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Supply Response of Pond Fish in District Mardan Khyber Pakhtunkhwa Pakistan

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ABSTRACT

The paper estimates the supply response of pond fish in district Mardan using normalized profit function. The study is based on the survey data collected from one hundred and twenty pond fish farmers randomly selected in district Mardan, Khyber Pakhtunkhwa, Pakistan. It was found that the feed price, wage rate, fingerlings price, pond rent, generator fuel price affect pond fish supply negatively. Pond area had a significantly positive effect on the fish supply. Furthermore, age of the fish farmers was not a significant factor in determining the fish supply. The study recommends more emphasis on proper fish management, use of their own fields feed for fish and promoting fish farming as a small enterprise to generate additional income for the farmers.
KEY WORDS: Pond fish, Canal water, Normalized profit function, Pond fish supply

INTRODUCTION

Fish is a very good source of low fat protein in human nutrition as compared to other meat sources (World Fish Center, 2003). The Supply and production of different fish species through fresh water and aquaculture for protein is being encouraged both in developed and developing countries. Fish meat is a healthy diet because it contains carbohydrate, unsaturated fat contents and a good source of Omega-3 fatty acids (Choo and Williams, 2003; Yildrim et al. 2008).

In Pakistan, total marine and inland fish production was estimated to be 514,500 metric tonnes in the year 2014 out of which 349,500 metric tonnes was marine production and the remaining catch came from inland waters (GoP, 2014). Pakistan exports one-quarter of its fishery products contributing about 1.1 percent to the total exports (GoP, 2010). In 2014, a total of 103,833 metric tonnes of fish and fish products were exported resulting in earnings of US$ 253.1 million. Fish consumption pattern shows that about 40 percent of the total fish is locally consumed, about 35 percent small non-edible fish is converted into low quality fish meal to supplement the poultry feed, about 10 percent salted and dried and 15 percent shrimps and fish are frozen for export purposes (GoP, 2013).

Semi-intensive pond fish farming techniques are widely adopted in Pakistan whereby fish farmers use fields grass, grains of various crops, animal manure, poultry manure and agricultural byproducts as fish feeds in ponds (Wasim 2007). Catfish raised through the intensive systems that is, in inland tanks or channels and are cultured for food and for commercial purposes in Nigeria (Amos 2013). In USA, catfish is formed in multi-batch system and stocked in different sizes of catfish in the same ponds. ensuring the availability of food-size fish throughout the year (Nguyen 2010).

The coastal areas of Sindh and Baluchistan are popular for supply of marine fish accounting for 60 percent of the total production of fish and shrimps in the country. The importance of pond fish in Pakistan has recently gained momentum contributing about 40 percent to the fish supply. Pond fish farming can be carried out in all the provinces of the country (Agriculture Statistics of Pakistan, 2013).

Pond fish farming exists in Pakistan in various forms depending on the availability of water and quality of land. Ponds are made on the surface of land called embankment. Some ponds are excavated while others are constructed on the stream referred to them as contour. All ponds have inlets and outlets for water inflow and out flow for water (Bard et al., 1976).

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Pond fish farming is basically the raising of fish naturally in controlled ponds. These ponds are in square and rectangle shapes with a slope ranging from one meter to two meters in length. Water from different sources are stocked in early days of March. Family and hired labors are widely employed in the pond fish farming. Fish is harvested after nine to twelve months. Fish production is a decent source of food, income and employment in rural areas of most of developing nations of the world (Carballo et al., 2008). In Mardan pond fish farming is done over more than 600 acres of land. Various fish species such as Rohu, silver, Morvi and grass are inhabitants in many agricultural and saline land of rural areas. Pond fish farming is usually combined with agriculture, lives stocks and poultry forms. It is a main source of income, food and recreational for the rural villagers (Fisheries Department Mardan, 2014).

In polyculture type of fish farming more than one fish species are produced in the same pond while in monoculture only one fish species in pond. Majority of common carp of different species are raised in deep pond of large sizes. Farmers use many species in one pond because of consumers varying preferences. For example Grass carp eat water plants, Silver carp phytoplankton, Black carp eat Molluses and Mud carp eat detritus on pond bottom. Polyculture may save time and resources of pond fish farmers. (Miah et al. 1993; Azad et al. 2004; Jena et al. 2007).

A large body of literature is available relating to supply response of agriculture crops and livestock. These is a dearth of studies concerning the supply response of pond fish to the price and other seasonal conditions. The present study aim at to analyze the fish supply response function to the market price and other seasonal variables. The ponds fish farming contributes the largest share of fish to the local market of Khyber-Pakhtunkhwa (Nasim 2010). Fish farmers are facing many problems such as increasing cost of production, unavailability of proper market for fish supply, lack of storage facilities and low prices of output in local market, seasonal variations. An analysis of this kind of problems requires knowledge of pond fish supply. However, estimates of the pond fish supply, to date, are inconsistent, unreliable, and in most cases generate insignificant and unstable coefficients (Waseem, 2007: Kouka and Engle, 1998). Therefore, this study aims to estimate the fish supply function not only to examine the economic factors but also many other socioeconomic factors on the supply of fish in district Mardan. Furthermore, this study will study the general characteristics of pond fish farming in different ecology, estimate cost and return from pond fish farming in district Mardan, examine different determinants of farmers profit from pond fish farming and investigate factors affecting the supply response of pond fish in district Mardan.

MATERIALS AND METHODS

Theoretical Model and Estimation

Given a set of technology, firms maximize profits. Let's assume a single output and multiple inputs such that:

$$Q_i = f(X_1, X_2 \cdots\cdots, X_n; Z_1, Z_2 \cdots\cdots, Z_m) - - - - - - - - - - - - - - - - (1)$$

Where Q_i *is* ith fish farm's output, X_n are variable inputs, *and* Z_m are fixed inputs. The short-run profit is equal to gross revenue minus variable cost as given under

$$\pi_i = p.f(X_1, X_2 \cdots\cdots, X_n; Z_1, Z_2 \cdots\cdots, Z_m) - \sum_i^n w_i X_i - vZ_m - - - - - - - - - - - - (2)$$

Where, π_i is the profit, p is product price, w_i is the vector of input prices and v is per unit cost of fixed capital. Profit function is non-decreasing in output price (p), non-increasing in input prices (w), homogenous of degree one and convex in output and input prices (Varian 1992). In order to accomplish these properties the profit function is normalized (Jorgenson and Lau, 1974). The normalized profit function is obtained by dividing the profit equation (2) by product price (p):

$$\pi_i/p = f(X_1, X_2 \cdots\cdots, X_n; Z_1, Z_2 \cdots\cdots, Z_m) - \sum_i^n \frac{w_i}{p} X_i - vZ_m - - - - - - - - - - - (3)$$

$$\pi^* = f(X_1, X_2 \cdots\cdots, X_n; Z_1, Z_2 \cdots\cdots, Z_m) - \sum_i^n w^* X_i - vZ_m - - - - - - - - - - - - (4)$$

Where π^* is the normalized profit function and w^* is a vector of output prices (p) and weighted inputs prices vector.

Supply function can be obtained by applying Hoteling's Lemma.

$$\frac{\partial \pi^*}{\partial p_i} = f(X) -(5)$$

Where X is the matrix of inputs

For empirical purposes, we write the general function as follows:

$$ln\pi^* = lnA^* + \gamma_1 lnw_L + \gamma_2 lnp_F + \gamma_3 lnp_f + \gamma_4\, lnp_F + \gamma_5 lnp_l + \gamma_6 lny_s + \gamma_7 lny_a + \gamma_8 lnd + \sum_{i=1}^{5} \delta_i\, D_i + \mu \ (6)$$

where π^* is the normalized profit, w_L is the normalized wage rate, p_F is the normalized fingerling's price, p_f is the feeds price, p_l is the fields feed price normalized by output price, d is the distance of pond from the markets, p_F is the fertilizer quantity in kilogram normalized by output price, y_s and y_a are the farm area and farmers age respectfully and $D_i$are the dummy variable if the Pond water and pond land.

More specifically, The following supply function is used for estimation after applying *Hoteling's Lemma* in equation (5).

$$lny = lnA + \beta_1 lnw_L + \beta_2 lnp_F + \beta_3 lnp_f + \beta_4 lnp_F + \beta_5 lnp_l + \beta_6 lny_s + \beta_7 lny_a + +\beta_8 lnd + \beta_9 lnp_F + \beta_{10} lnf_p + \sum_{i=1}^{5} \delta_i\, D_i + \mu \quad \text{---} (7)$$

where y is the fish output in kilograms (kg), w_L is the wage rate wage rate in rupees (Rs.), p_F is the fingerlings price in rupees, p_F is the feeds price, f_p is the fish price per kilogram p_l is the fields feed price, d is the distance of pond from the markets in kilometers, p_F is the fertilizer quantity in kilogram, y_s and y_a are the farm area and farmers age respectfully and $D_i$are the dummy categorical variables for Pond water and pond land.

Data

Data has been collected from 120 pond fish farmers randomly selected from district Mardan, Khyber Pakhtunkhwa. A questionnaire was designed to collect information about pond fish farmer's behavior, pond fish production techniques, and selected socio-demographic characteristics from the fish producers. The Questionnaire was pre-tested and edited accordingly.

RESULTS AND DISCUSSION

Socio-Economic Characteristics of Fish Farmers

Table 1 shows association of water types with different variables. In the study area canals, tube wells and stream water are widely used in pond fish farming. Streams water are low cost as compare to canals water and wells water. Pond slope, water erosion, and region are significantly associated with water types. Pond slops are high in the canal and stream water as compare to tub well water. There is no erosion in the ponds using stream water and is relatively more in the ponds using both canal, and tub well water. The study area was divided into four regions that is Mardan Khass, Takht-Bhai, Katling and Lund Hurd region. Regions have significant relationship with water types. Ponds using stream water are associated with the region Lund Hurd and Katling area. Most of the ponds are using canal water in all region. The shallow end usually of two to three feet and deep end may be from three to five feet in length. Shallow end and deep end are significantly association with canal water, both ends canal water are keep maximum ranges from three feet to five feet. Labor types are significantly associated with canal water. Pond fish farmers who used canal water hire more labor as compared to the farmer uses tub well and stream. Water erosion, deep end and stir month are insignificant with water types. Plants produce oxygen inside the pond water in the presence of sun lights. During winter and heavy clouds sun lights on the water surface reduces. Shortage of oxygen may cause fish death in pond. The fence around the pond is very important to protect the children from falling into the pond and reduce the chances of fish stooling. Pond dike around the pond is also important because it protect the inflow run off water and outflow of the pond water from the pond. Usually the dike is made by clay and mud. The pond dike made with sandy and rocky soil may cause leakage of water from pond.

Table 1: Pond Fish Farmer's Characteristics in Different Water Ecological Systems

		Canal	Tube well	Both	Stream	All	Chi-Square
Fish farming methods	Extensive	(2.5)	2(1.7)	5(4.2)	0(0.0)	10(8.3)	6.386(0.381)
	Simi Extensive	8(31.7)	7(5.8)	42(35.0)	16(13.3)	103(85.8)	
	Intensive	(3.3)	0(0.0)	3(2.5)	0(0.0)	7(5.8)	
Region	Mardan Khass	(5.8)	2(1.7)	20(16.7)	0(0.0)	29(24.2)	
	T-Bhai	6(13.3)	4(3.3)	14(11.7)	1(.8)	35(29.2)	

	Lund Hurd	(6.7)	3(2.5)	10(8.3)	7(5.8)	28(23.3)	29.675(0.000)
	Katlang	4(11.7)	0(0.0)	6(5.0)	8(6.7)	28(23.3)	
Pond slope	One meter	0(25)	3(2.5)	34(28.3)	8(6.7)	75(62.5)	14.50(0.025)
	One and half	(7.5)	6(5)	7(5.8)	4(3.3)	26(21.7)	
	Two meter	(5)	0(0)	9(7.5)	4(3.3)	19(15.8)	
Pond diversion	Embankment	(5)	1(0.83)	12(10)	3(2.5)	22(18.33)	4.50(0.599)
	Excavated	3(27.5)	8(6.67)	35(29.17)	11(9.17)	87(72.5)	
	Contour	(5)	0(0)	3(2.5)	2(1.67)	11(9.17)	
Water replace	Evaporation	4(36.67)	9(7.5)	47(39.17)	15(12.5)	115(95.83)	4.098(0.663)
	Seepage	(0)	0(0)	1(0.83)	1(0.83)	2(1.67)	
	Leakage	(0.83)	0(0)	2(1.67)	0(0)	3(2.5)	
Erosion	Yes	1(9.17)	3(2.5)	31(25.83)	0(0)	45(37.5)	25.745(0.000)
	No	4(28.33)	6(5)	19(15.83)	16(13.33)	75(62.5)	
Shallow End	Two feet	(1.67)	0(0)	1(0.83)	0(0)	3(2.5)	12.282(0.056)
	Three feet	0(25)	9(7.5)	38(31.67)	7(5.83)	84(70)	
	Four feet	3(10.83)	0(0)	11(9.17)	9(7.5)	33(27.5)	
Deep End	Four feet	3(10.83)	0(0)	11(9.17)	9(7.5)	33(27.5)	18.142(0.006)
	Five Feet	8(23.33)	9(7.5)	39(32.5)	7(5.83)	83(69.17)	
	Six feet	(3.33)	0(0)	0(0)	0(0)	4(3.33)	
Water Turbidity	High	(5)	2(1.67)	6(5)	4(3.33)	18(15)	3.388(0.759)
	Moderate	0(16.67)	2(1.67)	20(16.67)	5(4.17)	47(39.17)	
	Low	9(15.83)	5(4.17)	24(20)	7(5.83)	55(45.83)	
Labor type	Hire labor	1(25.83)	4(3.33)	44(36.67)	5(4.17)	84(70)	21.98(0.000)
	Fem labor	4(11.67)	5(4.17)	6(5)	11(9.17)	36(30)	

Source: Author's own calculations from survey data. The parenthesis shows percent of total.

Table 2 shows association of pond diversions with the different variables. Fish farming methods, pond slope, water replacement and shallow end are significantly associated with pond diversions. Three methods of fish farming are usually used in pond fish farming. These are extensive, semi-intensive and intensive. In extensive fish farming, low cost labor inputs as well fertilizers are generally used to increase fertility and thus fish production. Semi-intensive fish farming employ a moderate level of labor inputs, fertilizer and supplementary feeding. Sixty four percent of the total ponds used semi-intensive fish farming in excavated ponds as compared to embankment and contour fish ponds.

Canal and rain water may contain dissolved substances and dirt. The presence of these particles in pond water is usually a sign of water turbidity and pond water show a brown color. High amount of dissolved particles in water indicate high turbidity, a low amount of particles show moderate turbidity and very low amount of particles show low turbidity in pond water. High turbidity reduces the sun lights, production of oxygen in pond water and cause harm to fish gills as well as reduces the fish productivity. Turbidity of water is significantly high if pond diversion is embankment. On the other hand, if farmers used excavated pond or contour type water turbidity is moderate and low. One meter of pond slope has significant association with excavated pond and fifty one percent of the excavated ponds had one meter slope. Evaporation, leakages and seepages reduced the water level and caused shortage of pond water. Water shortage was a serious problems affecting water nutrition and fish growth of pond badly. The evaporation is a serious problems in fish farming. Evaporation take place in all kinds of ponds and are significantly high in excavated and embankment as compare to contour type of ponds. The pond water has different depth at the shallow end and at the deep end. The shallow end is of two to three feet and deep end may be from three to five feet in length. The water from this type of pond is easily drained with a little efforts and low cost of drainage. Three to five feet shallow end are significantly associated with excavated and embankment ponds.

Table 2: Association of Pond Diversions with Different Pond Fish Farming Variables

		Embankment	Excavated	Contour	All	Chi square
Fish farming methods	Extensive	6(5)	4(3.3)	0(0)	10(8.3)	14.041(0.007)
	Simi Extensive	16(13.3)	77(64.2)	10(8.3)	103(85.8)	
	Intensive	0(0)	6(5)	1(0.8)	7(5.8)	
Regions	Mardan khass	40(3.3)	23(19.2)	3(2.5)	29(24.2)	3.08(0.799)
	Takht-Bhai	8(6.7)	25(20.8)	2(1.7)	35(29.2)	
	Lund Hurd	4(3.3)	21(17.5)	3(2.5)	28(23.3)	
	Katlang	6(5)	18(15)	3(2.5)	28(22.3)	

Water Erosion	Yes	9(7.5)	32(26.7)	4(3.3)	45(37.5)	0.134(0.935)
	No	13(10.8)	55(45.8)	7(5.8)	75(62.5)	
Shallow End	Two feet	0(0)	2(1.7)	1(0.8)	3(2.5)	8.259(0.083)
	Three feet	15(12.5)	65(54.2)	4(3.3)	84(70)	
	Four feet	7(5.8)	20(16.7)	6(5)	33(27.5)	
Deep End	Four feet	7(5.8)	20(16.7)	6(5)	33(27.5)	5.421(0.240)
	Five feet	14(11.7)	64(53.3)	5(4.2)	83(69.2)	
	Six feet	1(0.8)	3(2.5)	0(0)	4(3.3)	
Stir month	December	8(6.7)	37(30.8)	2(1.7)	47(39.2)	2.731(0.604)
	July	9(7.5)	30(25)	5(4.2)	44(36.7)	
	Dec and July	5(4.2)	20(16.7)	4(3.3)	29(24.2)	
Turbidity of water	High	0(0)	16(13.3)	2(1.7)	18(15)	12.499(0.014)
	Moderate	5(4.2)	36(30)	6(5)	47(39.2)	
	Low	17(14.2)	35(29.2)	3(2.5)	55(45.8)	
Pond Slop	One meter	9(7.5)	61(50.8)	5(4.2)	75(62.5)	9.429(0.051)
	One and half m	6(5)	16(13.3)	4(3.3)	9(21.7)	
	Two meter	7(5.8)	10(8.5)	2(1.7)	19(15.8)	
Water Replace	Evaporation	17(14.2)	70(58.3)	5(4.2)	92(76.7)	8.023(0.091)
	Seepage	4(3.3)	9(7.5)	4(3.3)	17(14.2)	
	leakage	1(0.8)	8(6.7)	2(1.7)	11(9.2)	

Source: Author's own calculation from survey data. Values in parenthesis show percent of total.

Table 3 presents results of the estimated normalized profit function. Prices of variables inputs such as fertilizer, fields feed, fingerlings, generator fuel and labor prices have a negative effect on pond fish profit. A one percent increase in fertilizer price would lead to nine percent reduction in fish profit, while one percent increase in the price of labor would lead 94.8 percent reduction in fish profit, ceteris paribus. Fields feed and fingerlings prices have (-0.191), (-0.058) elasticities. It show a significant and negative effect on the fish profit. These elasticities indicate that among all inputs, the productivity of labor in pond fish production is significantly high. This is likely to reflect that labor is costly compared to the fertilizer. While pond size has positive and significant effect on the pond fish profit with elasticity of 1.536.. Water types has significant positive effect on the average profit of the ponds. The dummies of water types also show that the average profit of the fish farmer will be greater if using both types of water than those using only canal or tube well water. The R-square value is 37 which is not uncommonly low when using cross-sectional data.

Table 3: Parameter Estimates of Normalized Profit Function of Pond Fish Farming

Variables	Coefficient (Prob.)	Std. Error	t-value
(Constant)	-6.607 (0.282)	6.105	-1.082
Log of normalized Feed price	-1.661 (0.308)	1.622	1.024
Log of normalized Fertilizer price	-0.099 (0.931)	1.139	-0.087
Log of normalized Field Feed price	-0.663 (0.051)	0.335	-1.977
Log of normalized wage rate	-0.948 (0.048)	0.474	-1.997
Log of normalized Fingerlings price	-0.191 (0.831)	0.895	-0.214
Log of normalized pond rent	-0.083 (0.894)	0.617	0.134
Log of normalized generator price	-0.850 (0.458)	1.141	-0.745
Log of distance	-0.747 (0.007)	0.272	-2.75
Log of pond size	1.536 (0.001)	0.46	3.337
Log of age	0.409 (0.293)	0.387	1.057
Canal water	0.674 (0.029)	0.304	2.214
Tube well water	0.516 (0.259)	0.455	1.136
Both(canal Tube well)	0.904 (0.070)	0.493	1.832
Erosion	-0.375 (0.091)	0.22	-1.704
Agriculture land	0.064 (0.733)	0.186	0.342
R-squared 0.37	Observations:120		F- 4.17 (0.00)

Source: Author's own estimation from survey data.

Table 4 indicates a supply response of the fish to various economic factors. All the input prices have the negative sign with the supply and is according to economic theory although statistically insignificant. Pond size has a statistically positive significant on the fish supply. Market access measured by distance, pond rent, wages rate have all negative relationship and statistically significant. The most important fixed input in terms of pond fish supply response is area of land (elasticity of (0.486). This suggests that fish supply would expand by about 48% if land area under pond fish were to increase by 10 percent. The own-price elasticity of pond fish supply is positive as expected and is consistent with theory. A 10 % increase in the fish price would result into a 2.9 percent increase in the supply of fish, holding the prices of the variable inputs and the quantities of the fixed inputs constant. Pond fish supply is also responsive to market access measured through distance to markets (elasticity of -0.215). Fish farmer age has no effect on the fish supply in the study area.

Table 4: Parameter Estimates of Supply Function of Pond Fish Farming

Variables	Coefficients (Prob.)	Std. Error	t-value
Constant	2.983 (0.185)	2.236	1.334
Log of fields feed price	-0.019 (0.873)	0.117	-0.160
Log of feed price	-0.335 (0.390)	0.388	-0.863
Log of generator price	-0.002 (0.858)	0.014	-0.180
Log of fertilizer price	-0.131 (0.430)	0.166	-0.792
Log of pond size	0.486 (0.000)	0.060	8.159
Log of distance	-0.215 (0.000)	0.036	-5.909
Log of wage rate	-0.249 (0.000)	0.064	3.882
Log of pond rent	-0.220 (0.010)	0.083	2.636
Log age	0.044 (0.409)	0.053	0.829
Canal water	0.066 (0.112)	0.041	1.601
Tube well water	0.051 (0.419)	0.062	0.811
Both (canal tube well water)	0.067 (0.304)	0.065	1.032
Agriculture land	0.010 (0.699)	0.026	0.387
Erosion of water	-0.038 (0.214)	0.030	-1.249
Log of fish price	0.029 (0.893)	0.212	0.135

Conclusions

In this research, it was examined as to how responsive pond fish supply is to price and non-price factors using the normalized profit function. The study used cross-sectional farm-level primary data for 2014/2015 cropping year collected from 120 pond fish farmers in district Mardan. The empirical analysis of pond fish profit and supply yielded satisfactory results according to economic theory. The coefficients of normalized profit function and supply such as fertilizer price, fields feed price, wage rate, distance from the markets and water erosion have negative association at 95 percent level. In case of fixed inputs, pond area was found to be the most important factor that effects the pond fish supply positively. While, agriculture land and age of the farmer had no association with the fish supply significantly.

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