

## Original Research Article

### A Socio-Economic Analysis on Shrimp Culture (*Litopenaeus Vannamei*) in Godavari Districts of Andhra Pradesh

#### Abstract

Shrimp is a major exportable commodity, with high demand and prices on the international market. Andhra Pradesh is one of India's maritime states, with 974 kilometres of coastline. The state is the leading producer and exporter of farmed shrimp. Although shrimp farming has been practiced for many decades, a number of challenges that need to be addressed in order to improve the overall efficiency of the shrimp industry. In light of this, the present study was carried out to analyse the socio-economic status of shrimp farming in the East and West Godavari Districts of Andhra Pradesh. The findings of the study revealed that, the profitability of the venture with **Returns Per Rupee of Investment** of 1.79. The estimates of Cobb-Douglas production function analysis showed that, stocking density, feed, probiotics and feed supplements, labour, and season dummy has significant influence on the shrimp yield. The estimates of resource use efficiency revealed the under-utilization of inputs in the shrimp farms. The returns to scale in shrimp culture of 1.04 indicates increasing returns to scale in production.

**Keywords:** Shrimp, **Production Function, Resource Use Efficiency, Costs and Returns.**

#### Introduction

Aquaculture is the world's most rapidly expanding source of food production, with shrimp dominating in terms of economic value. In India, shrimp production has shown consistent growth and reached a new height of 8,15,745 tonnes during **2020-21** (MPEDA, **2020-21**). Presently, an area of about 1,08,526.27 ha. is under *Litopenaeus vannamei* culture in eight coastal states with Andhra Pradesh dominating in total area under culture and production (6,34,672 tonnes), followed by Gujarat (50,410 tonnes) and Tamil Nadu-Pondicherry (44,735 tonnes) (MPEDA, 2020-21). In Andhra Pradesh,

the shrimp industry faces certain challenges to its continued sustainability and growth, viz., the unavailability of high-quality seeds from Specific Pathogen Free (SPF) brood stock. Farmers struggle to differentiate between locally grown inbred seed and SPF bred seed due to a lack of testing facilities. Another major concern for *Litopenaeus vannamei* cultivation is disease outbreak, which poses more financial risk and slow industry expansion. Price volatility and lack of awareness on international prices and demand have resulted in financial losses for small-scale producers, even though a good market is available at the global level. Shrimp producers experience uncertainty over their profit margins due to the high price volatility. The global feed costs are progressively rising as a result of rising raw material and fishmeal prices, subsequently having a cascading impact on operational costs. The availability of adequate aquafeed ingredients is other major challenge which requires attention. Aquafeed demand has increased drastically during the last decade. Also, huge capital investment is required in brackish water shrimp farming during the initial years. All of these concerns have an immediate impact on the economics and profitability of shrimp farming operations. In this standpoint, the present study has been undertaken with the following specific objectives.

1. To estimate the costs, returns and profitability of shrimp farms in the study area.
2. To analyse the resource use efficiency of shrimp production.
3. To enumerate the major production constraints faced by shrimp farmers.

## **Materials and Method**

### **Sampling Procedure**

A stratified random sampling technique was employed for identifying the sample respondents. The Godavari delta of Andhra Pradesh comprising two districts viz., East Godavari and West Godavari was considered as the **universe** of the study. **As the** first stage of sampling, two mandals from each of the selected district, were purposively selected as the sample mandals considering number of brackish water shrimp farms available in the mandals. As the second unit of sampling 30 farms from each of the four sample mandals were selected at random, with ultimate sample size of 120 farms. **(You are saying stratified random sampling technique was employed, but you have selected the mandals purposively, how will you justify this)**

### **Tools for Analyses**

#### **Percentage analysis**

Percentage and averages were used to analyse the socio-economic characteristics, costs and returns from shrimp farming.

### Production Function Analysis

Production function analysis was employed as a quantitative tool to determine the factors affecting shrimp production. Seasonal effect was also accounted using season dummies. In order to study the input-output relationship in shrimp production, the production scenario of the farmers is considered to be specified by Cobb-Douglas production function which is presented as follows

$$Y = \alpha X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} D_1^{\beta_5} e^u \quad \dots (1)$$

Where, Y = Total shrimp production (in kilograms per acre), X<sub>1</sub> = Stocking density (in numbers per acre), X<sub>2</sub> = Quantity of feed used (in kg per acre), X<sub>3</sub> = Human labour (in man days per acre), X<sub>4</sub> = Probiotics and feed supplements cost (in rupees per acre), D<sub>1</sub> = Dummy variable for season (if, Summer =1, Winter =0) (which months you consider as summer and winter, how you have differentiated. Add base studies), i = 1, 2, 3, ..... , n farms, b<sub>0</sub> = Intercept, b<sub>1</sub>, b<sub>2</sub>, b<sub>3</sub>, b<sub>4</sub>, b<sub>5</sub> = Partial regression coefficients, μ<sub>i</sub> = Random variable.

The linear additive form of the function is given by,

$$\ln Y = \ln \alpha + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 D_1 + u \quad \dots (2)$$

### Resource Use Efficiency of Shrimp Farms (follow proper grammar, write small letters across this manuscript)

The resource use efficiency was estimated using the Marginal Value Product (MVP) and Marginal Input Cost (MIC) efficiency ratio, which indicates that, the increase in gross returns from use an additional unit of a given input while keeping the level of other inputs at constant level (Gawa and Kumar, 2017). For this purpose, MVP was computed at their respective geometric mean levels, and MIC was taken as the factor's unit price. The MVP/MIC ratio of different inputs were estimated as

$$MVP = \beta_i * \left( \frac{\bar{Y}}{\bar{X}_i} \right) * P_y$$

Where,  $\bar{Y}$  = Average yield of shrimp in kilogram per acre at geometrical mean level of all inputs,  $\bar{X}_i$  = Geometric mean level of  $i^{\text{th}}$  resource,  $\beta_i$  = Elasticity of production of  $i^{\text{th}}$  input,  $P_y$  = Market price of the output in Rs. (write the symbol of rupee throughout) per kilogram,  $P_{x_i}$  = Market price of  $i^{\text{th}}$  input in Rs. per kilogram.

The resource use efficiency was computed by comparing each resource MVP with the corresponding unit price of the factor or MIC.

If  $MVP/MIC = 1$ , the resource is optimally used,

If  $MVP/MIC < 1$ , the resource is over utilised,

If  $MVP/MIC > 1$ , the resource is under-utilised,

This resource ratio helps in decision-making regarding resource adjustments for increasing profits and minimizing losses for farms.

### **Garrett Ranking Technique**

Garrett ranking technique was employed to identify the various production constraints as perceived by the shrimp farmers and ranked as per the order of severity of problem. The order of merit assigned by the respondents were converted in to ranks using the formula,

$$\text{Percent position} = 100 \times \frac{R_{ij} - 0.5}{N_j}$$

Where,

$R_{ij}$  = Rank given for  $i^{\text{th}}$  reasons by the  $j^{\text{th}}$  individual,  $N_j$  = Number of reasons ranked by  $j^{\text{th}}$  individual.

By referring to Garrett's table, the percentage positions estimated were converted in to scores and then for each factor the scores of various respondents were added and mean value was arrived at. These means were arranged in descending order. The problem having the highest mean value was considered as the most important and was given the highest rank and vice versa.

### **Results and Discussion**

#### **Socio-Economic Profile of Shrimp Farmers**

A brief profile of shrimp farmers in the study area is presented in the Table 1 and 2. Data summarized below, showed that 43.33 per cent of shrimp farmers were at

middle age group and 40 per cent of farmers were found at the old age group, and 16.67 per cent of farmers were at the young age. It was observed that, 36.67 per cent of shrimp farmers were educated up to secondary level followed by 30 per cent at graduation level, 26.67 per cent at higher secondary level, 3.33 per cent of farmers were educated up to primary level, and another 3.33 per cent were post-graduates.

**Table 1. Socio-Economic Profile of Shrimp Farmers (write in small letters)**

S.No	Particulars	Category	Frequency (n=120)
1.	Age Wise Distribution (in Years)	Young age (up to 35)	20 (16.67)
		Middle age (between 35-50)	52 (43.33)
		Old age (above 50)	48 (40.00)
2.	Education	Primary	4 (3.33)
		Secondary	44 (36.67)
		Higher secondary	32 (26.67)
		Graduate	36 (30.00)
		Postgraduate	4 (3.33)
3.	Occupation	Aquaculture	40 (33.33)
		Aquaculture and Agriculture	20 (16.67)
		Aquaculture and other business	60 (50.00)
4.	Farming Experience (in Years)	5-10	52 (43.33)
		10- 20	48 (40.00)
		More than 20	20 (16.67)
5.	Annual Income (in Lakhs)	below 5	4 (3.33)
		Between 5-10	39 (32.50)
		Between 11-20	62 (51.67)
		above 20	15 (12.50)

(Figures in the parenthesis indicates percentage to total sample size)

As far as their primary occupation is concerned, the majority of farmers occupation pattern was 'aquaculture and other business' (50 per cent), followed by 'aquaculture only' (33.33 per cent) and 'aquaculture with agriculture' (16.67 per cent). All shrimp farmers were experienced, and around 43.33 per cent of farmers had experience between 5 to 10 years, followed by 40 per cent of farmers between 10 to 20 years and 16.67 per cent with farming experience of more than 20 years. The annual income of 51.67 per cent of shrimp farmers was between 11 to 20 lakhs, followed by 32.50 per cent of farmers between 5 to 10 lakhs, 12.5 per cent of farmers with more than 20 lakhs, and 3.33 per cent of farmers with less than 5 lakhs.

**Table 2. Details on Shrimp Ponds of Farmers**

S.No	Particulars	Category	Frequency (n=120)
1.	Land Holding	Less than 2	32 (26.66)

	(in ha.) (Water Spread Area)	Between 2-5	44 (36.67)
		Between 5-10	32 (26.67)
		More than 10	12 (10.00)
2.	Ownership	Own	44 (36.67)
		Leased in	48 (40.00)
		Own and leased in	28 (23.33)
3.	Social Participation	Input traders	88 (73.33)
		Input traders and Department of Fisheries (DoF)	24 (20.00)
		Input traders, DoF, and Marine Products Export Development Authority (MPEDA)	8 (6.67)
4.	Crops Per Year	Two	104 (86.67)
		Three	16 (13.33)
5.	Stocking Density (nos. per m <sup>2</sup> )	21-30	1 (0.83)
		31-40	29 (24.17)
		41-50	90 (75.00)

(Figures in the parenthesis indicates percentage to total sample size)

From table 2, it could be observed that around 36.67 per cent of the shrimp farmers were having land between 2 to 5 hectares followed by 26.67 per cent shrimp farmers with land between 5 to 10 hectare and 26.66 per cent of shrimp farmers with land less than 2 hectare. Only 10 per cent of shrimp farmers were having a farm size of 10 hectare and above. About 40 per cent of the shrimp farmers operating their farm on lease basis whereas, 36.67 per cent of farmers had own farms, followed by 23.33 per cent of farmers operating their own farm and also leased in farms.

More than three-fourth of the farmers (73.33 per cent) were participating in meetings conducted by input traders. Barely 20 per cent of farmers were participating in trainings conducted by input traders and Department of Fisheries and only around 6.67 per cent of farmers were participating in meetings conducted by input dealers, DoF and MPEDA. The majority of the farmers (86.67 per cent) were taking up two crops per year. About 75 per cent of shrimp farmers maintained a stocking density between 41-50 nos. per m<sup>2</sup> i.e., intensive type farming.

### **Economics of Shrimp Farming**

The details on total costs and returns of shrimp farms are presented in Table 3. The capital investment for intensive shrimp farms worked out to Rs. 5,11,840 per acre which includes pond construction, electricity installation, farm buildings construction, and on farm equipments viz., pump motors, aerators, check tray, feeding boat and biosecurity set up. The total fixed costs worked out to Rs. 2,44,763 per acre. The share

of rental value for owned or leased in land was 43.49 per cent which accounted for a major share in total fixed costs, followed by salaries to permanent labour (30.23 per cent). The depreciation on various categories of equipment's by considering their respective life span and interest on capital investment worked out to 13.73 per cent and 12.55 per cent respectively.

The total variable costs were estimated at Rs. 13,24,002 per annum which accommodates two crops. On an average, the cost of preparing pond before stocking accounts for 3.70 per cent to the total variable costs. *L. vannamei* seeds (PL'12) were purchased at an average rate of Rs. 0.40 per unit from the commercial hatcheries in the study area. The average cost of feed was Rs. 2,125 per 25 kilogram bag which occupied the major share, accounting 68.82 per cent to the total variable costs followed by seed cost (10.88 per cent). The average cost incurred for probiotics, minerals and feed supplements accounts for 4.11 per cent to the total variable costs. Electricity and generator charges accounted for 4.62 per cent as mechanical aeration is a major component of energy use in the shrimp farming. The rest of the variable costs were water quality testing charges, labour charges, interest on working capital, urea, potash, formalin, and minerals which accounted to 0.41 per cent, 0.93 per cent, 4.94 per cent and 0.60 per cent respectively. The net returns for per acre of shrimp farm was Rs. 12,36,643 with Returns Per Rupee of Investment (RPOI) of 1.79, which reflected the profitability of the venture in the study area. In a similar study conducted by Kumar et al. (2020) found that, *L. vannamei* was highly profitable business earned a net profit of Rs. 5,82,636 per acre.

**Table 3. Costs and Returns of Shrimp Farm (in small letters)**

S.No	Particulars	Amount (in Rs. per acre)
<b>1.</b>	<b>Capital Investment</b>	<b>5,11,840</b>
<b>2.</b>	<b>Annual Fixed Costs</b>	
i.	Rental value of own land	1,06,450 (43.49)
ii.	Depreciation on Pump motors, Aerators, and Buildings	33,603 (13.73)
iii.	Salaries to permanent labour	74,000 (30.23)
iv.	Interest on capital investment	30,710 (12.55)
	<b>Total Fixed Costs (TFC)</b>	<b>2,44,763 (100.00)</b>
<b>3.</b>	<b>Annual Variable Costs</b>	
i.	Pond preparation	48,970 (3.70)
ii.	Cost of seed	1,44,000 (10.88)
iii.	Feed cost	9,11,200 (68.82)
iv.	Electricity and Generator charges	61,150 (4.62)

v.	Urea, Potash, and Formalin	7,955 (0.60)
vi.	Probiotics, Minerals and Feed supplements	54,367 (4.11)
vii.	Water quality testing charges	5,450 (0.41)
viii.	Repairs and maintenance	13,200 (1.00)
ix.	Harvesting labour charges	12,313 (0.93)
x.	Interest on working capital	65,397 (4.94)
	<b>Total Variable Costs (TVC)</b>	<b>13,24,002 (100.00)</b>
	<b>Total costs</b>	<b>15,68,765</b>
	Yield of shrimp (in tonnes)	6.876
	Average price of shrimp (Per kg)	408
	Production cost (Per kg)	228
	Gross Returns	28,05,408
	Net Returns	12,36,643
	Returns per rupee of Investment	1.79

(Figures in the parenthesis indicates percentage to total)

### Estimated Production Function for Shrimp Farming

Production Function Analysis used in the study was log-linear or double log form, which showed that coefficient of multiple determination ( $R^2$ ) is 0.85. It implied that 85 per cent of the variation in the yield of shrimp could be attributed by the explanatory variables included in the model. The overall regression result was significant at 1 per cent level with F value of 131.48, and hence the model is a good fit. The log-linear form estimates are presented in the Table 4, which shows that all inputs are positively related to the output of *L. vannamei* shrimp. Dummy variable introduced in analysis for representing seasonal variation had a positive and significant effect on yield. Furthermore, stocking density, feed, and seasonal dummy significantly affects the output of the shrimp at 1 per cent level, probiotics and feed supplements affects the output of the shrimp at 5 per cent level, while labour affects the output of the shrimp at 10 per cent level of significance.

**Table 4. Estimated Production Function for Shrimp Farms**

S.No	Variables	Coefficient	T ratio	p-value
1.	Yield	-	-	-
2.	Intercept	-7.520**	-2.208	0.029
3.	Stocking density	0.295 ***	7.679	0.000
4.	Feed	0.450***	8.269	0.000
5.	Labour	0.155*	1.736	0.085
6.	Probiotics & Feed supplements	0.135**	3.045	0.003
7.	Seasonal variation	0.551***	5.395	0.000
	$R^2 = 0.85$ , Adj. $R^2 = 0.84$ , $F = 131.48$ , Prob > F = 0.000			

*\*, \*\*, and \*\*\* are 10%, 5% and 1% levels of significance*

The estimated coefficients of stocking density, feed, labour, probiotics and feed supplements and seasonal dummy are 0.295, 0.450, 0.155, 0.135 and 0.551 respectively. Therefore, it could be inferred that 1 per cent increase in the stocking ( $X_1$ ) from its present average level will increase output of shrimp by 0.29 per cent. Increasing 1 per cent in the feed ( $X_2$ ) will increase the output of shrimp by 0.45 per cent. For labour ( $X_3$ ), 1 per cent increase, the output will increase by 0.15 per cent. Moreover, increase by 1 per cent in the use of probiotics and feed supplements ( $X_4$ ) will increase the output of shrimp by 0.13 per cent. In the estimated function, the sum of returns to scale was 1.04, exhibiting increasing returns to scale. Therefore, an increase in inputs by one per cent from the mean levels would result in a more than proportionate increase in yield.

### **Resource Use Efficiency**

The allocative efficiency ratios of resources in the production of shrimp farms are presented in Table 5. The allocative efficiency for seed, feed, labour, probiotics, and feed supplements were 5.75, 1.45, 6.09, and 39.21 respectively. It could be inferred that, seed, feed, labour, probiotics and feed supplements were under-utilized with efficiency ratios more than one which implies that adding one unit of these respective input would improve the ratios and gross returns.

**Table 5. Resource Use Efficiency of Shrimp Farms**

<b>S.No</b>	<b>Inputs</b>	<b>MVP</b>	<b>MIC</b>	<b>MVP/MIC</b>	<b>Decision rule</b>
1.	Stocking density	2.24	0.39	5.75	Under-utilized
2.	Feed	123.86	85.13	1.45	Under-utilized
3.	Labour	1800	295.66	6.09	Under-utilized
4.	Probiotics & feed supplements	42901.37	1094	39.21	Under-utilized

### **Constraint Analysis**

The major production constraints expressed by the shrimp farmers were ranked according to their mean score and presented in Table 6. The most important constraint encountered by the farmers was lack of availability of quality seed from hatcheries (63.43). The quality of the seed is mostly determined by the physiological state of the brood stock as well as the ambient circumstances in hatching tanks.

**Table 6. Constraints Faced by Shrimp Farms**

S.No	Particulars	Garrett's Score	Rank
1.	Lack of availability of quality seed	63.43	I
2.	Outbreak of disease	54.87	II
3.	Exorbitant feed cost	47.27	III
4.	Lack of credit facilities	28.17	IV
5.	High electricity cost	18.97	V

The second important constraint encountered by the farmers was disease outbreak in the production site (54.87). Poor handling of brood stock in hatcheries resulted in the emergence of several diseases in the farms. The third constraint was the exorbitant feed cost (47.27), which is increasing day by day due to raw material and fish meal price hikes. The fourth constraint was lack of credit facilities (28.17), owing to non-institutional credit with higher interest rates and insufficient credit from banks. High electricity cost (18.97) was ranked as fifth constraint. The regular use of aerators and pumping motors led to an increase in the electricity cost of farms, which is unavoidable.

**Conclusion and Policy Implications (rewrite the conclusion in one or two paragraphs along with policy suggestions separately)**

- The lack of availability of quality seed from the hatcheries was the foremost constraints in shrimp production in the study. Hence, Provision of high-quality shrimp seeds, as well as certification by state fisheries department is suggested so that it could eliminate disease outbreaks and assure a high survival rate, resulting in increased productivity per acre.
- The feed cost in the shrimp production occupies the major share in the operating costs. Since, feed plays a very important role in shrimp farming, the government may make efforts to provide feed at a subsidised rate to shrimp farmers. (If the govt provides feed at subsidized rate for all the farmers, how can it be viable then)
- The shrimp farm resources were under-utilized in the study area. Therefore, Governmental fisheries extension authorities may ensure farm level optimal usage of inputs viz., seed, feed, labour, probiotics and feed supplements vide periodical trainings so as to enhance the production efficiency of shrimp.

- The outbreak of diseases in pond was the major constraints faced by farmers in shrimp production. To lessen financial losses and risks associated with shrimp farming, insurance is required, and the government may contribute a portion of the premium. Hence, the government and insurance companies may create conducive crop insurance policies for the shrimp culture on the similar lines existing in agriculture and allied sectors. (justify how the constraints been identified, then make the claim)
- Compare the results with previous regional, national and international studies.
- Mention the optimum (recommended) stocking density from govt reports and then compare it with the present study, try to make the inferences from the results (model) you got, not only from the constraints they face.
- Add recent studies from the area and map of the study area

## References

- Ara, L. A., Alam, M. F., Rahman, M. M., & Jabbar, M. A. (2004). Yield gaps, production losses and technical efficiency of selected groups of fish farmers in Bangladesh. *Indian Journal of Agricultural Economics*, 59(4), 808-818.
- Beena, K. B. (1992). *Socio-Economic Study of Prawn Farmers in Ernakulam District* (Doctoral dissertation, Central Marine Fisheries Research Institute).
- Charishma, E., Sivakumar, S. D., Chadrakumar, M., & Selvi, R. G. (2022). An Analysis of Shrimp Culture Business in Nellore District, Andhra Pradesh, India. *Asian Journal of Agricultural Extension, Economics & Sociology*, 40(10), 620-628.
- Chittem, P. B., & Kunda, S. K. (2018). Socio-economic condition of the *Litopenaeus vannamei* farmers with implementation of better management practices BMP's in Andhra Pradesh, India. *International Journal of Fisheries Aquatic Studies*, 6(6), 325- 331.
- Gawa, S., & Kumar, N. R. (2017). Economics and Factors Affecting Rainbow Trout (*Oncorhynchus mykiss*) Production in Kashmir. *Indian Journal of Agricultural Economics*, 72(2), 166-176.
- Jayaraman, R., Purushotham Sai, J., Rao, V. S., Joshuva, K., & Ramesh Babu, K. R. (1990). Economic analysis of prawn culture in Andhra Pradesh-Some preliminary findings. In *CMFRI Bulletin-National symposium on research and development in marine fisheries Sessions III & IV 1987* (Vol. 44, No. 2, pp. 403-406). CMFRI Kochi.
- Kumar, B., Sharma, R., Lakra, W. S., Sharma, A., Prakesh, S., & Sharma, M. M. (2016). Economic Assessment of Shrimp Farming (*Litopenaeus vannamei*) in Gujarat-A Profitable Venture. *International Journal of Innovative Research in Science, Engineering and Technology*, 5(8), 15334-15342.
- Kumar, S., Samsai, T., & Kandeegan, M. (2020). Production and marketing aspects of shrimp (*litopenaeus vannamei*) in East and West Godavari Districts of Andhra Pradesh. *International Journal of Development Extension*, 9(2).
- Lekshmi, N. M., Praveen, K. V., Sreekanth, G. B., Singh, N. P., Vennila, A., Kumar, R. R., & Pandey, P. K. (2019). Economic Evaluation of Different Aquaculture

- Systems in Coastal waters of Goa, Southwest Coast of India. *Fishery Technology*, 56, 231-241.
- MPEDA 2021. Marine Products Export Development Authority, Kochi, India. retrieved [https://mpeda.gov.in/?page\\_id=651](https://mpeda.gov.in/?page_id=651) (Accessed on October 2024).
- Reddy, G. P., Reddy, M. N., Sontakki, B. S. and Bala Prakash, D. (2008). Measurement of efficiency of shrimp (*Penaeus monodon*) farmers in Andhra Pradesh, *Indian J. Agric. Econ.*, 63(4): 653-657.
- Sadafule, N. A., Shyam, S. S., & Pandey, S. K. (2013). Economic analysis of shrimp farming in the coastal districts of Maharashtra. *Journal of Fisheries, Economics and Development*, 14(1), 42-54.
- Sathiadhas, R., Najmudeen, T. M., & Prathap, K. S. (2009). Break-even Analysis and Profitability of Aquaculture Practices in India. *Asian Fisheries Science*, 22(2), 667-680.
- Subba Reddy, S., Ram P. R., Sastry, T. V. N., and Devi, I. B. (2004), "Agricultural Economics", (New Delhi: A Unit of CBS Publishers & Distributors Private Ltd.), pp: 46,47.
- Tandel, J. T., Tandel, K. V., Tandel, G. M., & Patel, M. R. (2016). A Socioeconomic survey of shrimp aquaculture practices in Valsad district, Gujarat, India. *International journal of research in applied, natural and social sciences*, 4(9), 93-98.
- Thriveni, K., Jayaraman, R., Senthikumar, V., Sujathkumar, N. V., Anand, C., & Ramana, T. V. (2022). Technical efficiency analysis of shrimp farms in Andhra Pradesh, India using stochastic frontier approach. *Indian J. Fish*, 69(2), 119-127.
- Uma Devi, K. and Eswara Prasad, Y. 2004. A study on technical efficiency of shrimp farms in coastal Andhra Pradesh, *Agric. Econ. Res. Rev.*, 17(2): 175-186.
- Umamaheswari, L., Chandrasekar, V., Swaminathan, N., & Poonguzhalan, R. (2013). Technical efficiency of freshwater aquaculture farms in the Union Territory of Puducherry: frontier production function approach. *Indian J. Fish*, 60(2), 93-98.
- Vasanthi, R., Rohini, A., Uma, K., & Narkis, C. (2021). An economic analysis of shrimp (*Litopenaeus vannamei*) in Nagapattinam district of Tamil Nadu. *Asian Journal of Agricultural Extension, Economics & Sociology*, 39(10), 449-454.