

## Time Series Modeling for Forecasting the Adoption Behaviour of Shrimp Farmers

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### ABSTRACT

*Commercial shrimp culture has emerged as a prominent sector of the coastal economy of India, by virtue of the foreign exchange returns, rural employment it generates, and the economic viability of the enterprise and high market demand for the produce. The present study was conducted in Nellore and Nagapattinam districts of India to forecast the adoption of scientific technologies for a period of 17 years from 2004-2020, by the shrimp farmers using time series statistical modeling. The background data collected from 1997 to 2003 on the adoption behaviour of the farmers formed the database for predicting the adoption behaviour of the technologies. The study revealed that of the two statistical methods employed, namely Holt linear model and Holt exponential smoothing model, the goodness of fit generated by the Holt linear model with an R<sup>2</sup> value of 0.97 exhibited a higher degree of model adequacy over the Holt exponential smoothing model which revealed that in the years 2019 and 2020, the overall extent of adoption exceeded 100 percent which implies the development of new technologies by the research system and its subsequent adoption by the farmers. Besides factors such as changes in demography, demands in the export and local markets would motivate the shrimp farmers in future to adopt more of the improved technologies for getting higher yields.*

**Key words :** *Shrimp farming; Adoption; Time series modeling;*

Shrimp culture, which was started a century ago as the traditional practice in the form of trapping, holding and harvesting has undergone a metamorphosis in the past two decades and has scaled great heights and consequently attained the status of an industry. India is at present the fifth largest producer of Cultured Shrimps in the World, and Cultured Shrimps contribute about 85.79 per cent of the total shrimp exports in term of value in 2001-02 (Ranjan, 2002).

The increased production of cultured shrimps can be attributed to the adoption of improved technologies by the shrimp farmer as well as to the technological advancements made in this direction. In this context, the adoption behaviour of the shrimp farmer becomes a subject for empirical investigation.

Against this background an attempt was made to predict the adoption behaviour of the shrimp farmers in the coming years, which would reflect the future status of this lucrative industry. The null hypothesis formulated for the study was that there will be no difference between the observed and forecast values for the future extent of adoption of shrimp culture technologies. The present study was carried out to

predict the adoption behaviour of the shrimp farmers in the future.

### METHODOLOGY

The research work was carried out in Nellore district of Andhra Pradesh and Nagapattinam district of Tamil Nadu. Andhra Pradesh state has the largest area under shrimp culture and Tamil Nadu state has the unique advantage of having the highest productivity in shrimp. These formed the criteria for the selection of the two coastal states for the present study. The districts selected for the study were Nellore district of Andhra Pradesh and Nagapattinam district of Tamil Nadu state. The former was selected since it formed the birth place for Shrimp culture in the Country and the latter selected based on the criteria on that it had the largest area under Shrimp culture in that state.

Three blocks in Nellore district and three blocks from Nagapattinam district having substantial number of Shrimp farmers were selected purposively. Two villages were selected randomly from each of the three blocks of Nellore district and Nagapattinam district.. The list of registered Shrimp farmers for each of the selected villages was collected from the Directory of

registered Shrimp Farmers Association of each of the respective districts, of the respective states. Employing random sampling procedure, ten Shrimp farmers from each village were selected. Thus 60 Shrimp farmers from Nellore district and 60 Shrimp farmers from Nagapattinam district were selected. Thus the total sample size for the present study was 120 Shrimp farmers.

A total of 17 independent variables which formed the Socio-personal, Socio-psychological and Socio-economic variables such as age, education, occupational status, shrimp farm size, annual income, family size, family type, ownership of Shrimp farm, material possession, marketing behaviour, social participation, information seeking behaviour, extension participation, economic motivation, risk orientation and credit orientation were selected for the study.

The dependant variable used for the study was the adoption behaviour of Shrimp farmers.

(1) *Adoption behaviour of Shrimp farmers* : The adoption behaviour for the study referred to the extent of adoption of selected improved Shrimp farming practices recommended for Shrimp farming of the species *Penaeus monodon*, by the Shrimp farmers. In the present study to measure the adoption behaviour of Shrimp farmers, the adoption quotient developed by Balasubramaniam (1998) was used for this study.

$$\text{Adoption quotient} = \frac{\sum_{j=1}^M \left\{ \frac{e_j}{E_j} \times w_j \right\}}{\sum_{j=1}^M W_j} \times 100$$

$e_j$  = Extent of adoption of  $j$ th practice in terms of magnitude

$\Sigma_j$  = Potentiality for adoption of  $j$ th practice in terms of magnitude

$W_j$  = Weightage assigned to  $j$ th practice

$M$  = No. of applicable practices

$\Sigma$  = Summation

Selection of shrimp culture practices for the study

Practices	Weightage	Rank
Health management	4.90	I
Feed management	4.85	II
Water management	4.70	III
Acclimatization and stocking	4.55	IV
Soil management	4.55	V
Liming of pond	4.55	VI
Measurement of soil pH	4.20	VII
Predator eradicator usage	3.75	VIII
Manures and fertilizer	3.40	IX
Pond bottom sterilization	3.15	X
Pond bottom conditioning	3.1	XI
Harvesting	3.0	XII
Use of pond sealing materials	2.60	XIII
Administration of antibodies	2.00	XIV

Based on judges ranking, 12 improved shrimp farming practices starting from Pond preparation till harvest were selected, in terms of its degree of importance of adoption for getting higher yield, as detailed in the table below.

The data on the extent of adoption of Shrimp farming practices were collected from the respondents. The extent of adoption of each practice was compared with the recommendation and the following scoring procedure was followed to quantify the extent of adoption.

Extent of adoption	Scores
Non-adoption of a recommended practice	1
Partial adoption of a recommended practice	2
Full adoption of a recommended practice	3

(2) *Designing of Diffusion Simulation modeling* :

Diffusion simulation modeling was used to predict/forecast the future adoption behaviour of Shrimp farmers. Since simulation means “running” the model forward through (simulated) time and watching what happens, it was decided to collect the background data with respect to the adoption behaviour of the respondents for the period of Seven years from 1997 onwards till 2003. Shrimp culture being relatively new to the country is only a decade old. It started in the early 1900s when most of the important technologies such as feed management, water management and health management were not yet developed by the research system and were transferred to the target community only after 1995, both in Nellore and Nagapattinam, which formed the locale of Research. Hence a reasonably good sample of farmers practicing scientific Shrimp culture, could be obtained only from 1997 onwards. Out of the total 120 respondents who constituted the sample, each respondent was asked to indicate his farming experience in terms of years. Based on the farming experience of each Shrimp farmer, for each year starting from 1997 onwards, the list of Shrimp farmers were tabulated, along with their adoption behaviour for all the 12 Shrimp culture technologies. The mean adoption behaviour in percentage for all the 12 Shrimp culture technologies was worked out for seven years starting from 1997 till 2003. This formed the database for forecasting the adoption behaviour for the next 17 years. i.e. 2004-2020.

(3) *Development of Statistical time series model* :

Statistical modeling essentially consists of developing a model to adequately represent the salient features of the problem under study (Venugopalan and Srinath, 1998). Subsequently, it is used to forecast future values of an underlying phenomena which may be for

example the adoption behaviour of Shrimp farming technologies. Holt (1957) had developed the time series modeling named as Holt linear smoothing model, and Holt's exponential smoothing model, wherein the model is a function that relates the values of a time series to precious values of that time series, its errors or other related time series. These two statistical models were used for the present study. The model follows the equation

$$St = a Xt + (1- a) (st-1 + bt-1)$$

$$bt = ? (st-st-1) + (1- ?) bt-1$$

$$Ft + m = St + m.bt.$$

Where m = the no of months ahead to be forecasted,

Ft + m = forecast m periods ahead

St, st-1 = Smoothened value at time t and t-1

a = general smoothing coefficient,

? = trend smoothed coefficient

bt = trend component

### RESULTS AND DISCUSSION

An analysis of Table 1 revealed the observed, predicted and forecast values of the overall extent of adoption of shrimp culture technologies, by shrimp farmers.

With respect to the two time series models namely Holt Linear Model and Holt Exponential Model it is seen that the predicted values are fairly close to the observed values. Both the models exhibit an increase in trend with respect to the extent of adoption from the year 2004 onwards; but with difference in their magnitudes.

With respect to the Holt linear model, it is seen that in the years 2009, and 2018 the extent of adoption of shrimp culture technologies are 90.43 per cent and 101.07 per cent. This might be due to factors such as higher profits accruing from this enterprise, expansion of market, higher demand, which might have motivated the farmers to go in for a greater adoption of the technologies. A closer look at the Table 1 shows that during the years of 2019 and 2020, the overall extent of adoption exceeds 100 percent, which implies the development of new technologies, by the Research system and its subsequent adoption by the farmers.

Changes in demography, demands in the export and local markets, would motivate farmers to adopt more of the technologies for getting higher yields.

Table 1. Summary Statistics of Holt Linear Model and Holt Exponential Smoothing Model Fit

Model	Parameters				
	st	bt	Alpha	Gamma	R2
Holt linear model	74.77	1.267	0.44	1.00	0.97
Exponential smoothing model	74.47	1.025	0.186	1.00	0.76

Table 2: Holt Linear and Holt Exponential smoothing models showing the observed, predicted and Forecast Values for Overall Extent of Adoption Of Shrimp Culture

Models	(N = 120)																								
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Observed (%)	75.4	77.3	78.4	80.1	80.4	81.5	83																		
Predicted (%)	76.03	77.24	78.48	79.72	81	82.19	83.36																		
Forecast (%)								84.53	85.71	86.88	88.07	89.25	90.43	91.61	92.79	93.97	95.16	96.34	97.52	98.7	99.88	101.1	102.3	103.4	
Observed (%)	75.40	77.30	78.40	80.10	80.40	81.50	83.00																		
Predicted (%)	76.34	77.90	79.45	80.75	82.02	82.83	83.45																		
Forecast (%)								84.16	84.95	85.76	86.58	87.40	88.23	89.07	89.91	90.77	91.63	92.50	93.38	94.27	95.16	96.07	96.98	97.90	

Further observation of Table 1 shows that though the Holt exponential smoothing model predicts a gradual increase in the extent of adoption from the year 2004 to 2020, the increase is gradual, when compared to the Holt linear model. An analysis of Table 2, gives the summary statistics of Holt linear model and Holt exponential smoothing model fit. It is observed that from the goodness-of-fit given by the R<sup>2</sup> value, the Holt Linear Model with an R<sup>2</sup> value of 0.97 exhibits a higher degree of model adequacy over the exponential smoothing model which has an R<sup>2</sup> value of only 0.75. Thus the Holt Linear Model is able to explain 97 per cent of the prediction in the extent of adoption of shrimp culture technologies in comparison to the Holt exponential smoothing model which is able to explain only 75 per cent of the prediction in the extent of adoption of shrimp culture technologies.

### CONCLUSION

The foregoing study revealed that shrimp aquaculture is going to emerge as a sunrise sector in

the Indian Aquaculture Scenario. With the enormous demand for cultured shrimp in the domestic and export market and with the generation of newer technologies and more technologies in the pipeline to combat disease problems, production of specific pathogen free brood stock for production of disease free seeds and with improvements in technology of water and soil quality management, commercial shrimp culture is bound to make a profound impact on the economy of the country in terms of rural employment generation, foreign exchange earnings and as a giant food producing sector.

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