Production Risk, Inefficiency and Sustainability of Pangas Fish Farming: Lessons from the Bangladesh Aquaculture Sector

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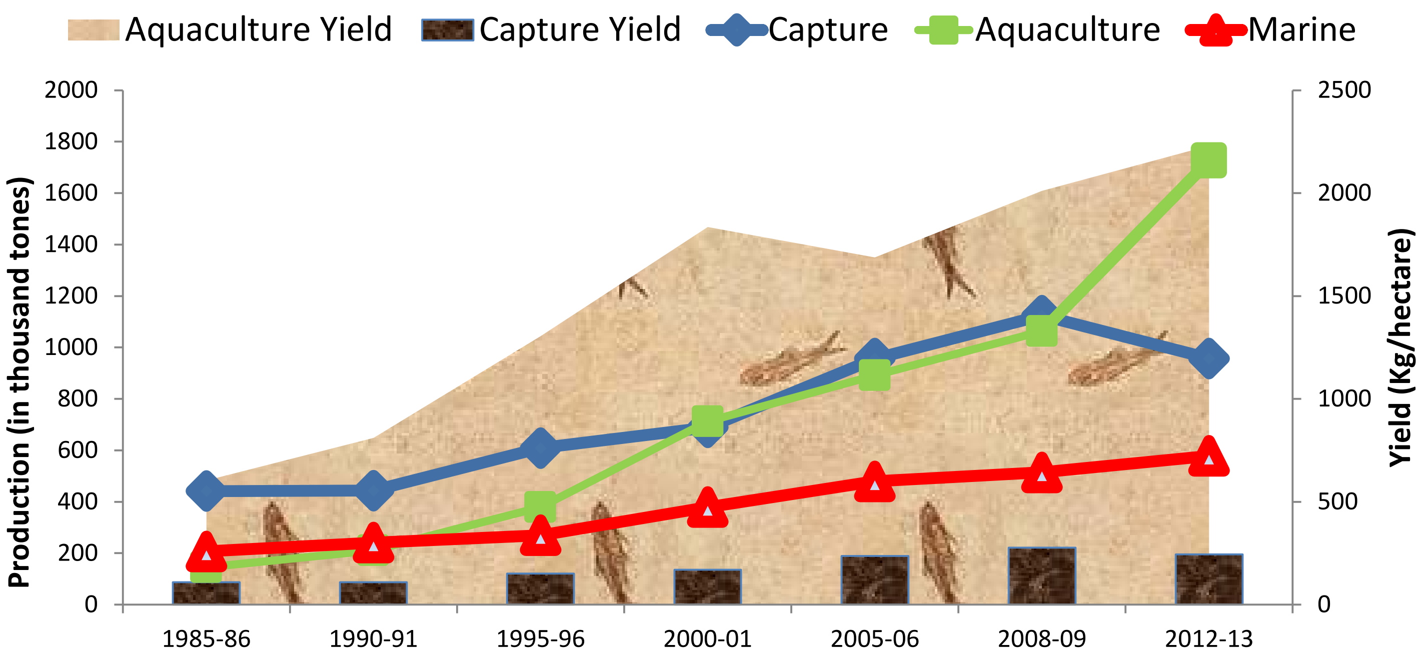
Overview of Bangladesh Fisheries

- In Bangladesh, fisheries is playing a vital role in providing food and nutrients, creating employment (12 million people) and poverty alleviation.
- Fish is the **second largest export** commodity, contribute **4.37% of total GDP** and **3% of total export earning** (BBS 2015) .
- Bangladesh is the **fourth largest inland** freshwater fish producing country in the world (FAO 2014)



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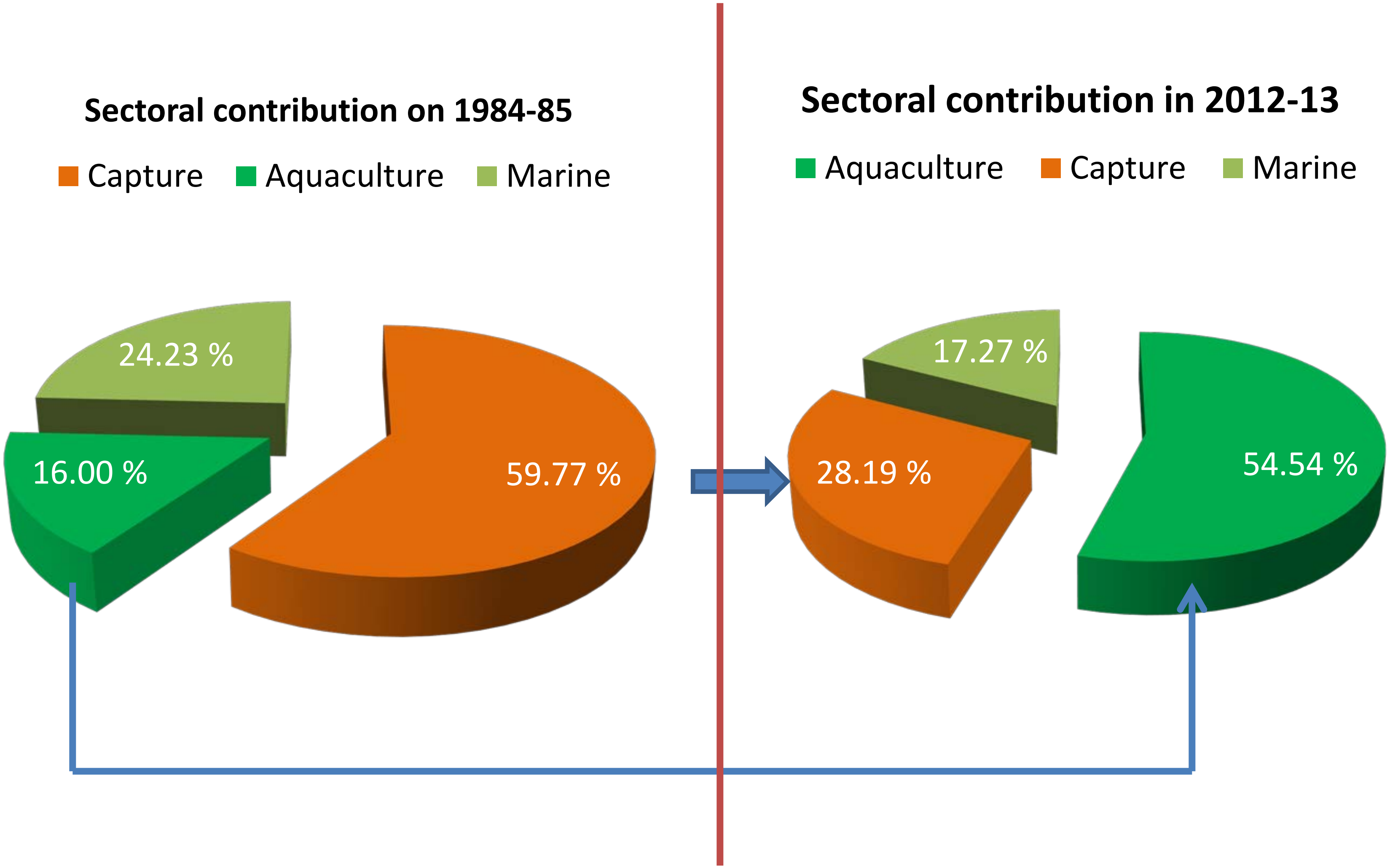
Scenario of sectoral contribution



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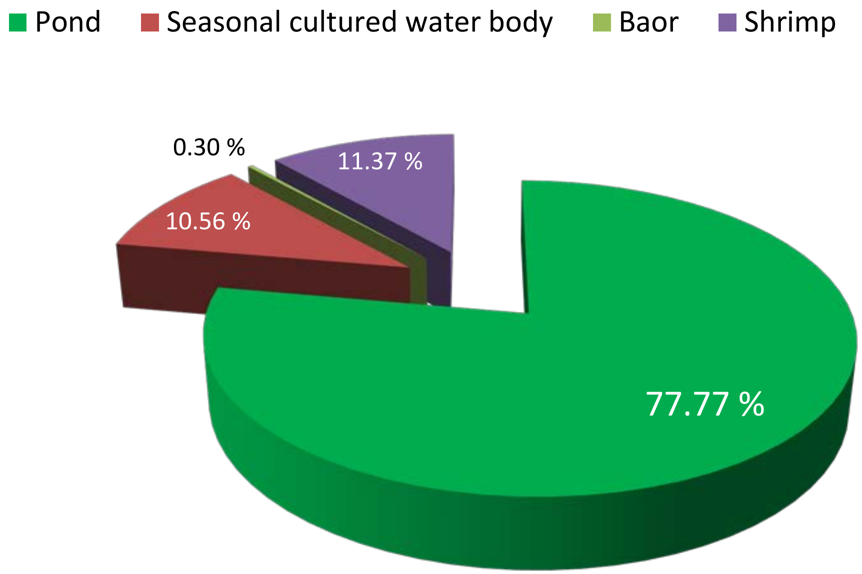
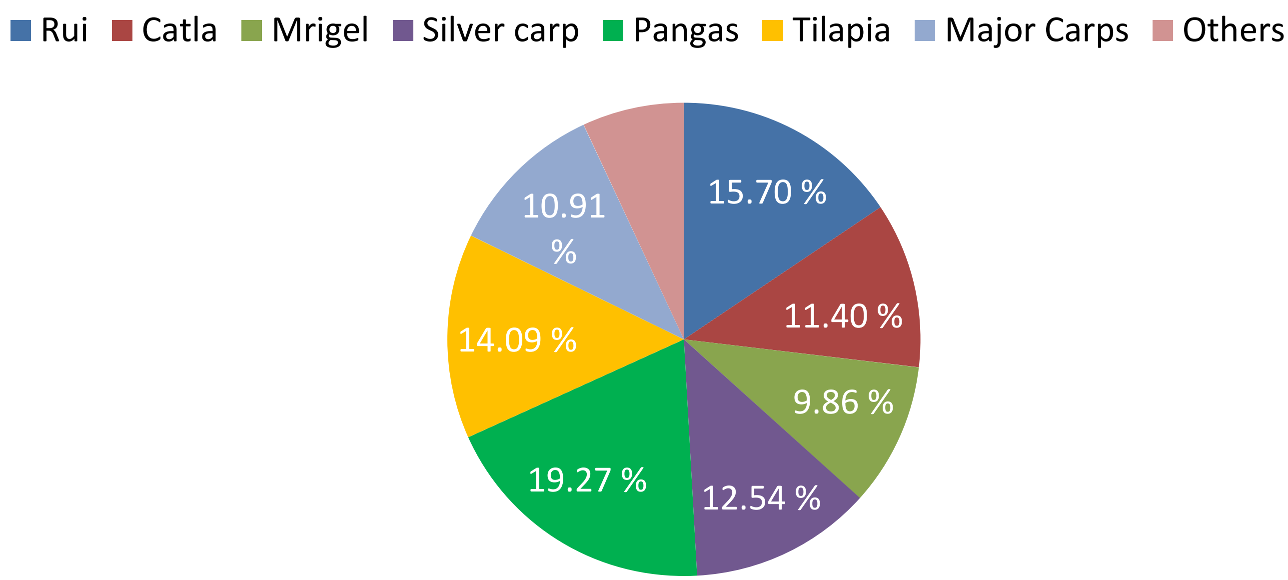
Percentage of total aquaculture production



Why Pangas?

- Pangas *(Pangasius hypophthalmus)* is relatively new and fast growing species, tolerate high density, and reach a marketable size within just five to six month.

- It is known as "fish for the poor" due to low market price.



- Potential for export earnings (Vietnam earns USD 2 billion)

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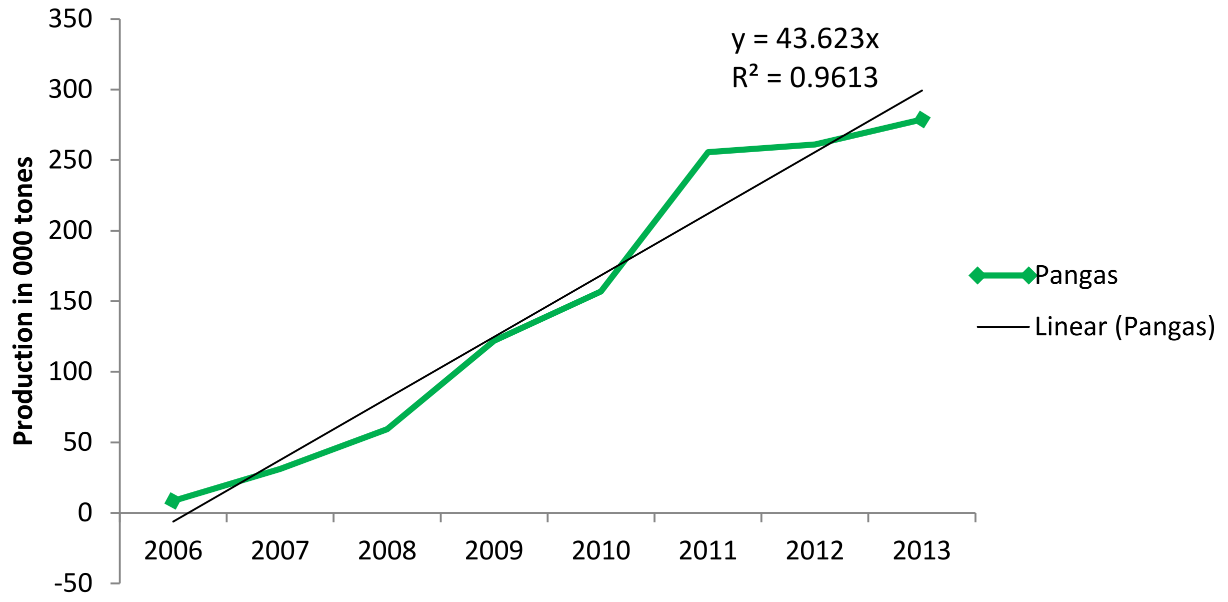
Why Pangas?

Production trend since 2006



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What is problem?

- Number of **stochastic biophysical and socioeconomic factors** may influence on production system and differentiate production practice

- **Production variability observed** from farm to farm and location to location, might be due to input use variation and lack of proper management practices (institutional support-credit, extension services and socioeconomic characteristics- capital)

- **Production cost** has increased due to high input price specially feed (compared to output price) resulted farmers stop producing pangas

- **Small farmers cannot purchase** feed in proper time and sufficient amount because of capital constraint. Therefore, input use variability among farmers may create production risk

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What is problem?

- Some input may reduce output risk while many increases risk
- There is substantial scope for controlling the level of production risk through efficient use of input quantities.
- Question of sustainability (due to low price, high input cost, other fish culture)
- Literature: Asche & Tveterås (1998, 1999), Kumbhakar (2002, 2003), Kristin Roll (2008) etc. but no literature on Bangladesh aquaculture

Research question

What are the input risk factors that affect production of pangas farming? Are all the fish farmers technically efficient?

Will all size of farms sustain in the long run?

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Methodology

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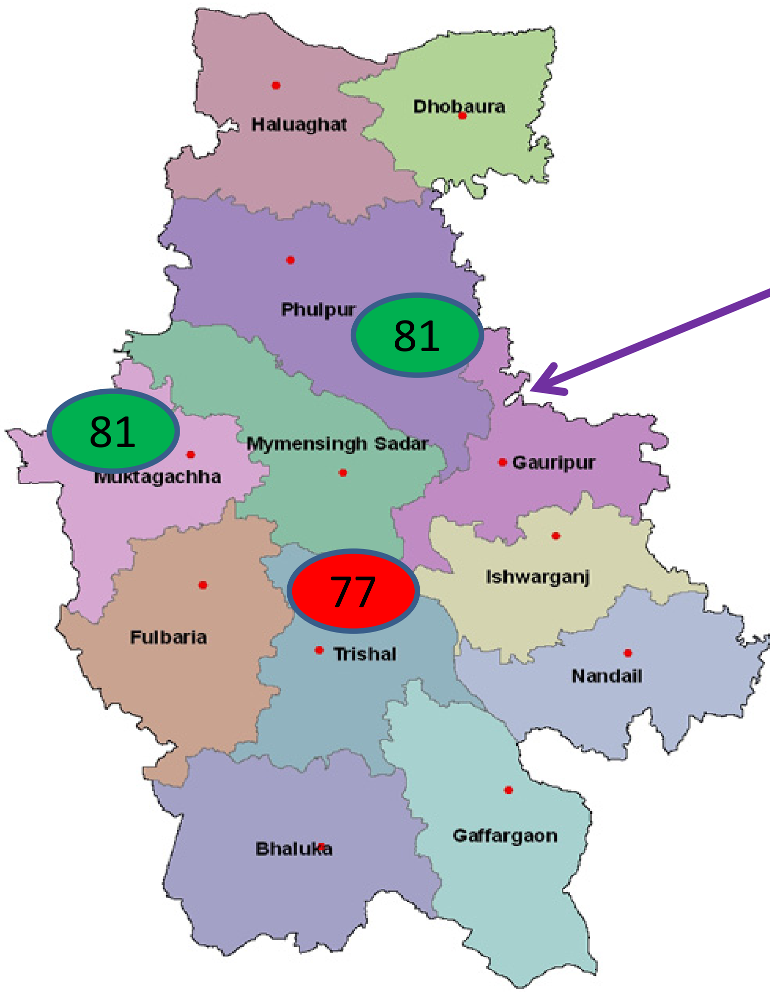
Study area, data collection and sample size



About 57 % pangas produced
Land conversion from rice to fish

Analytical Technique

- Cost-benefit analysis

- Model developed by Just and Pope (1978) and further extended by Kumbhakar (2002) where mean, risk and inefficiency function

$$y = f(x;\alpha) + h(x;\beta)v - q(z;\gamma)u$$

- Mean production function:

$$\ln[f(x;\alpha)] = \alpha_0 + \sum_{i=1}^{5} \alpha_i \cdot \ln(X_i) + \frac{1}{2}\sum_{i=1}^{5}\sum_{j=1}^{5} \alpha_{ij} \cdot \ln(X_i) \cdot \ln(X_j) + \sum_{d=1}^{2} \delta_d \cdot D_d + \mu$$

- Risk function:

$$\ln[h(x;\beta)] = \beta_0 + \sum_{i=1}^{5} \beta_i \cdot \ln(X_i) + \sum_{d=1}^{2} \delta_d \cdot D_d + \lambda$$

- Inefficiency function:

$$q(z;\gamma) = \gamma_0 + \sum_{s=1}^{6} \gamma_s \cdot S_s + \sum_{d=1}^{2} \delta_d \cdot D_d + v$$

- Sustainability analysis

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Testing functional forms, risk and inefficiency

Hypothesis	LR test statistics	No. of restriction	Mixture $\chi^2_{0.01}$ critical value	Decision
Functional form test: I. Cobb-Douglas half-normal versus Translog half-normal	32.24	14	29.384	Reject
II. Cobb-Douglas truncated versus Translog truncated	32.31	14	29.384	Reject
III. Translog half-normal versus Translog truncated	2.41	1	5.412	Accept
Test of homoskedasticity. Test of the variance function : $H_0: \beta_1 = ... = \beta_5 = 0, \delta_1 = \delta_2 = 0$	20.17	7	17.755	Reject
Test of no inefficiency. No effects of socioeconomic variables on inefficiency: $H_0: \gamma_1 = ... = \gamma_6 = 0, \delta_1 = \delta_2 = 0$	10.54	1	5.412	Reject

Results

Cost and Return (per acre)

Items	Quantity	Cost (in BDT)	USD
(I) Labour (Man-days)	128	25,074	321
(II) Fingerlings (Number)	26,807	47,349	607
(III) Feed (Kg)	10946	312,015	4000
(IV) Fertilizer (Kg)	302	3,409	44
(V) Other cost (Tk.)		11,956	153
A. Variable cost (Tk.)		399,803	5126
B. Lease Value (Tk.)		24,068	309
C. Capital cost (Tk.)		42,737	5488
Gross Cost (A+B+C)		466,608	5982
Production (Kg/acre)	8,151		
Output price per kg	66.64		
Gross Return (BDT / acre)		541,665	6944
Gross Margin (BDT / acre)		166,489	2134
Net Return or Profit(BDT / acre)		75,057	962
Benefit-Cost ratio (BCR)		1.16	

1 USD = 78 BDT, 100 decimal = 1 acre and 2.47 acre = 1 hectare

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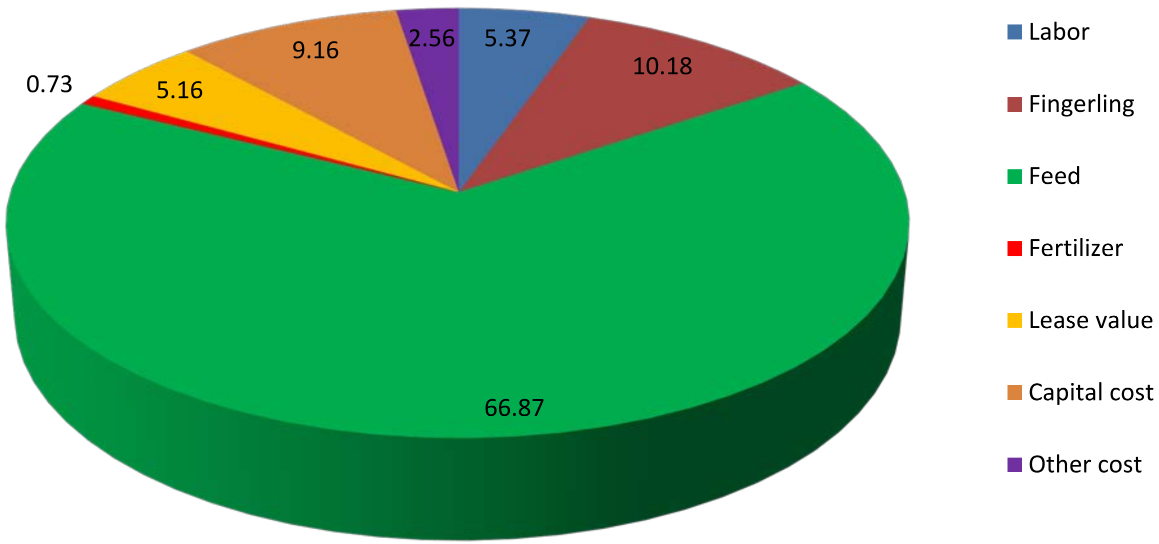
Cost share



Production risk and inefficiency measurement

Parameters estimates of mean function, f(x, α)

Variables	Coefficient	Std. error
ln Labour	0.147***	0.053
ln Fingerling	0.027	0.025
ln Feed	0.551***	0.033
ln Capital cost	0.133***	0.035
ln Farm Size	0.127*	0.067
ln Labour × ln Labour	-0.152	0.27
ln Fingerling × ln Fingerling	-0.182*	0.095
ln Feed × ln Feed	0.115	0.101
ln Farm size × ln Farm size	-0.763	0.494
ln Labour × ln Fingerling	0.074	0.118
ln Labour × ln Feed	-0.216**	0.089
ln Fingerling × ln Feed	0.091	0.073
ln Capital × ln Labour	0.094	0.076
ln Capital × ln Fingerling	-0.135*	0.08
ln Capital × ln Feed	-0.160*	0.109
ln Farm size × ln Labour	0.273	0.333
ln Farm size × ln Fingerling	0.114	0.171
ln Farm size × ln Feed	0.205*	0.107
ln Capital × ln Farm size	0.098	0.068
Trishal (1 if Trishal, 0 otherwise)	-0.026	0.027
Muktagachha (1 if Muktagachha, 0 otherwise)	0.012	0.03
Constant	0.115***	0.034

The coefficients of feed, labour, capital and farm size are positive and influence the production significantly. The positive sign implies that an increase in the use of these input factors would increase production. The input of feed has the highest influence on production of pangas having a positive elasticity of 0.551, which implies that production increases 0.551% with a 1% increase in the use of feed.

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Parameters estimates of risk function h(x,β)

Variable	Coefficient	Std. error
ln Labour	-0.628	0.614
ln Fingerling	0.893**	0.409
ln Feed	-0.800*	0.435
ln Capital cost/investments in physical assets	-1.045**	0.487
ln Farm size	2.132**	0.843
Trishal (1 if Trishal, 0 otherwise)	-0.137	0.415
Muktagacha (1 if Muktagachha, 0 otherwise)	0.804**	0.389
Constant	-5.305***	0.399

Labor- family labor
Fingerling- Believe that more fingerling – more production, oxygen become low and creation of toxic by product such as carbon dioxide and ammonia increases and its decreases the production.
Feed- Large farm apply sufficient amount of feed but small cannot due to capital constraint
Capital- increasing investment in equipment (STW, boat, house of feed, water pump, net etc. reduce risk)

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Parameters estimates of inefficiency function q(z,γ)

Variable	Coefficient	Std. error
Age (years)	-0.011	0.027
Education (years of schooling)	-0.042	0.055
Experience (years)	-0.071	0.100
Training (number of days)	-0.041*	0.022
Credit (dummy)	-1.154*	0.663
Extension Service (dummy)	-1.22***	0.476
Trishal	-0.167	0.709
Muktagachha	-0.645	0.943
Constant	-1.406	1.097
Mean technical efficiency (%)	0.92	
Maximum (%)	0.995	
Minimum (%)	0.609	

An average TE score of 0.92 is relative high compared to other studies of TE in aquaculture (not pangas) production in Asian countries (Sharma and Leung 2003, Iliyasu et al. 2014).

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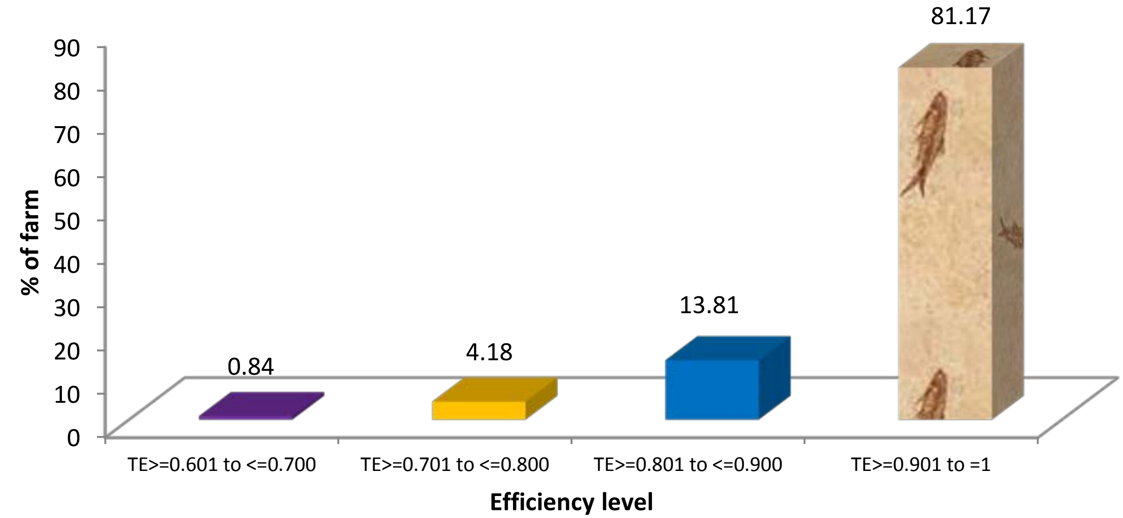
Distribution of efficiency level



About 81 percent farmer’s technical efficiency level is greater than 90% and no farms operate below 60% level.

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Uses of different input on the basis of efficiency level

Efficiency Level	Labor (man-days/acre)	Fingerling (No. of pieces/acre)	Feed (kg/acre)	Production (kg/acre)	FCR (Feed conversion ratio)
0.951-1.00	123	23770	14644	9747	1.50
0.901-0.950	117	23471	10320	7079	1.48
0.851-0.900	103	23969	8595	5289	1.61
0.801-0.850	126	24807	9547	5935	1.62
0.701-0.800	92	25644	8001	4338	1.84
≤ 0.700	106	25613	5537	3238	1.71

Inefficient farmers use less quantity of labor but more fingerling stocking rate.

More feed gives more production and eficient farmer is more productive conpared to inefficient farmer. But the feed conversion ratio (FCR) is less for efficient farmers compare inefficient farmers.

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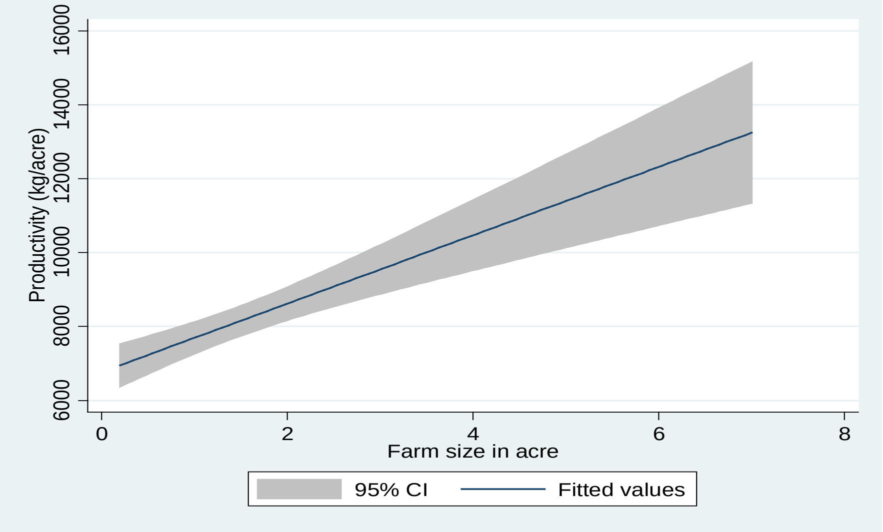
Ratio of observed input and efficient input according to farm size (*Under and over use of input)*

Input	Farm size (acre)						
	≤0.50	0.51-1.00	1.01-1.50	1.51-2.00	2.01-2.50	≥2.51	All farms
Labor	0.92	0.87	0.95	0.92	1.11	1.18	0.95
Fingerling	1.04	1.09	1.06	1.05	0.80	0.74	1.01
Feed	0.77	0.84	0.74	0.80	0.96	1.06	0.83

Considering all farms, inputs dosage the pangas farmers currently apply is 5% lower for labor, 17% lower for feed. But overall fingerling stocking rate is optimal in the study area.

Sustainability (farm size –productivity relationship)



Examined whether the **inverse relationship** holds for pangas farms in Bangladesh. The relationship is tested using a **simple local polynomial regression** line with 95% confidence interval. Figure shows that there is a **positive relationship** between farm size and productivity, which implies that larger farms are more productive compared to smaller farms.

The result may be explained by the fact that large farm has economic, technical, management and financial advantages compared to small farm.

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Sustainability (experience – efficiency and farm size relationship)

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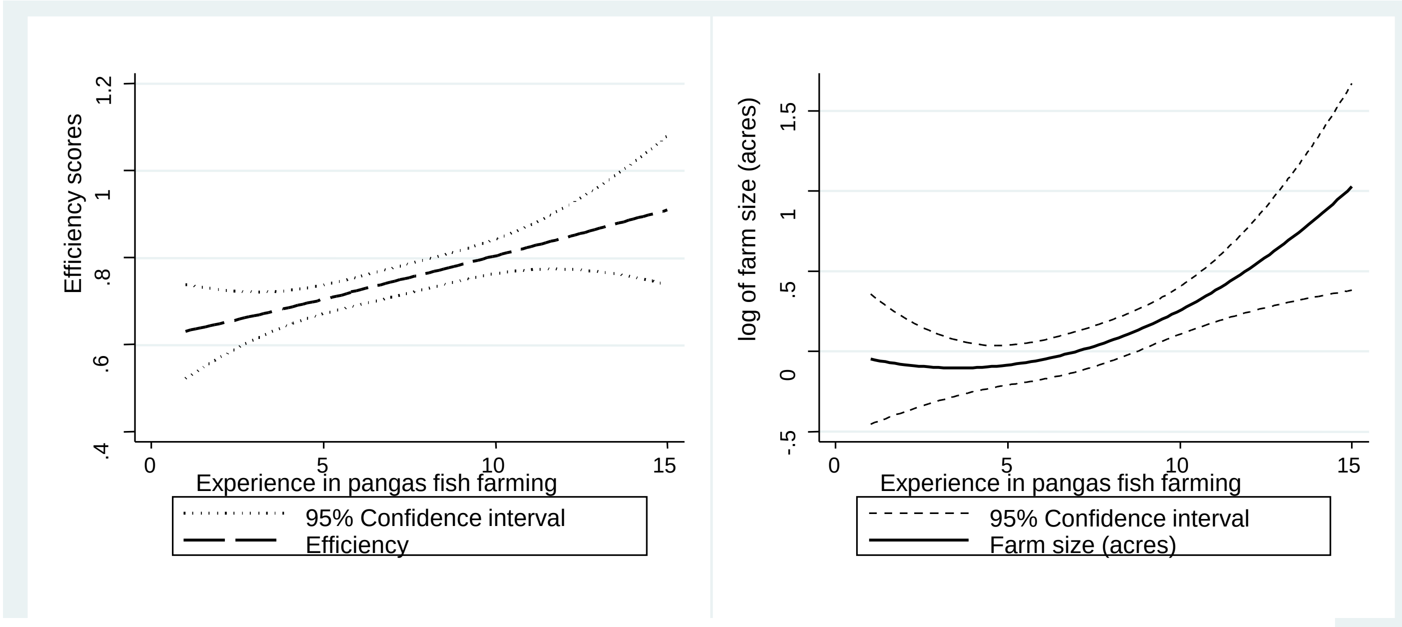

Quadratic prediction of efficiency and fish farm size on experience in fish farming

Since experience in fish farming is defined as the time a farmer has spent in fish farming, it allows us to say something about sustainability in fish farming.

We explain how farm size and efficiency levels vary with experience in fish farming

Both efficiency and farm size significantly increase with increasing experience in fish farming.

Sustainability (farm size-efficiency relationship)

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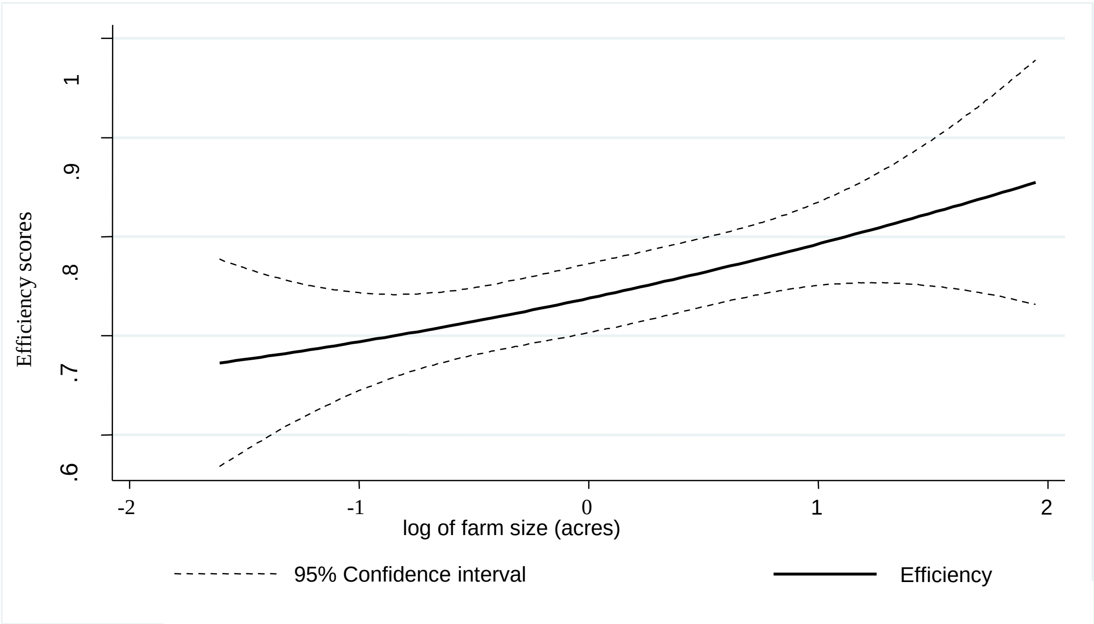

Quadratic prediction of efficiency and farm size

Efficiency increases with increasing farm size. These results imply that farmers with small farm size and little experience are less efficient.

This suggests that in the short-run, new pangas fish farmers are at the lower end of their learning curve and at the same time have small farm size. But as the fish farmers get more experienced, their efficiency levels improve while at the same time they accumulate their farm size over time.

Sustainability (farm size- access to credit and training relationship)

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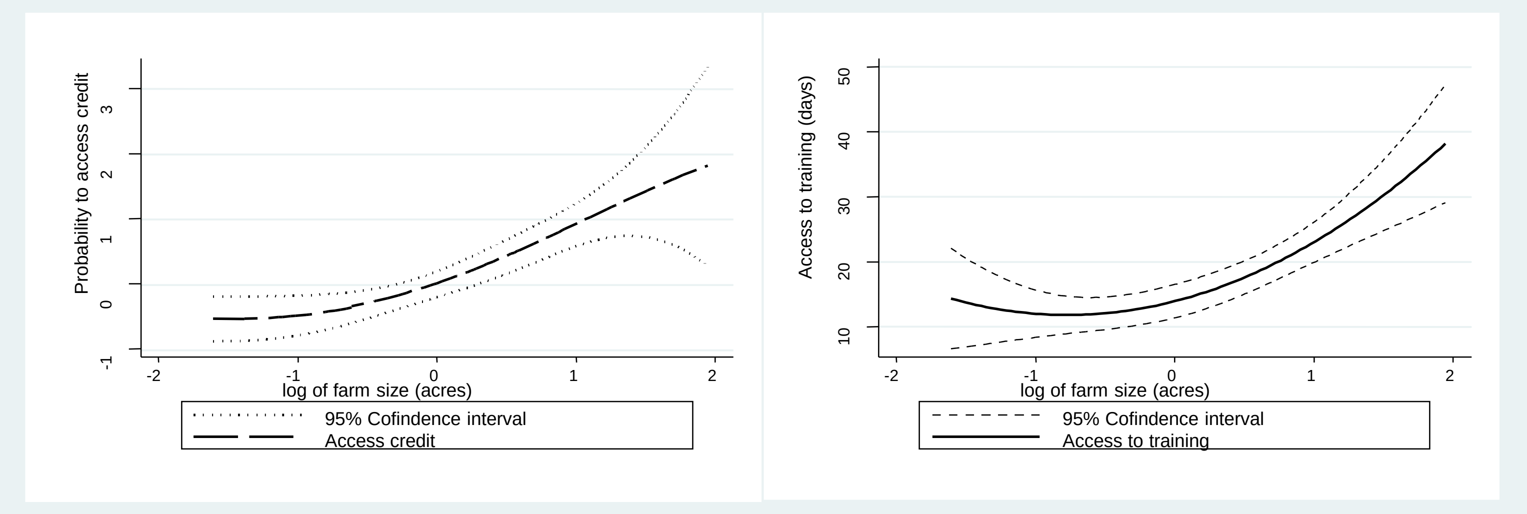

Fractional polynomial prediction with probit model of access to credit on farm size, and quadratic prediction of number of days of training in fish farming on farm size

we observed from field that farmers with small farm size not only faced credit constraints but also had limited access to fish farming training services.

This suggests that unless farmers with small farm size gain access to productivity enhancing services like credit, training, they may be less efficient in the short-run and hence less sustainable. Above figure confirms this conjecture.

The probability to access credit increases with increasing farm size and that farmers holding relatively large farm sizes have better access to training services than farmers holding small farm sizes.

Concluding remarks

- Feed is the most important component of pangas production and pangas fish farming is profitable.
- Labour, feed and capital (investments) significantly increase the mean production.
- Increasing use of capital and feed have a risk reducing effect, while fingerlings have risk increasing effect.
- Access to credit could also reduce the risk among the farmers who receives credit if the money is spend on risk-reducing inputs, such as, feed, capital and extension service.
- Inverse relationship is not applicable to pangas farming in Bangladesh i.e. large farmers are more productive and efficient.

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Concluding remarks

- Both efficiency and farm size significantly increase with increasing experience in fish farming, and efficiency increases with increasing farm size.
- In addition, large farm has better probability to access credit and training- these indicating that large farm might sustain in the long run.
- Bangladesh government should take more initiative to provide loans especially for small scale fish farmers that are not able to pay high interest rate or have less collateral and provide extension service for small scale farmers to promote pangas fish farming in Bangladesh.

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