production (kg); α , β_1 , β_2 , β_3 , β_4 , β_5 , β_6 , β_7 , β_8 , β_9 , β_{10} , β_{11} , β_{12} , β_{13} are the parameters to be estimated; X_1 = agriculture lime (Kg), X_2 = cow dung (Kg), X_3 = probiotics (Kg), X_4 = human labour (man days), X_5 = total pond area (ha), X_6 = age of farmers (years), X_7 = education of farmer (years), X_8 = farmer's aquaculture experience (years), X_9 = farmer's *Pangasius* experience (years), X_{10} = seed stocked (no.), X_{11} = family Size (no.), X_{12} = feed (₹), X_{13} = days of culture (no.), E = error term

The return to scale was estimated as the sum of coefficients for all the input variables.

$$r = \sum \beta_i$$

Increasing, decreasing and constant returns to scale are marked with increase in output by more than 'm', less than 'm' and equal to 'm', when all the factors of production are increased by 'm', respectively.

The estimated coefficients of the relevant independent variables were used to compute the marginal value products (MVP) and their corresponding marginal factor costs (MFC). The ratio of the MVP to MFC was used to determine the resource use efficiency as shown in equation (1)

$$r = \frac{MVP}{MFC} \dots\dots\dots(1)$$

Where, r = efficiency ratio, MVP = $\beta_i(Y/X) \cdot P_y$ (β_i = Coefficient of respective inputs, Y = Geometric mean of Output, X = Geometric mean of *i*th input, P_y = Price of output) MFC = Marginal factor cost (Price per unit input). The values were interpreted thus; if r = 1 resource being efficiently utilized, r > 1 resource underutilized and r < 1 resources are over utilized.

Results and Discussion

Socio-economic status of an individual plays vital role in choosing business/enterprise and influence overall production activities of the same. Socio-economic details of sample farmers are presented in Table 2. Perusal of the table revealed that all sample fish farmers were male with average age of 47.6 years, inferring that it is mainly a male dominated

Table 2. Socio-economic profile of sample fish farm households

Sl. No.	Particulars	Small Farmers (n=63)	Large Farmers (n=57)	Overall Farmers (n=120)
1.	Average Family Size (nos)	4.00	4.38	4.18
2.	Sex Ratio (female/1000 male)	785.71	748.14	767.27
3.	Age of farmers (years)	46	48	47
4.	Gender of farmers (%)			
	a. Male	100	100	100
5.	Marital Status of farmers (%)			
	a. Married	100	100	100
6.	Educational Status of farmers (%)			
	a. Primary School	0.00	1.75	0.83
	b. High School	36.51	17.54	27.50
	c. Higher Secondary	34.92	31.58	33.33
	d. Graduate	25.40	35.09	30.00
	e. PG and above	3.17	14.04	8.33
7.	Aquaculture exp. (years)	11.61	12.70	12.14
8.	<i>Pangasius</i> culture exp. (years)	4.57	5.39	4.96

activity. Asamoah et al. (2012) also reported that males were dominating the aquaculture activity in Ghana. The average family size of sample households were 4 with sex ratio of 767 female per 1000 male in contrast to sex ratio of Andhra Pradesh (993 female per 1000 male) (Census, 2011). All fish farmers were literate, out of which 33% were educated up to higher secondary. Singh (2003) and Agboola et al. (2011) emphasized on logical relation between the level of education and its effect on various facets of characteristics associated with human behavior *i.e.* the knowledge level, skill development, exposure to production technology, marketing and adoption of improved technology. Onumah & Acquah (2010) found that high level of formal education lead to better technical efficiency. It indicates better learning and decision making ability in sample farmers.

Fish farmers had experience of about 12 years in aquaculture and 5 years in *Pangasius* culture, which indicate their expertise in aquaculture practices. The years of experience in aquaculture and expertise makes Andhra Pradesh fish farmers more accomplished in taking challenges in aquaculture sector of India. Aquaculture experience for fish farmers in Andhra Pradesh was in the range of 5 to 12 years (Abraham et al. 2010). Andhra Pradesh has a history of nearly 30 years of aquaculture. The district Nellore in Andhra Pradesh first initiated the fish culture in 1985. These farmers are called "Experienced Practitioners" in aquaculture sector of India (Ramakrishna, 2013).

The category wise fish farm sizes were estimated for sample fish farmers and are presented in Table 3.0. It was found that out of total operational pond area, 49.50% were under ownership of farmers and 50.5% were taken on lease. Larger pond area was taken on

lease by the large farmers (60.78%) as compared to small farmers (16.54%). This may be due to the better financial capacity of the large farmers, as they can afford to lease in more pond area. On an average size of operational fish farm was 5.05 ha, where as that of large farmers was 8.17 ha and of small farmers, 2.23 ha.

The costs and return in *Pangasius* culture was estimated according to farm size category on sample farms and presented in Table 4. On the overall, total cost incurred by farmers in *Pangasius* culture was ₹ 943516 ha⁻¹ which increased with increase in farm size from ₹ 832111 ha⁻¹ on small farms to ₹ 972987.9 ha⁻¹ on large farms. This may be due to better financial capacity of large farmers. Out of total cost of *Pangasius* culture, variable cost accounted for about 85% and rest 15% by fixed cost. The share of variable cost in total cost was almost same for both categories of farms *i.e.* small farms (84%) and large farms (85%). Alam (2011) found total variable cost involved in *Pangasius* culture as 90% and fixed cost to be 10% of total cost. The total variable cost in case of large farm (₹ 826213 ha⁻¹) was higher in comparison to small farm (₹ 696016.2 ha⁻¹). Item wise analysis of variable cost revealed that expenditure of feed was the major cost accounting for about 80% on large farm and 76% on small farm with overall 79% of the total variable cost. Similar results were reported in case of Vietnam and Bangladesh (Ahmed, 2007; Binh, 2009; Alam, 2011). The farmers were using two kinds of feed; farm based (rice bran) and commercially available feed (pelleted feed). Small farmers had spent more on rice bran (₹ 284761 ha⁻¹) in comparison to pelleted feed (₹ 243906.9 ha⁻¹) whereas; large farmers had spent more on pelleted feed (₹ 378370.1 ha⁻¹) as compared to rice bran (₹ 282106.8 ha⁻¹). Commercial feed was costly in comparison to rice bran which might had compelled small farmers to

Table 3. Pond ownership and distribution pattern on sample fish farm

Sl. No.	Category of farm	Sample Size (no.)	Pond Area (ha)		
			Owned	Leased in	Operational area
1)	Small	63	1.86 (83.45)	0.37 (16.55)	2.23 (100)
2)	Large	57	3.20 (39.22)	4.96 (60.78)	8.17 (100)
3)	All farms	120	2.50 (49.48)	2.55 (50.52)	5.05 (100)

Figures in parenthesis indicate the percentage of total operational pond area

Table 4. Economics of Pangasius culture on sample farms (Values in ₹ ha⁻¹)

Sl.No.	Input	Small	Large	Overall
A	Fixed Cost			
	Interest on fixed capital	19856.02 (14.59)	9105.60 (6.22)	11590.75 (8.10)
	Depreciation on fixed capital	5682.24 (4.18)	2685.73 (1.83)	3378.96 (2.36)
	Permanent labour	7775.30 (5.71)	11885.48 (8.10)	9560.80 (6.68)
	Annual Repair and Maintenance	1883.91 (1.38)	525.80 (0.36)	839.79 (0.59)
	Rental value of land	100898.2 (74.14)	122545.1 (83.49)	117796.2 (82.28)
	Total Fixed Cost (TFC)	136096.2 (100.00)	146774.4 (100.00)	143166.5 (100.00)
B	Variable Cost	(n=63)	(n=57)	(n=120)
	Fertilisers and chemicals	2179.71 (0.31)	2802.87 (0.34)	2664.33 (0.33)
	Seed	96912.11 (13.92)	96559.08 (11.69)	96691.2 (12.08)
	Feed			
	Rice bran feed	284761.5 (40.91)	282107.3 (34.14)	283633.9 (35.44)
	Pelleted feed	243908 (35.04)	378370.1 (45.80)	348436 (43.54)
	Labour cost	12756.3 (1.83)	4876.68 (0.59)	8849.92 (1.11)
	Harvesting charges	17762.42 (2.55)	23206.10 (2.381)	21931.97 (2.74)
	Miscellaneous Expenses	9451.14 (1.36)	4235.33 (0.51)	5441.53 (0.68)
	Interest on working capital	28284.98 (4.06)	34054.41 (4.12)	5441.53 (4.09)
	Total Variable Cost (TVC)	696016.2 (100.00)	826213.5 (100.00)	800348.9 (100.00)
C	Total Cost TC=TFC+TVC	832111.8	972987.9	943516
	Gross Income	1420778	1370458	1381044
	Net income (₹)	588666	397470.3	437528.9
	Yield (Kg ha ⁻¹)	36665.24	36055.19	36314.25
	Price (₹ Kg ⁻¹)	38.51	37.97	37.97
	Cost of production (₹ Kg ⁻¹)	22.46	26.74	25.67

Figures in parenthesis indicate the percentage

use less quantity of commercial feed in comparison to large farmers who were more resourceful in comparison to small farmers.

The seed cost was the second most important cost which accounted for about 14, 12 and 12% on small,

large and across all farms, respectively. Binh (2009) also reported the similar findings that cost of fingerlings accounted for 13.5% of total variable cost in Vietnam. In case of Bangladesh, cost of fingerling accounted for 9.54% of total variable cost (Alam, 2011).

The cost of casual human labour on overall basis accounted for about 3.85% of total variable cost which was 4.38% on small farms and 3.4% on large farms. Alam (2011) reported that cost of labour was (4.46%) of the total variable cost in *Pangasius* production in Bangladesh. The higher share of casual labour cost on small farms may be due to very low level of permanent labour on small farms in comparison to large farms.

Among fixed costs, rental value of land was the major component accounting for about 74.2% on small farms whereas 83.5% on large farms and overall it was 82.3%.

The gross income per hectare across all farms was ₹ 1381045 which varied from ₹ 1420778 for small farms to ₹ 1370458 in large farms. Further, net income across all farms was ₹ 437527.9 ha⁻¹ which varied from ₹ 397478.8 ha⁻¹ on large farms to ₹ 588666 ha⁻¹ on small farms. The production per hectare across all farms was 36314 Kg which varied from 36055 kg on large farms to 36665 kg on small farms. The average production cost across all farms was ₹ 25.67 kg⁻¹. Phan et al. (2009) reported cost of production of *Pangasianodon hypophthalmus* in the range of 11000 VND (₹ 31.55) to 17000 (₹ 48.67), with a mean production cost of 14200 VND (₹ 40.65 kg⁻¹) in Vietnam.

The C-D production function was fitted using SPSS-IBM20 package. The step-wise regression was

performed and variables retained in last run were used in production function for all the three categories of the farms. The results so obtained are presented in Table 5. The F-statistics indicate the goodness of fit of all the three production functions. The Durbin Watson statistics reflects that there is no autocorrelation among respective sample category farms. Out of 13 independent variables considered in production function analysis, only five variables namely size of fish farm, feed, seed, days of culture and experience of fish farmer in *Pangasius* culture were retained in last run which were significantly contributing in fish production on the sample farms. Kurbis (2000); Inoni (2007); Asmah (2008) and Asamoah (2012) also found that stocking density, feed, fertilizers, labour were the factors affecting significantly to the fish yield.

Across all farms, coefficient of production for feed was 0.125 which indicated that 10% increase in feed alone will results in 1.2% increase in fish production. The coefficient of feed was 0.09 on large farms which indicate that 10% increase in feed will results in 0.9% increase in fish production. Most of the farmers followed mix feeding strategy that is use of rice bran and pelleted feed in two different phases and kept no standardization in feeding practices. High prices of pelleted feed and low prices of rice bran also made feeding strategy a bit complex. Hence, effective combinations of two types of feed at right phases could aid in optimizing the use of feed and thereby cost incurred and efficient production.

Table 5. Estimated Cobb-Douglas Production Function in *Pangasius* culture on sample fish farms

N = 120	Unstandardized Coefficients		
	Small (n=63)	Large (n=57)	Overall (N=120)
DW	1.79	1.68	1.7
R ²	82	94	96
Feed (₹)	0.145	0.09**	0.125*
Seed (Kg)	0.249*	0.283*	0.144*
Fish farm area	0.479*	0.389*	0.419*
Days of culture (No.)	0.1	0.19*	0.403*
Experience in <i>Pangasius</i> culture (y)	0.184*	0.191*	0.130*
Return to Scale	1.15	1.14	1.2
F-statistics	df (4,59)77.8	df (5,52)315.62	df (5,115)728.73
	p-value 0.000	p-value 0.000	p-value 0.00

*Significant at 1% level of significance, **Significant at 5% level of significance

In case of seed stocking across all farms, coefficient was 0.144 which reflects that 10% increase in seed will result in 1.4% increase in fish production whereas in case of small and large farmers the coefficients were 0.249 and 0.283, respectively. This implies, increasing of stocking density to increase fish production. The present scenario in stocking of seed was constrained by unavailability of uniform size of seed on time in the market. Hence, in order to increase Pangasius production, increase of stocking density is required with optimum size of fingerling.

Coefficient for days of culture was 0.403 across all farms, which reflects that increase in culture days by 10% will result in 4.0% increase in fish production. The coefficient in small (0.1) and large farms (0.19) reflects that with increase in days of culture by 10% will increase fish production by 1% and 1.9%, respectively. This may be due to high uncertainty in prices of Pangasius, which does not allow farmers to extend the culture period and harvest the crop at an early date. Size of fish farm affects the fish production directly. Coefficient of farm size for overall farms was 0.419, whereas for small and large farm it was 0.479 and 0.389. Which imply that increase in farm size by 10% will result in increase in fish production by 4.1, 4.7 and 3.8% across all farms, small and large farms, respectively. In case of experience of farmers in Pangasius culture coefficient was 0.130 across all farms that imply increase in 10% of experience of farmers in

Pangasius culture will result in 1.3% increase in fish production. The coefficient of Pangasius culture experience for large farmers (0.191) implied greater significance than that of the small farmers (0.184). This indicates with passage of time, experience of farmers in Pangasius culture will help in harvesting higher yield in Pangasius.

The resultant proportionate change in output due to the proportionate change in the level of all inputs used is referred as returns to scale. It also infers economies of scale because of duality in production theory (Jehle & Reny 2001). The returns to scale of the production technology is of essential interest, given its implications for potential changes to the targeted size of future production units (Kurbis, 2000). The returns to scale was estimated by adding coefficients of the variables presented in Table 5. Production function on overall basis depict return to scale of 1.22 which indicate that increase of 1% in all inputs will lead to 1.22% increase in fish production and hence increasing returns to scale. The small farmers and large farmers have shown the returns to scale 1.15 and 1.14 respectively. This infers that increase in 1% in all inputs by small farmers and large farmers will lead to 1.15 and 1.14% increase in fish production, respectively. Asamoah (2012) found similar results that small farmers exhibited constant returns to scale and large farmers shown increasing returns to scale in Ghana. The overall estimate of return to scale was larger than

Table 6. Resource use efficiency

Resource Input	Coefficient	MVP	MFC	Efficiency Ratio (r)
Small Farms				
Fish farm area	0.479	670854.59	*52060.36	12.89
Seed	0.249	12.48	3.39	3.68
Feed	0.145	3.44	11.56	0.30
Large Farms				
Fish farm area	0.389	540864.84	50667.58	10.67
Seed	0.283	14.51	3.37	4.31
Feed	0.090	1.98	10.89	0.18
Overall				
Fish farm area	0.419	577473.65	37188.54	15.53
Seed	0.144	7.19	3.37	2.13
Feed	0.125	2.84	12.44	0.23

*MFC = for farm area is taken for a single cycle of production

unity implies *Pangasius* production can be increased from scale economies. This implies that *Pangasius* production in this region has high potential.

The resource use efficiency was examined for those variables which had significant effect on the dependent variable. The ratio of Marginal Physical Product and Marginal Factor Cost determined the efficiency of employed resources, *i.e.* $r = MVP/MFC$. If $r=1$ it indicates resources are efficiently allocated or optimally utilized. The results so obtained has been presented in Table 6. Perusal of table revealed that, size of fish farm, seed and feed were the inputs used at inefficient levels since, resource allocative efficiency for *Pangasius* production among farmers of Andhra Pradesh, in India, 'r' is not equal to 1.

The estimates of 'r' for resources employed in *Pangasius* production were 15.53, 2.13 and 0.23 respectively for fish farm area, seed and feed in case of overall farmers. Unexpected low prices of output during previous years and intention of safeguarding against high risk, many *Pangasius* fish farmers may have under-utilized fish farm area. Financial limitations might also have discouraged the utilization of fish farm area. Inoni (2007) quotes that the under-utilisation of pond size for fish production may be due to inadequate and untimely access to production credit among fish farmers of Delta State, Nigeria.

The seed was being under-utilised by *Pangasius* farmers which may be due to lack of knowledge and also due to unavailability of seed on time. Also, size variation in available seed of *Pangasius*, might have discouraged the farmers from stocking more seed. It was observed that feed was over-utilized resource across all farms (0.23), large farmers (0.18) and small farmers (0.30). This suggests that use of feed should be reduced to save cost. *Pangasius* farmers in Andhra Pradesh, pre-dominantly use rice bran and pelleted feed. The high price of pelleted feed in comparison to rice bran had raised the overall feed cost. Therefore, considerable reduction in the use of pelleted feed, with replacement of rice bran may reduce the feed cost. Hence, in order to increase profitability and efficient use of resources, use of pelleted feed must be reduced, more area should be brought under *Pangasius* culture and stocking density should be increased. In case of small and large farmers efficiency ratio of fish farm area was 12.89 and 10.67 respectively this probably reflects that both category of farmers were under utilising the fish farm area. This was probably due to the

financial limitations which found more stringent in case of small farmers than large farmers. Further, estimated value of 'r' for 'seed' on small farmers and large farmers was 3.68 and 4.31 respectively, this indicates under utilisation of the 'seed' and this was probably due to irregular availability of seed, size variation in seed and to control cost.

Pangasius culture was found profitable on both the category of farms. 'Large farms' can cut down their cost through reduced use of pelleted feed. Major factors contributing to the yield were feed, seed, fish farm area, days of culture and experience in *Pangasius* culture. To obtain better production figures, these inputs need to be efficiently used. Except the feed in case of small farms, both the categories of farms can increase the yield/production through increased use of feed and seed. Increased farm area, days of culture and experience in *Pangasius* culture will increase the yield and profitability. Unavailability of local *Pangasius* seed, creates the opportunity for local fish breeders to learn the breeding of *Pangasius* and establish hatcheries to cater the need. *Pangasius* culture in the region exhibited increasing returns to scale. The overall estimate of the returns to scale was larger than unity implies *Pangasius* production can be increased from scale economies. There is a need to find alternative feed to reduce cost in production. *Pangasius* being an omnivore gives opportunity to find alternative feed.

Enhancement of technical capacity in *Pangasius* breeding, is of prime concern to harness its full potential. Government through department of fisheries should guide and encourage the farmers to culture *Pangasius* on the line of 'Pangasius Aquaculture Dialogue'. Intensifying the production with the efforts mentioned above will keep 'Pangasius' profitable.

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References

- Abraham, T. J., Sil, S. K. and Vineetha, P. (2010) A comparative study of the aquaculture practices adopted by fish farmers in Andhra Pradesh and West Bengal. *Indian J. Fish.* 57:3: 41-48
- Agboola, W. L. (2011) Improving fish farming productivity towards achieving food security in Osun State, Nigeria: a socioeconomic analysis. *Ann. Biol. Res.* 2 (3): 62-74

- Ahmed, N. (2007) Economics of aquaculture feeding practices: Bangladesh. In: Economics of Aquaculture Feeding Practices in Selected Asian Countries, FAO Fisheries Technical Paper 505 (Hasan, M. R., Ed), pp 33–64. Food and Agriculture Organization (FAO) of the United Nations, Rome, Italy
- Ahmed, N. and Hasan, M. R. (2007) Growing pangas industry faces constraints in Bangladesh. *Global Aquaculture Advocate*. 10: 60-62
- Alam, M. F. (2011) Measuring technical, allocative and cost efficiency of pangas (*Pangasius hypophthalmus*) (Sauvage 1878) fish farmers of Bangladesh. *Aquacult. Res.* 42: 1-14
- Anon (2011) Official for regulation of *Pangasius* fish culture, The Hindu, AP Edition, Eluru, India. (assessed March, 2015)
- Asamoah, E. K., Ewusie Nunoo, F. K., Osei-Asare, Y. B., Addo, S. and Sumaila, U. R. (2012) A production function analysis of pond aquaculture in Southern Ghana. *Aquacult. Econ. Manage.* 16(3): 183-201
- Asmah, R. (2008) Development potential and financial viability of fish farming in Ghana. PhD Thesis. University of Stirling, Scotland. 289 p
- Ayyappan, S. (2012) "Indian Fisheries on a Fast Tract." The Economic Times (New Delhi, India), September 28
- Bimbao, G. B., Paraguas, F. J., Dey, M. M. and Eknath, A. E. (2000) Socioeconomics and production efficiency of tilapia hatchery operations in the Philippines. *Aquacult. Econ. Manage.* 4(1-2): 47-61
- Binh, T.V. (2009) Analysis of Vietnam's *Pangasius* Industry in Transition (1995–2007), Ph.D. Thesis. Antwerp, Belgium: University of Antwerp, Faculty of Applied Economics
- Census (2011) assessed on 11th march 2013 retrieved through <http://www.census2011.co.in/>
- Debnath, B., Biradar, R. S., Pandey, S. K., Ananthan, P. S., Mugaonkar, P. and Das, A. (2013) Technical efficiency of fish culture in relation to technology adoption - the case of Tripura state in India. *Indian J. Fish.* 60(4): 69-75
- Dey, M. M., Paraguas, F. J., Bimbao, G. B. and Regaspi, P. B. (2000) Technical efficiency of tilapia growout pond operations in the Philippines. *Aquacult. Econ. Manage.* 4(1-2): 33-47
- Dey, M., Javien Paraguas, F., Srichantuk, N., Xinhua, Y., Bhatta, R. and Thi Chau Dung, L. (2005) Technical efficiency of freshwater pond polyculture production in selected Asian countries: estimation and implication. *Aquacult. Econ. Manage.* 9(1-2): 39-63
- Inoni, O. E. (2007) Allocative efficiency in pond fish production in Delta State, Nigeria: A production function approach. *Agricultura Tropica Et Subtropica* 40(4): 127-134
- Jayaraman, R. (1997) Carp culture in Thanjavur district, Tamilnadu, India: An economic analysis, *Asian Fish. Sci.* 9: 284
- Jehle, G. A. and Reny, P. J. (2001) *Advanced Microeconomic Theory* 2nd edn., 543 p. Boston; London, Addison-Wesley
- Kurbis, G. (2000) An Economic Analysis of Tilapia Production by Small Scale Farmers in Rural Honduras. M.Sc.Thesis. Department of Agricultural Economics and Farm Management. University of Manitoba. Winnipeg, Manitoba, 102p
- Miller, E. (2008) An assessment of CES and Cobb-Douglas production functions. Congressional Budget Office
- Murthy, K. V. (2002) Arguing a case for Cobb-Douglas production function Review of Commerce Studies. pp 20-21
- Onumah, E. E. and Acquah, H. D. (2010) Frontier analysis of aquaculture farms in the Southern Sector of Ghana. *World Appl. Sci. J.* 9 (7): 826-835
- Phan, L. T., Bui, T. M., Nguyen, T. T., Gooley, G. J., Ingram, B. A., Nguyen, H. V. and De Silva, S. S. (2009) Current status of farming practices of striped catfish *Pangasianodon hypophthalmus* in the Mekong Delta, Vietnam. *Aquaculture*. 296(3): 227-236
- Ramakrishna, R., Shipton, T. A. and Hasan, M. R. (2013) Feeding and feed management of Indian major carps in Andhra Pradesh, India. Food and Agriculture Organization of the United Nations
- Rao (2010) A comprehensive study report Present Status of *Pangasius* Farming in Andhra Pradesh, India. (Submitted to NFDB)
- Sharma, K. R. and Leung, P. S. (2000a) Technical efficiency of carp pond culture in south Asia: An application of a stochastic meta-production frontier model. *Aquacult. Econ. Manage.* 4(3-4): 169-189
- Sharma, K. R. and Leung, P. S. (2000b) Technical efficiency of carp production in India. A stochastic frontier production function analysis. *Aquacult. Res.* 31: 937-948
- Singh, R. K. P. (2003) *Economics of Aquaculture*. Daya Publishing House. Delhi, India
- Singh, K., Dey, M. M., Rabbani, A. G. Sudhakaran, P. O. and Thapa, G. (2009) Technical efficiency of freshwater aquaculture and its determinants in Tripura, India. *Agricult. Econ. Res. Rev.* 22: 185-195
- Smith, I. R. (1982) Micro-economics of existing aquaculture production systems: basic concepts and definitions. In: *Aquaculture Economics Research in Asia*. Proceedings of a workshop held in Singapore, June 2–5, 1981. Ottawa, Canada. International Development Research Centre. [ICLARM, Manila, Philippines]