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Economic Analysis of Modern Technologies in Shrimp Farming: A Case Study from Karnataka State

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Abstract

The modern technologies such as air oxi tubes, pond lining and biofloc technology have evolved as a feasible solution to solve predicaments such as poor feed conversion ratio and undesired concentration of dissolved oxygen. The study attempts to quantify the economic benefits realized by shrimp farmers on adoption of modern technologies. For the study, three innovative farmers who have adopted modern technologies were selected from Udupi district of Karnataka and their performance was compared with ten farmers practicing conventional method. The shrimp farming with modern technologies required an initial capital investment of Rs. 13.06 lakh which is 91.63 % higher compared to conventional method (Rs.6.82 lakh). The cost benefit analysis of shrimp farming indicated that farmers realized net returns of Rs. 154.79 kg^{-1} which is 54.83% higher compared to conventional method (Rs. 99.97 kg^{-1}). The economic benefit of modern technologies per acre per year came to Rs. 32.64 lakh reflecting the worthiness of modern technologies. Adoption of such technologies on wider scale will have a win win situation i.e., generating enough returns on one hand and meeting exacerbating demand on other hand.

Keywords: Biofloc, air oxi tube, partial budgeting

Introduction

Adoption of biofloc technology is found to be cost effective, sustainable and environment friendly (Jena, 2017). Biofloc is a technology which aims at increasing feed use efficiency in shrimp farming. It acts as a stimulant in the process of assimilation of unused inorganic nitrogen in the feed as well as feces sediment at the bottom of pond by heterotrophic bacteria. These bacteria will flocculate organic matter, microorganisms and suspended solids to form biofloc (Rathore et al., 2016). The maintenance of desired concentration of dissolved oxygen is considered as other major problem. Its concentration is usually lower during cloudy weather than clean weather. This may cause sudden death of phytoplankton leading to low levels of dissolved oxygen. Through water exchange, excessive phytoplankton and microbial metabolites could be flushed out, but this practice does not greatly improve dissolved oxygen concentration in ponds. The concentration of dissolved oxygen depletes during night hours which is not congenial for shrimp growth. Hence, the maintenance of desired concentration of dissolved oxygen is indispensible. Its insufficient supply may cause loss of appetite, susceptibility to diseases, reduced feed conversion ratio, high mortality and low production. The maintenance of desired concentration of dissolved oxygen is achieved through mechanical aeration (Nunes & Nusig, 2006). Mechanical aeration is applied to aquaculture ponds to enhance the supply of dissolved oxygen, prevents dissolved oxygen depletion at night and circulates oxygenated water over the pond bottom. It improves pond water quality, bottom soil conditions, enhances survival, growth, feed efficiency, increases production potential, increases ability of pond to assimilate wastes, reduces water exchange and pollution loads in pond effluents. The usual practice of mechanical aeration in earthen ponds is through paddle wheel aerators which are fraught with technical constraints such as non operation during feeding, formation of air bubbles of undesired size, more power consumption and noise pollution. To overcome these problems, adoption of air oxi-tube system is preferred. The present study attempts to analyze the economic benefits of adoption of biofloc technology and air-

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oxi tube system of mechanical aeration in shrimp cultivation.

Materials and Methods

Biofloc, air oxi tube system of aeration and pond lining are integrated technologies adopted by few innovative farmers in the study region and hence have been considered as modern technologies for the study. To assess the economic impact of these technologies in shrimp farming, three innovative farmers who have adopted all these technologies were selected from Udupi district of Karnataka state as the number of such farmers were not many. To examine the extent of economic advantages that could be accrued to farmers on adoption of modern technologies, a sample of ten farmers practicing shrimp farming with conventional method were selected as control from the same location. The data on capital investment, labour use pattern, materials, output realized was elicited from farmers for the agricultural year 2016-17. The enterprise budgeting technique was used to assess profitability of shrimp farming. Partial budgeting technique was used to estimate the economic impact of modern technologies in shrimp farming over conventional method. To arrive at variable costs, quantity of variable resources used and market prices of respective resources was considered. In case of fixed cost, to account for depreciation, straight line method was used. Information on purchase price, junk/salvage value and useful life of the assets were elicited from farmers and used in estimation of depreciation. Straight line method= ((Purchase price-Junk value) /Useful life year of the asset). Interest on working and fixed capital was worked to cost account opportunity cost of capital considering prevailing market interest rate levied by commercial banks. The modern technology enabled farmers to take up three crops in a year each of duration 90-100 days across three seasons. Accordingly, cost benefit analysis was worked out across seasons. While, conventional method enabled farmers to take up two crops in a year, for which accordingly cost benefit analysis was performed.

Results and Discussion

The capital investment made on shrimp farming with modern technologies was compared with conventional practice and presented in Table 1. The total investment made on shrimp farming per acre with modern technologies came to Rs. 13.06 lakh while it was Rs.6.82 lakh on conventional practice, the investment in modern technologies being 91.63% higher than conventional methods. The pond being a prerequisite for shrimp farming accounted for 5.74% of the total investment in case of modern farm and 11.01% in conventional practice. The pond was covered with HDP UV geomembrane lining material accounting for 22.97% of the expenditure in case of modern farms. Lining of ponds prevents seepage of ions, enables easy surveillance of shrimp growth and disease incidences, reduces threat from external predators such as crab, eases harvesting operation and reduces frequency of water exchange. Pond lining was not observed in case of conventional method which posed threats from predators like crab. To overcome this, an expenditure of Rs.9000 was made towards creation of crab fencing all along the pond walls with dimension of 4 ft width and 4 ft height.

Aeration system practiced on modern farms differed from conventional farms. It formed a major item of expenditure at 37.9% in case of modern farms and 31.18% in conventional farms. Aeration system on modern farms comprised of membrane diffusers, air-oxi tubes and air blower of 10 hp capacity. Air-oxi tube system employs an air blower to force air through fine bubble diffusers positioned on or near the pond bottom. They form the bubbles of desired size and enhance the concentration of dissolved oxygen leading to proper growth of shrimps. On conventional farms, paddle wheel aerators were employed to create mechanical aeration. The aeration paddles required relatively more power to create oxygenation than air-oxi tube system. The bubbles created by the system are of larger size having lesser surface area limiting the extent of oxygenation. The sound emanating from the system is relatively more compared to air oxi tube system creating noise pollution.

In order to ensure continuous aeration from 40th day of stocking to harvest in conventional method, generator of 15 kv capacity was used (36.68% of total investment). A power back up facility was used to ensure continuous aeration on modern farms which accounts for only (7.66% of total investment).

On conventional farms, due to peripheral placement of paddle aerators in pond, the unused feed, feces and other suspended solids settle at the centre due to circular motion created by the aerators. To drain out these, shrimp toilet of 5-6 m diameters and 1 m depth was created at the centre of pond. Later, using slurry pump of 5 hp capacity, wastes were

Table 1. Capital investment on shrimp farming using modern and conventional technologies

Particulars	Modern			Conventional		
	Qty (No.)	Rate	Value (Rs.)	Qty (No.)	Rate	Value (Rs.)
1) Pond creation			75000 (5.74)			75000 (11.01)
2) Pond lining			300000 (22.97)			
3) Mechanical aeration						
Air blower of 10 hp capacity	2	125000	250000 (19.14)			
PVC pipes + other fittings + Labour charges			45000 (3.45)			
Membrane diffusers	75	1000	75000 (5.74)			
Airoxi tubes (mts)	200	500	100000 (7.66)			
Labour charges	50	500	25000 (1.91)			
Pedal wheels				5	35000	175000 (25.68)
Cable				600	50	30000 (4.40)
Starter				5	1500	7500 (1.10)
4) Pump and motors						
Diesel engine of 10 hp capacity	1	50000	50000 (3.83)			
5 hp pump set to lift and drain water	2	18000	36000 (2.76)	2	18000	36000 (5.28)
Slurry pump			20000 (1.53)			20000 (2.93)
5) Water conveyance structure			22000 (1.68)			
6) CFL bulbs			8000 (0.61)			4000 (0.59)
7) Shed			150000 (11.49)			
8) Electrification charges (15 KV)			100000 (7.66)			250000 (36.68)
9) Cat walk & check trays			10000 (0.77)			10000 (1.47)
10) Nylon fishing net			40000 (3.06)			
11) Sluice gate						50000 (7.34)
12) Fencing						
Crab fencing						9000 (1.32)
Bird fencing						5000 (0.73)
13) Shrimp toilet						10000 (1.47)
Total			1306000			681500

drained from the pond. This reduces the frequency of water exchange and economizes shrimp farming through reduction in pumping cost.

The other expenditure on modern farms included construction of cat walk at the borders to facilitate feeding and inspection operations, a shed, fishing nets and 5 hp motor to pump water into the pond, lighting arrangements with CFL bulbs to enable watch and ward during night hours and water conveyance structure to facilitate inlet of water into the pond. On conventional farm, the other items of expenditure included sluice gate to pump sea water into the pond. The same gate served as an outlet to drain out turbid pond water at the time of water exchange. Two pumpsets of 5 hp capacities were employed to pump sea water into the pond.

The details of cost of shrimp farming with modern and conventional technologies is presented in Table 2. The modern technologies enabled farmers to take up three crops while conventionally only two crops are practiced. The total cost of shrimp farming inclusive of variable and fixed cost per acre per year came to Rs.54.58 lakh in case of modern farms whereas it was Rs. 19.56 lakh on conventional farms. Of this, variable cost came to Rs. 50.76 lakh (93.02%) and fixed cost came to Rs. 3.81 lakh (6.98%) on modern farms. In comparison, it was Rs. 17.6 lakh (90.01%)and Rs. 1.95 lakh (9.99%) on conventional farms (Table 2).

The expenditure on feed was the major constituent of total variable cost at 53.02% and 41.87% in modern and conventional farms, respectively. Commercial feed, a rich source of protein and carbohydrates was fed to shrimps @ 2 kg per 1 lakh fingerlings during first month. Later, quantity was increased at the rate of half a kg every day. From subsequent months, the quantity of feed to be provided will be decided using check trays (Ahamad Ali, 2006). When shrimp attains the age of 60 days, feed placed in check trays will be increased to 5 gm and duration will be reduced to 1.5 h. The feed conversion ratio usually ranges between 1.4:1 to 1.8:1. Due to biofloc technology on modern farms, feed conversion ratio of 1.3:1 was attained while it was 1.4:1 on conventional farms. Poor feed conversion ratio increases cost of production. Consumption of bioflocs by shrimps reduces feed conversion ratio and improves feed use efficiency. The effectiveness of biofloc technology depends on the CN ratio. The desired CN ratio for effective functioning of heterotrophic bacteria is more than 20 (Schryver et al., 2008). The commercial feed used in shrimp farming possesses CN ratio of 10, which is not sufficient to stimulate the activity of bacteria. Hence, to stimulate bacteria, widening of CN ratio was indispensable and was attained through application of carbon rich source as supplemental feed. Rice bran and sugar were added to the pond as a source of carbohydrate to widen CN ratio and to activate heterotrophic bacteria (Liu et al., 2014).

The expenditure on fingerlings of *Litopenaeus vannamei* formed 13.85% of the total cost on modern farms and 8.59% on conventional farms. About 1140 mandays of labour was required to perform feeding, cleaning and supervision operations in shrimp farming on modern farms while it was 564.56 mandays on conventional farms. The total expenditure made on labour came to Rs. 6.89 lakh and Rs. 2.82 lakh in modern and conventional farms.

Calcium and magnesium are the divalent cations whose concentration in pond water decides alkalinity and hardness (Krishnani et al., 2006). They are of immense importance in formation of exoskeleton in shrimps. Shrimp farms encountered imbalance of ionic ratios in pond water causing stress and cascading effect. The optimum ratio of Na:K (28:1) and Mg:Ca (3.4:1) is crucial. In order to maintain it, farmers practicing modern technologies applied mineral mixtures such as dolomite @ 300kg per crop per acre and magnesium chloride @ 200 kg per crop per acre. It was supplemented @ 10 kg per crop per year on modern farms. On conventional farms due to poor feed conversion, unused feed settled at the bottom along with feacal matter and other suspended solids. This layer of sediment created anaerobic condition by reducing the concentration of dissolved oxygen in bottom layer creating stress to the shrimps (Claude, 2003). Shrimps dwell in the bottom layer and feed on benthic organisms. The turbidity created in the pond reduced transparency, restricted penetration of light and inhibited microbial activity. Thus, farmers have to resort to frequent water exchange to maintain desired transparency and dissolved oxygen concentration for the better growth of shrimps. The desired level of transparency is 25-40 cm and dissolved oxygen is 5-7 ppm. The other possible way of overcoming anaerobic condition and increasing dissolved oxygen concentration is through application of probiotics. The quantity of probiotics used on conventional farms was four times that of modern farms at 128 kg $year^{-1}$.

Table 2. Comparative cost estimates of shrimp production

	Modern Value (Rs.)				Conventional Value (Rs.)		
I. Variable cost Particulars	1st Crop	2nd Crop	3rd Crop	Total	1st Crop	2nd Crop	Total
1) Seed	252000	252000	252000	756000 (13.85)	84000	84000	168000 (8.59)
2) Feed	780000	955500	1157813	2893313 (53.02)	378000	441000	819000 (41.87)
3) Labour	222000	229200	237500	688700 (12.62)	140000	142280	282280 (14.43)
4) Biofloc (Kg)							
Rice bran	9000	9000	9000	27000 (0.49)			
Sugar	4200	4200	4200	12600 (0.23)			
Dolomite	3000	3000	3000	9000 (0.16)			
Magnesium chloride	2000	2000	2000	6000 (0.11)			
Probiotics	20000	20000	20000	60000 (1.10)	76800	76800	153600 (7.85)
Mineral supplements					32000	32000	64000 (3.27)
Lime					7500	7500	15000 (0.77)
5) Electricity charges	120000	120000	120000	360000(6.60)	77950	77950	155900 (7.97)
6) Diesel	38000	30000	30000	98000 (1.80)			
7)Annual repairs	7200	5350	5350	17900 (0.33)	18500	16800	35300 (1.80)
8) Interest on working capital @12% for 3 months	43722	48908	55226	147855 (2.71)	32590	35133	67723 (3.46)
Total variable cost	1501122	1679158	1896088	5076368 (93.02)	847340	913463	1760803 (90.01)
II. Fixed cost							
1) Depreciation	58139	58139	58139	174416 (3.20)	31825	31825	63650 (3.25)
2) Interest o fixed capital @12%	52240	52240	52240	156720 (2.87)	40890	40890	81780 (4.18)
3) Leasing of land	16667	16667	16667	50000 (0.92)	25000	25000	50000 (2.56)
Total fixed cost	127045	127045	127045	381136 (6.98)	97715	97715	195430 (9.99)
Total cost	1628167	1806203	2023134	5457504	945055	1011178	1956233

Liming of pond is a prerequisite on conventional farms to neutralize soil acidity, increase alkalinity and total hardness concentration in water (Chakrabarti, 2017). An expenditure of Rs. 15000 was incurred on liming per year.

Among fixed cost component, depreciation formed 3.2% of the total cost on both the farms, interest on fixed capital formed 2.87 and 4.18% on modern and conventional farms, respectively. Rental value of land formed 0.92 and 2.56% of the total cost on modern and conventional farms.

In conventional method, partial harvesting was practiced to strike balance between biomass and mechanical aeration with existing capacity of paddle

Table 3. Profitability of shrimp farming

	Modern	Conventional					
Count	Value (Rs.) 1st Crop	Value (Rs.) 2nd Crop	3rd Crop	Total	1st Crop	2nd Crop	Total
100	230000	230000	230000	690000			
80	250000	250000	250000	750000			
70	300000	300000	300000	900000	150000	150000	300000
60	325000	325000	325000	975000	260000	260000	520000
50	1400000	2030000	2756250	6186250	350000	350000	700000
30					494000	722000	1216000
Total yield (t)	8	9.8	11.88	29.68	3.6	4.2	7.8
Gross returns (Rs.)	2505000	3135000	3861250	9501250	1254000	1482000	2736000
Total cost (Rs.)	1628167	1806203	2023134	5457504	945055	1011178	1956233
Net returns (Rs.)	876833	1328797	1838116	4043746	308945	470822	779767
Cost kg^{-1}				183.91			250.80
Net returns kg^{-1}				136.27			99.97

wheel aerators. It was performed at four counts such as 70, 60, 50 and 30. In comparison, on modern farms partial harvesting was done at five counts such as 100, 80, 70, 60 and 50. Annually farmers harvested one ton of prawn @ 0.5 t $crop^{-1}$ at 70^{th} count, 1.6 t @ 0.8 t $crop^{-1}$ at 60^{th} count, 2 t @ 1 t $crop^{-1}$ at 50^{th} count and entire biomass (3.2 t) at 30^{th} count in conventional method. While farmers practicing modern technologies harvested 12 t of prawn @ 3 t $harvest^{-1}$ at 100^{th}, 80^{th}, 70^{th} and 60^{th} counts and entire biomass at 50^{th} count (17.68 t). Inverse relation was observed between price and shrimp counts and shrimp counts and weight (Fig. 1 and 2). The gross returns realized per acre per year came to Rs. 27.36 lakhs on conventional farms while it was Rs. 95 lakhs on farms with modern technologies (Table 3). The cost incurred and net returns accrued per kg of shrimp came to Rs. 250.80 and Rs. 99.97 on conventional farms while it was Rs. 183.91 and Rs. 136.27 on modern farms. Net returns realized $kilogram^{-1}$ of shrimp on farms with modern technologies was 54.83% higher compared to conventional method.

To practice shrimp farming with modern technologies, an additional cost of Rs. 36.91 lakh was incurred on fingerlings, feed, labour, biofloc enrichers, electricity and diesel, interest on working capital, depreciation and interest on fixed capital. These technologies resulted in saving of costs on items such as probiotics, repairs and mineral supplements to the tune of Rs. 1.90 lakh. Additional returns of Rs. 69.55 lakh were accrued to farmers due to higher yields of 21.88 t (Table 4).

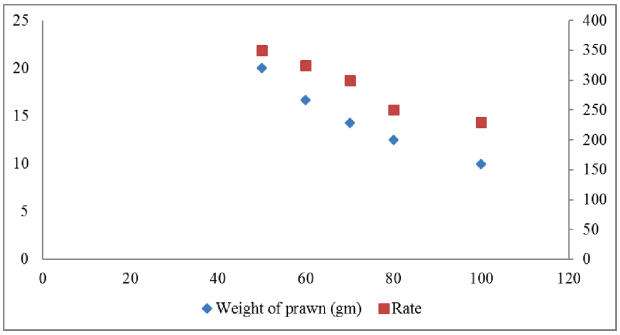

Fig. 1. Inverse relation between market price and shrimp counts and shrimp counts and body weight of shrimps

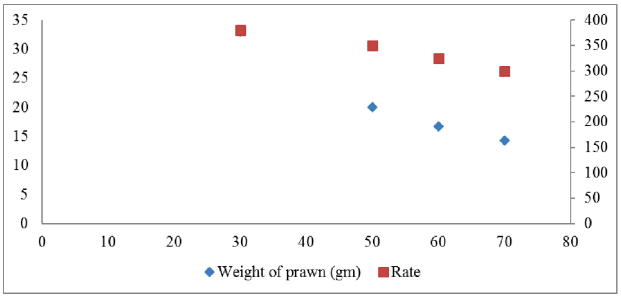

Fig. 2. Inverse relation between market price and shrimp counts and shrimp counts and body weight of shrimps

Table 4. Economic worthiness of modern technologies in shrimp farming (Rs./acre)

Added costs			Reduced costs		
Fingerlings	=	588000	Probiotics	=	93600
Feed	=	2074313	Annual repairs	=	17400
Labour	=	406420	Mineral supplements and lime	=	79000
Biofloc	=	54600			
Electricity charges	=	204100			
Diesel	=	98000			
Interest on working capital	=	80132			
Depreciation	=	110766			
Interest on fixed capital	=	74940			
Total added costs	=	3691271	Total reduced costs	=	190000
Reduced returns			Added returns		
Nil			On account of additional yield	=	Rs. 6765250
Debit	=	Rs. 3691271	Credit	=	Rs. 6955250
Economic worthiness of technologies				=	Rs. 3263979

Adoption of modern technologies demands skills in farmers. Farmers must have enough knowledge regarding maintenance of optimum level of heterotrophic bacteria and ammonia in pond water. Technology led production risks in shrimp farming constrain wider adoption of such technology. Financial risk is in the form of huge initial capital investment.

The present study assessed economic impact of modern technologies in shrimp farming over conventional method. The result indicated that, capital investment on modern technologies was 91.63% higher compared to conventional method. The cost benefit analysis of shrimp farming indicated that farmers realized 54.83% higher net returns compared to conventional practice. The economic worthiness of modern technologies per acre per year came to Rs. 32.64 lakh. Adoption of modern technologies not only brings revenue to the farmers but also protects environment from seepage effect and noise pollution. In order to meet the demand for shrimps, adoption of cost effective, highly profitable, eco and environmental friendly technologies is recommended.

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