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Forecasting and Comparison of Nonlinear Statistical Growth Models for Fish Seed Production in Eastern Coastal States of India

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MR and AB did the conceptualization and designing of the research work. Author MHK did the data collection. Authors MR and AB did the analysis of data and interpretation. Authors MR and AB did the preparation of manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study was carried out to compare the goodness of fit of three non–linear growth models viz., Monomolecular, Logistic and Gompertz growth models and analysing the instability index among the collected fish seed Production data from the eastern costal states of Indian for the period from 1994–1995 to 2019–2020. The parameters of each model were estimated using Levenberg–Marquardt (LM) iterative method. The 'independence' and 'normality' of error terms were examined

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by using 'Run–test' and 'Shapiro–Wilk test'. Among the three models tested, monomolecular model was found as best model to describe variation in fish seed production in all Eastern Costal States of India. The values of CDI for fish seed production were 146.94 %, 79.30 % and 63.41% respectively which revealed that fish seed production had high instability in Odisha, Tamil Nadu and Andhra Pradesh while low instability (14.93 % and 13.13%) in West Bengal and India.

Keywords: Fish seed production; nonlinear models; levenberg-marquardt method; run-test; shapiro-wilk test; goodness of fit.

1. INTRODUCTION

In India, during the year 2019–20, the fish production was 141.64 lakh tonnes accounting 37.27 lakh tonnes of marine fish and 104.37 lakh tonnes of inland fish mainly from culture fisheries with fish seed production of 52,170.6 million fry [1]. As the marine fish production declined heavily in recent years, the fish production of the country entirely relies on inland fish production especially through culture fisheries. Earlier days, the fish farmers completely relied on wild collection seeds from natural breeding grounds like river, stream, reservoir, estuaries etc., which supplied more than 85%of total requirement of seed for fish culture [2]. However, fish seed availability from natural source declined sharply due to destruction of natural breeding grounds though natural and man-made activities. It has been noticed from an estimate that collection of hatchling from natural sources decreased from more than 20,000 kg in mid eighty to less than 6,000 kg in mid–ninety. Apart from that, natural seeds were poor in quality and mixed with wild species of fishes. It alarmed the necessity of producing fish seed intensively through artificial breeding techniques to bridge the gap in fish seed supply. Hence, few decades back, the fish seed hatcheries especially for Indian Major Carps, were established by few entrepreneurs utilizing the available effective breeding technologies like hypophysation [3,4].

As the seed production from these hatcheries were not sufficient to meet the actual requirement of the fish seed for fish culture, the government of India established 435 Fish seed Hatcheries and 3679.36 Fish Seed Rearing Area (ha) under Blue Revolution Scheme during 2015–16 to 2019–20 in various part of the country. Culture fisheries mainly depends on the availability of quality fish seeds in time of need. To ensure this service government has given due emphasis on the production of improved fish seeds by establishing Fish Seed Multiplication Farms (FSMFs) in different areas [5]. Fishing is important for Indian economy; the gross value added by fishing and aquaculture was 126370 crore (1.2 per cent) at constant price. The growth rate of fishing and aquaculture was smooth with 1.0 per cent. The possible targeted fish production level achieved was 15 million tonnes during 2015-16 to 2019-20 in inland sector but estimated all India production of fish was 14164 thousand tonnes during 2019- 20. Average fish productivity from ponds and tanks was 3 tonne/ ha/year in India. In India, the top producers of freshwater fish through aquaculture are Andhra Pradesh, West Bengal [6,7]. In India, the states located in Eastern Coastal states such as Tamil Nadu, Andhra Pradesh, Odisha and West Bengal are always in lead position in fish seed production.

It is vital to understand the function of fish seed systems which is influenced by three important criteria. Of which first one is quality of fish seed which includes genetic, sanitary and survival [8], the second one is sustainability in business [9,10] and the third one is evolution on seed systems over time and shape through changes in business incentives, technological, biophysical, socioeconomic, and institutional factors [11].

Our understanding of changes in such drivers and their interactions within fish seed systems is far from perfect, yet designing of cost–effective dissemination systems for distribution of good quality fish seed is highly critical. Hence it is pivotal to study these problems through appropriate functional models to assess the status and predict the future output of the business. Non–availability of quality seed and inadequate or no finance becomes major constraints in the development of fresh water aquaculture. The status and trend of the fish seed system can be studied by applying non linear models as used for other domains by various researchers [12,13,14,15,16].

Nonlinear statistical models are widely used in agricultural and biological sciences due to existence of wide population fluctuations and complex non-linear interrelationship among variables of interest [17,18]. Similarly, in fisheries also, the nonlinear theoretical models have been extensively used than empirical models. These nonlinear growth models are employed to elucidate the growth pattern of individuals belong to a particular species. Further, the major advantage of the non–linear growth models is that it provides parameters which describe the biological growth along the entire lifetime [19,20].

In this context, the present study was designed to analyse the past and future trends and instability in the fish seed production in Eastern Costal States of India by appropriating the production data obtained for a period of last 26 years from 1994–95 to 2019–20 into various nonlinear growth models.

2. MATERIALS AND METHODS

The secondary data on production of fish seed for the period 1994-95 to 2019-20 were collected from the document of Handbook Fisheries Statistics, Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Government of India. The collected data were appropriated into different nonlinear growth models for obtaining best fit of the model which will aid in predicting the future trend of seed production.

In this study we have compared different non linear models for estimating the growth of fish seed production to find the best fit using certain statistical tools such as R^2, Residual sum of square (RSS) and Root mean square (RMSE).

2.1 Nonlinear Growth Models

A mathematical model is an equation or a set of equations which represents the behaviour of a system. In present investigation three different nonlinear growth models were chosen for fitting the seed production data. They are:

2.1.1 Monomolecular model

Monomolecular model [21] describes the progress of a growth situation in which it is believed that the rate of growth at any time is proportional to the resources yet to be achieved. This model is represented as;

$$Y(t) = \alpha - (\alpha - \beta)\exp(-kt) + \varepsilon, \quad \beta = Y(0) \qquad (1)$$

2.1.2 Logistic model

The Logistic model [22] contains the parameters of simple physical interpretation. The mathematical form of the Logistic model as followes;

$$Y(t) = \frac{\alpha}{1 + \beta\exp(-kt)} + \varepsilon, \; \beta = \frac{\alpha}{Y(0)} - 1 \qquad (2)$$

In this, the graph of y(t) versus 't' is elongated and the curve is 'S' shaped and symmetrical about its inflexion.

2.1.3 Gompertz model

This model [23] also follows sigmoid type of behaviour and it is quite useful in biological work despite it is not symmetric about its point of inflexion unlike logistics model. This function model is given as;

$$Y(t) = \alpha\exp(-\beta\exp(-kt)) + \varepsilon, \; \beta = 1/Y(0) \qquad (3)$$

Where Y(t) is the fish seed production as dependent variable observed during the time 't'; 't' is time trend (in years) as independent variable; 'α', 'β', 'k' and 'm' are the parameters, and 'Ɛ' is the error term. The parameter 'k' is the intrinsic annual growth rate, the parameter 'β' is the function of 'Y_0' and the parameter 'α' represents the carrying capacity for each model.

2.2 Fitting of Non-linear Growth Model

As the non-linear equations cannot be solved accurately, the iterative procedures are employed alternatively for solving the equations. In nonlinear regression, the parameters are estimated using the least squares method. In this, three methods were used to obtain approximate analytical solutions by employing iterative procedures viz., Linearization (Taylor series) method, steepest descent method and Levenberg-Marquardt's method.

In non-linear regression, the parameters are estimated using the least squares method. Among the various methods generally used to obtain approximate analytical solutions by employing iterative procedures, we have used the Levenberg-Marquardt method in this study. This method overcomes the drawbacks of the other methods [24].

Model diagnostics was carried out in order to check the assumptions of nonlinear regression. The two assumptions such as Randomness and normality of residuals of nonlinear regression models were tested using Run Test [25] and Shapiro-Wilk test [26] respectively. Moreover normality of residuals was also checked using normal Q-Q plots.

2.3 Goodness of fit of Nonlinear Statistical Models

In order to compare fitting of different nonlinear models,various goodness of fit statistics were worked out. The goodness of fit of a model was assessed by using the statistical tools such as Co-efficient of Determination (R^2), Mean Square Error (MSE) and Root Mean Squared Error (RMSE) [27]. Subsequently the growth in the fish seed production was forecasted using the statistical SPSS software version 21. The methods of determining different goodness of fit statistics employed in the study are furnished below;

2.3.1 Co-efficient of determination (R^2)

The goodness of fit of the fish seed production data for the eastern states of India was examined using the coefficient of determination (R^2), considered to be the most appropriate tool for determining goodness of fit in non-linear statistical models [28]. The potential range of R^2 values is between 0 and 1. The fit of a model is satisfactory if R^2 is close to unity. For non-linear models, its value can be negative if the selected model fits less well than the mean.

$$R^2 = \frac{ResidualSumofSquare}{CorrectedSumofSquare} \quad (4)$$

2.3.2 Root mean square error (RMSE)

RMSE is a kind of generalized standard deviation and was calculated as follows:

$$RMSE = \left[\sum \frac{(Y-\bar{Y})^2}{n} \right]^{1/2} \quad (5)$$

RMSE value is one of the most important criteria to compare the suitability of used growth curve models. In this, the model which has lowest RMSE is declared as best fit.

2.3.3 Mean square error (MSE)

Mean square error [29] is the average of the squared difference between estimated value and observed value and is given as

$$MSE = \frac{\sum (Y-\bar{Y})^2}{n-p} \quad (6)$$

Where ‘n’ is the total number of observed values and ‘p’ denotes the number of parameters in the model.

Non -linear estimation is a general fitting procedure that would estimate any relationship between a dependent or response variable, and a list of independent variables. In this study, the data collected on fish seed production from eastern states of India were appropriated into different growth models that could describe nonlinear curve fitting change patterns. Thus, it aids in developing nonlinear growth models for production of fish seed for Eastern Costal States of India and to understand the past performance as well as forecasting the future possibility of production trend.

2.4 Instability Index Analysis

The simple coefficient of variation often contains the trend component and thus overestimate the level of instability in time series data characterized by long term trends. To overcome this problem, the Cuddy-Della Valle index (CDI) was used [30]. The CDI is calculated as,

Cuddy - Della Valle Instability Index (CDVI) = $C.V \times \sqrt{1-\bar{R}^2}$

Where, C.V. is coefficient of variation in percentage, R^2 is coefficient of determination adjusted by degree of freedom. The level of instability was categorized into low (between 0-15), medium (15< instability 30) and high (>30).

3. RESULTS AND DISCUSSION

The fish seed production from the Eastern Costal States of India for the period from 1994–95 to 2019–20 was presented in Fig. 1.

After attempting different sets of initial values to assure convergence of the nonlinear models, it could be found that all the three models i.e. Monomolecular, Logistic and Gompertz converged appropriately during analysis. The parameter estimation and selection criteria for the Eastern Costal States of India as a whole using the three different models for the fish seed production from 1994-95 to 2019-2020 were worked out. The parameters estimated for all the three models studied are depicted in Table 1. The LM iteration procedure aided in converging the data in all three growth models applying various numbers of iterations. Among all three models, it was observed that Logistic model had the highest carrying capacity while Gompertz model had the lowest among all Eastern Costal States of India.

The test statistics were evaluated to check the goodness of fits for each model that are presented in Table 2. All the three models are significantly fitted to fish seed production data. It could be inferred that that monomolecular model has maximum value of R^2 and least value of MSE and RMSE for India, Andhra Pradesh, Tamil Nadu, Odisha and West Bengal state as a whole (Table 2). As a result, monomolecular model was found as the best fit for computation of compound growth rates and predicted value for Eastern Costal States of India as a whole.

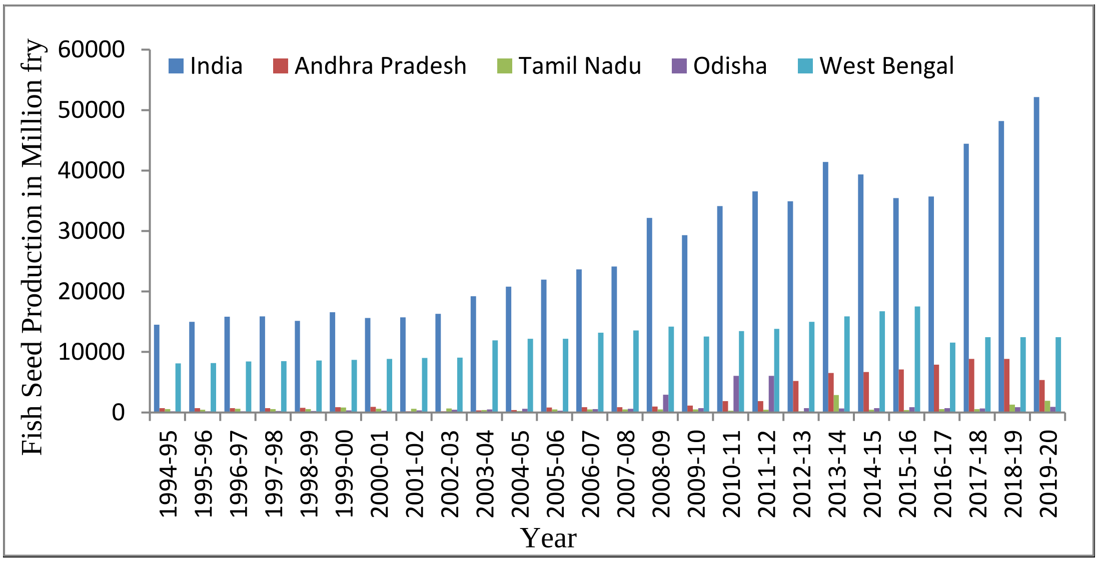

Fig. 1. Fish seed production from eastern costal states of India

Table 1. Parameter estimates of various model fitted on Fish seed production

Parameters		Monomolecular	Logistic	Gompertz
India	α	-635.633	**1.133**	**-0.005**
	β	11930.00	-1.000	-9.197
	k	-0.054	-2.01E-06	1.258
Andhra Pradesh	α	-838.688	**0.755**	**1.66E-05**
	β	-196.606	-0.999	-16.946
	k	-0.106	-1.93E-05	-0.007
Tamil Nadu	α	530.515	**572.651**	**520.562**
	β	600.515	0.000	-1.98E-07
	k	-0.987	-0.335	-0.601
Odisha	α	-2143000.00	**1.202**	**3.38E-05**
	β	225.246	-0.998	-16.709
	k	-2.83E-05	-3.22E-05	-0.002
West Bengal	α	-5614000.00	**1.754**	**-0.2380**
	β	7999.00	-1.000	-10.509
	k	-5.10E-05	-2.97E-06	0.2380

Table 2. Goodness of fit statistics obtained from different nonlinear models

Goodness of fit statistics		Monomolecular	Logistic	Gompertz
India	R^2	**0.9410**	0.9140	0.9400
	RMSE	**2964.96**	3579.11	2982.52
	MSE	**8790968.51**	12810000.00	8895416.79
Andhra Pradesh	R^2	**0.808**	0.656	0.794
	RMSE	**1392.63**	1864.71	1442.78
	MSE	**1939407.63**	3477128.57	2081611.41
Tamil Nadu	R^2	**0.258**	0.255	0.255
	RMSE	**504.33**	505.15	505.26
	MSE	**254347.84**	255172.49	255289.61
Odisha	R^2	**0.087**	0.045	0.006
	RMSE	**1569.46**	1604.93	1592.82
	MSE	**2463203.62**	2575814.32	2537070.15
West Bengal	R^2	**0.615**	0.522	0.565
	RMSE	**1810.79**	2016.74	1923.83
	MSE	**3278959.84**	4067229.52	3701105.97

Table 3. Test for randomness and normality of residuals of fitted models for Fish Seed production

Model	Test	Monomolecular	Logistic	Gompertz
India	Run Test	-3.403 (0.106)	-2.602 (0.209)	-3.403 (0.072)
	Shapiro-Wilk test	0.984 (0.942)	0.902 (0.018)	0.974 (0.731)
Andhra Pradesh	Run Test	-3.803 (0.877)	-3.002 (0.090)	-3.803 (0.373)
	Shapiro-Wilk test	0.936 (0.107)	0.830 (0.061)	0.927 (0.066)
Tamil Nadu	Run Test	0.154* **(0.000)**	-1.693* **(0.003)**	-0.891* **(0.000)**
	Shapiro-Wilk test	0.471* **(0.000)**	0.507* **(0.000)**	0.482* **(0.000)**
Odisha	Run Test	-0.845 (0.000)	-0.801 (0.000)	-2.202 (0.000)
	Shapiro-Wilk test	0.535* **(0.000)**	0.431* **(0.000)**	0.455* **(0.000)**
West Bengal	Run Test	-4.202 (0.398)	-4.203 (0.072)	-4.203 (0.028)
	Shapiro-Wilk test	0.972 (0.686)	0.927 (0.066)	0.945 (2.286)

Values in parenthesis are the p-values, * significant at 5%los

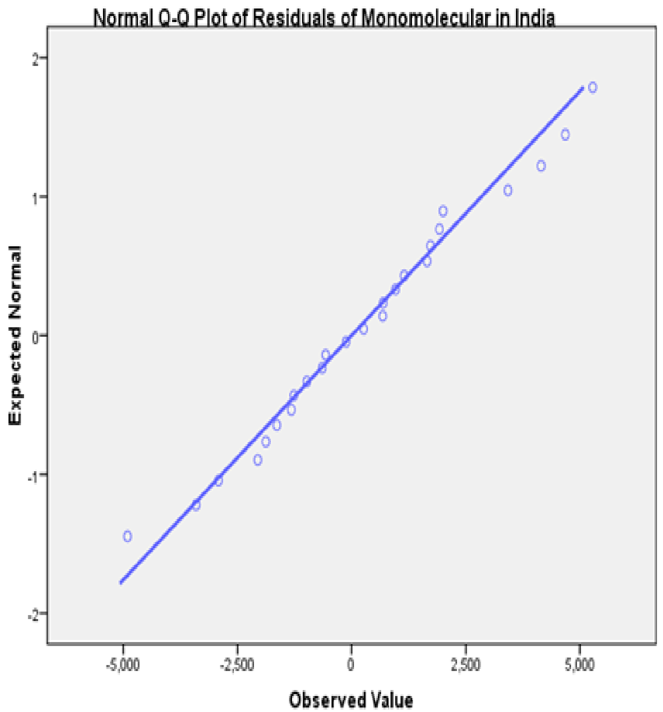

Fig. 2. Normal Q-Q plot of residuals of Monomolecular model fitted on fish seed production of India

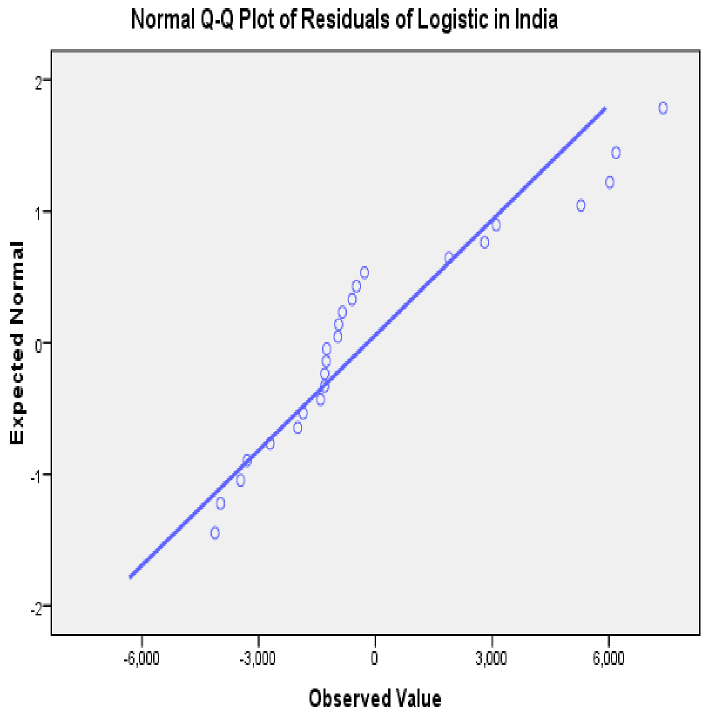

Fig. 3. Normal Q-Q plot of residuals of Logistic model fitted on fish seed production of India

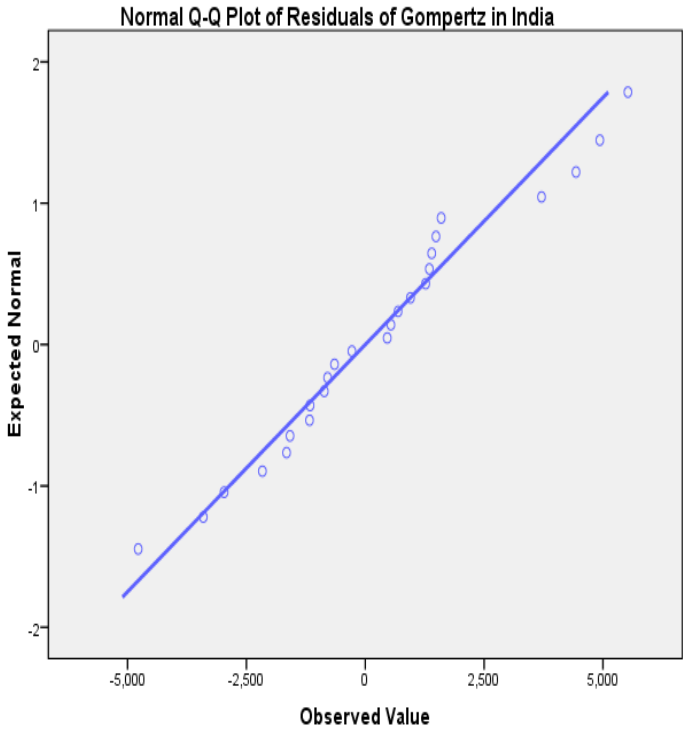

Fig. 4. Normal Q-Q plot of residuals of Gompertz model fitted on fish seed production of India

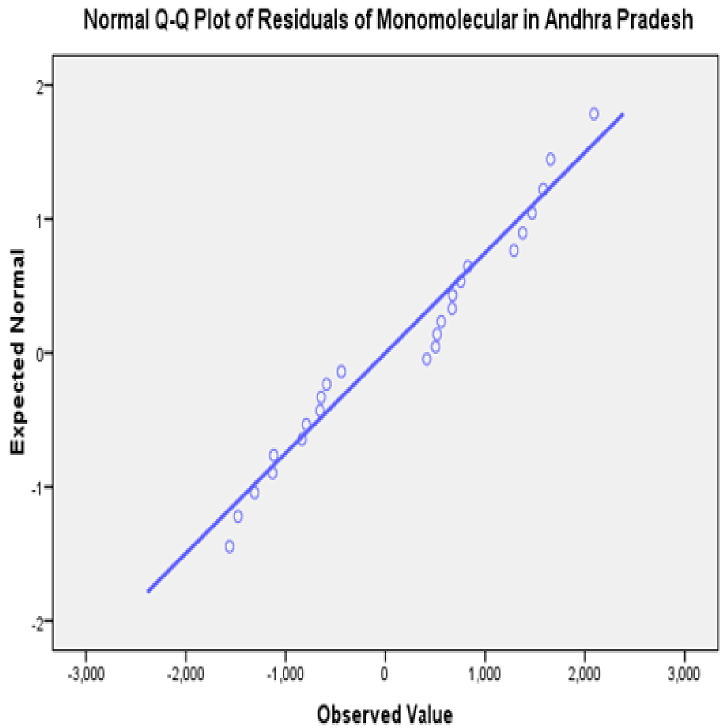

Fig. 5. Normal Q-Q plot of residuals of Monomolecular model fitted on fish seed production of Andhra Pradesh

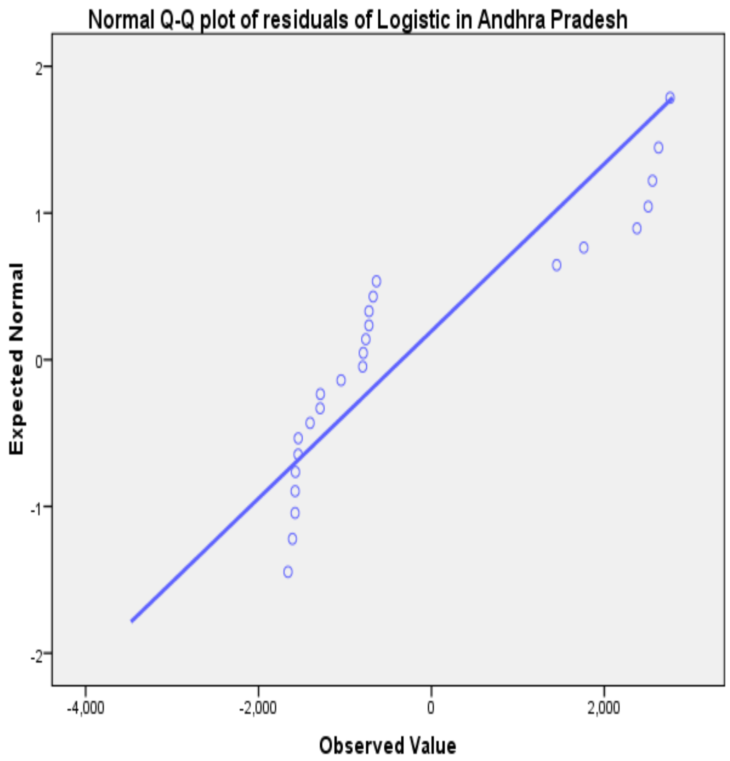

Fig. 6. Normal Q-Q plot of residuals of Logistic model fitted on fish seed production of Andhra Pradesh

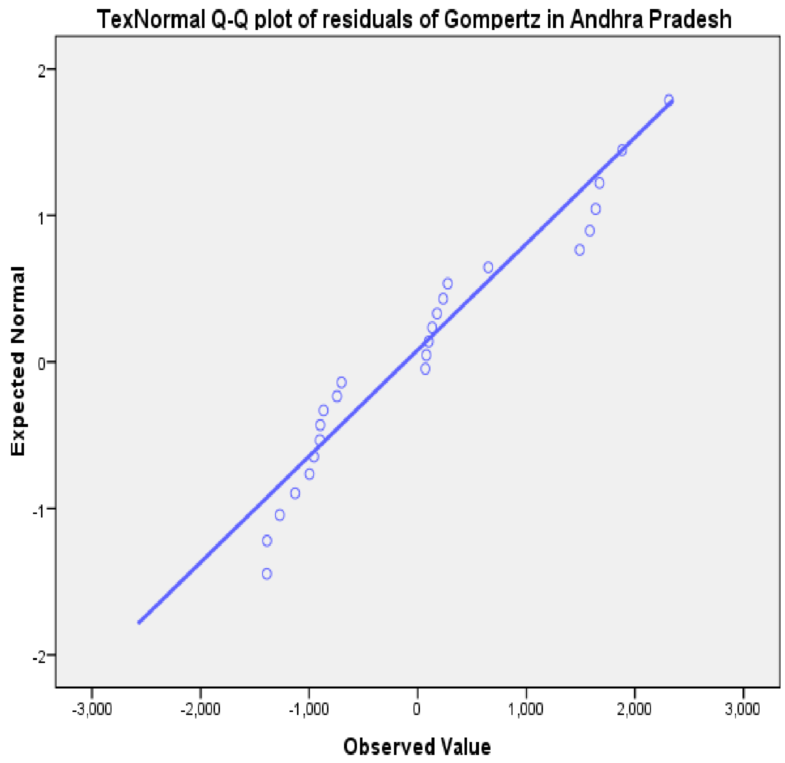

Fig. 7. Normal Q-Q plot of residuals of Gompertz model fitted on fish seed production of Andhra Pradesh

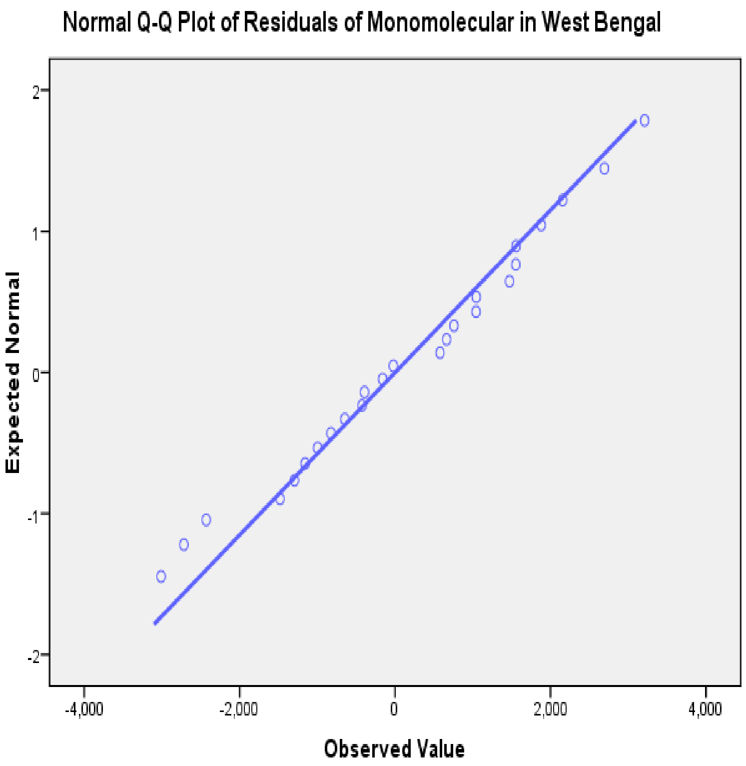

Fig. 8. Normal Q-Q plot of residuals of Monomolecular model fitted on fish seed production of West Bengal.

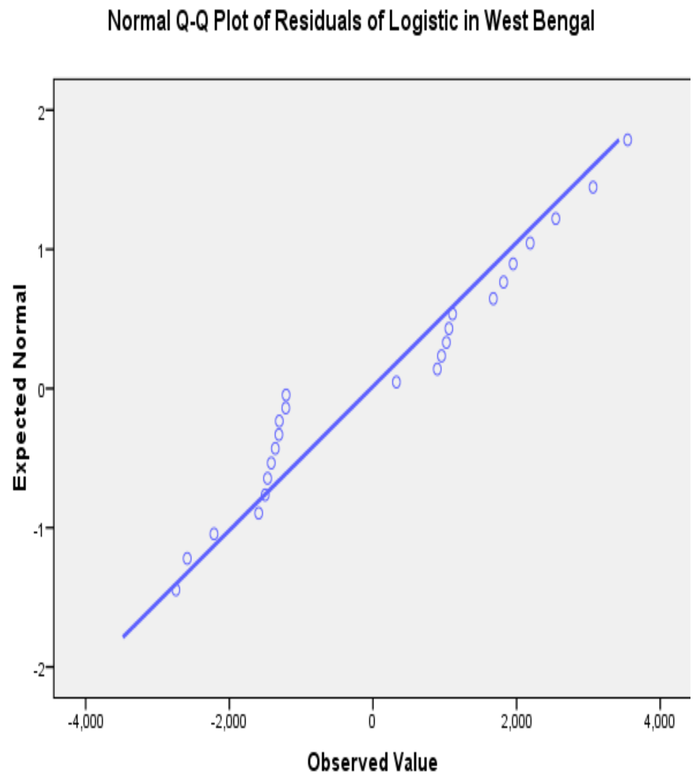

Fig. 9. Normal Q-Q plot of residuals of Logistic model fitted on fish seed production West Bengal

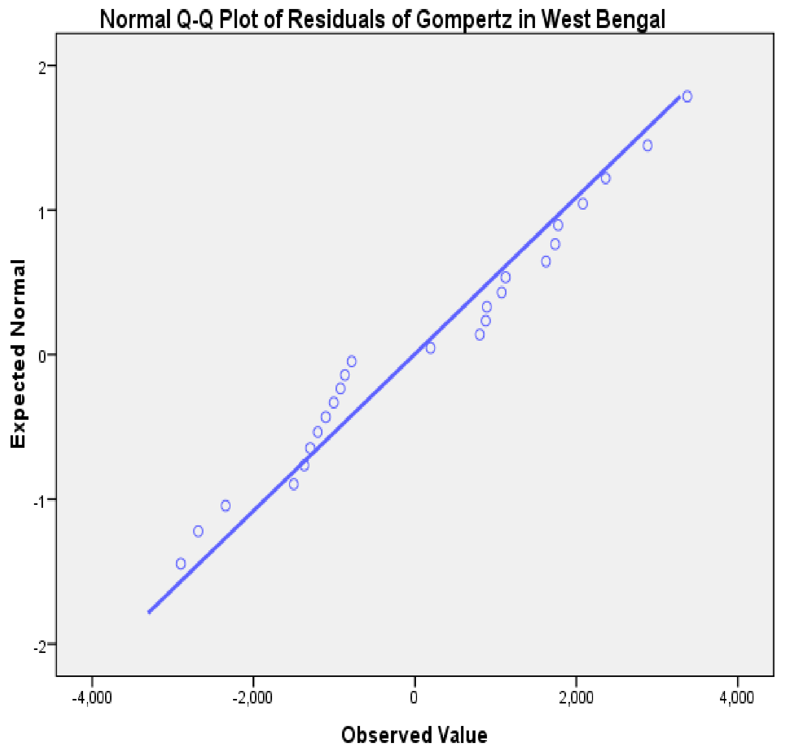

Fig. 10. Normal Q-Q plot of residuals of Gompertz model fitted on fish seed production West Bengal

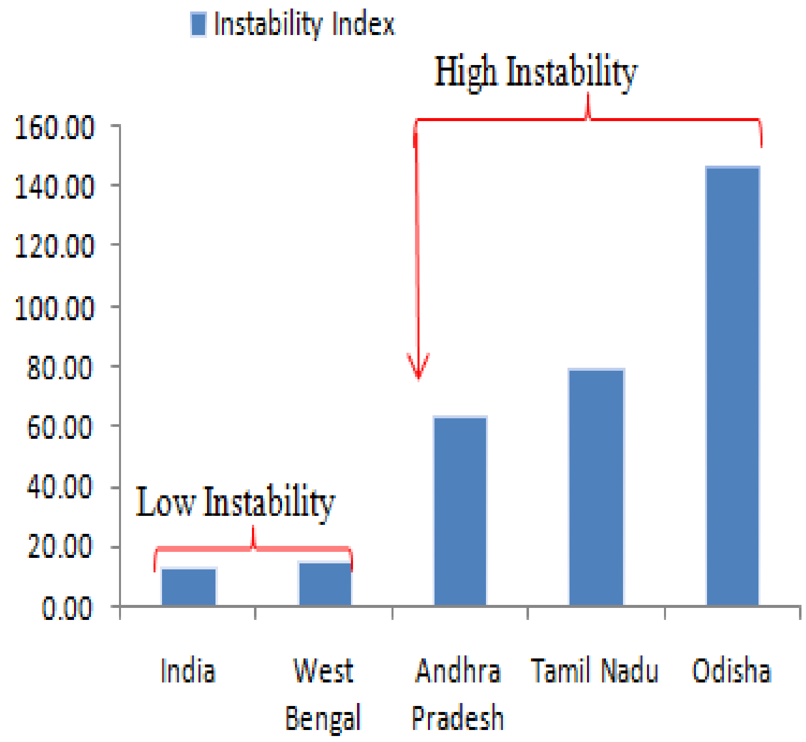

Fig. 11. Instability Index of Fish Seed Production for Estrean costal states of India

Model diagnostics of the fitted models were carried out using residual analysis. The main assumptions of 'independence' and 'normality' of error terms of each model were examined by using the 'Run-test' and 'Shapiro-Wilk test'. The test statisticsand probability values are presented in Table 3.

The results of both Shapiro-Wilk and Run Test Statistic values were found non-significant ($P > 0.05$) in all the models for the seed production data of India, Andhra Pradesh and West Bengal. Further, the normal Q-Q plots for all the three models revealed that residuals were normally distributed in state of Andhra Pradesh, West Bengal and India (Figs. 2 – 10). It is thus inferred that residuals i.e. the difference between predicted and observed value of seed production data, were normally and randomly distributed. Hence, the assumptions of independence, randomness of residual and normal distribution of residual were satisfied and accepted for the state of Andhra Pradesh, West Bengal and India as a whole.

Nevertheless, the Shapiro-Wilk test statistic values were found significant ($P < 0.05$) in all the models for the seed production data of Tamil Nadu and Odisha. Moreover, the run-test values were also found to be significant for all the models in states of Tamil Nadu and Odisha. It revealed that the residuals obtained did not follow the normality and random distribution. On observation of significance in the model while applying non-parametric tests like Monomolecular, Logistic and Gompertz, it could be understood that the prediction of fish seed production data for the state of Tamil Nadu and Odisha could not obtain properly compared to other states of Andhra Pradesh, West Bengal and India. The improper prediction of fish seed data for the state of Tamil Nadu and Odisha might be due to poor availability of observed fish seed production data collected during certain period of the study.

It is known that when the data doesn't fit for the normality, whatever the predictor values couldn't give proper sense. The pictograph form of interpretation and inference are given in Fig. 15 and Fig.16.

On the basis of model diagnostics and validation of fitted models, Monomolecular model was found as best described for the variability for fish seed production data of Eastern Costal States of India. Thus, the Predicted value corresponding to the observed value of fish seed production was computed by using Monomolecular model for all four states including India and are represented graphically in Fig. 12 and Fig.16.

It was observed that production of fish seed for the years 2008-09 and 2013-14 in India increased (9,411) slightly from the predicted value (8,671) though the production was negligible (Fig. 12). The increase might be due to demand for the fish seed for culture practices in the country [31] especially from states like Andhra Pradesh and West Bengal. Similarly negligible amount of decline was observed during the year 2015-16 and 2016-17 in the country. The sudden decline might be due to destruction of natural breeding grounds though natural and man-made activities undertaken for urbanization along the natural water bodies in certain states like West Bengal and Tamil Nadu. However, the seed production was almost uniform from 1994-95 to 2007-08 in India and in later years the production level gradually increased (Fig. 12). It might be due to the slower adoptability of the farmers to the hatchery produced seeds during the earlier period and later various new schemes and polices implemented by central and state governments in consequent years fetched improvement in technical efficiency among the farmers and establishment of increased number of fish seed hatcheries ultimately led to expansion of fish culture practices.

In Andhra Pradesh, the production of fish seed increased rapidly during the year 2011-12 and observed sharp decline during the year 2019-20 (Fig.13). The rapid increase production might be due to the demand for fish seed in view of expansion of culture area and sudden decline was due to covid-19 pandemic, lack of finance, poor marketing and non availability other logistics supports [32].

In West Bengal, it was observed that production of fish seed was rapidly increased in the year 2015-16 followed by 2008-09 and 2003-04 (Fig. 14). The rapid increase occurred due to emphasis on the production of improved fish seeds, fulfilling demands for seeds from other states like Andhra Pradesh, financial support from Government of India for establishing Fish Seed Multiplication Farms. However, in the state, a sudden decline in seed production was noticed during the year 2016-17. It might be attributed to poor water quality, brood stock availability and heavy seed mortalities due to high temperature [15]. Moreover, Prevailing demand of fish seed is reached at more than 1400 million standards fry against of which 2880 million have been produced in 2020-21. Fisheries sector is very importance in generating of employment [6].

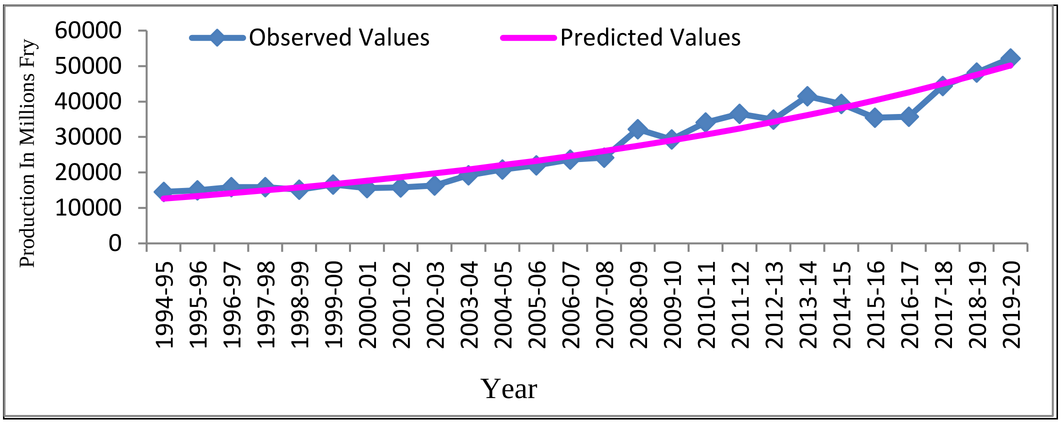

Fig. 12. Observed and Predicted values of fish seed production in India using Monomolecular model

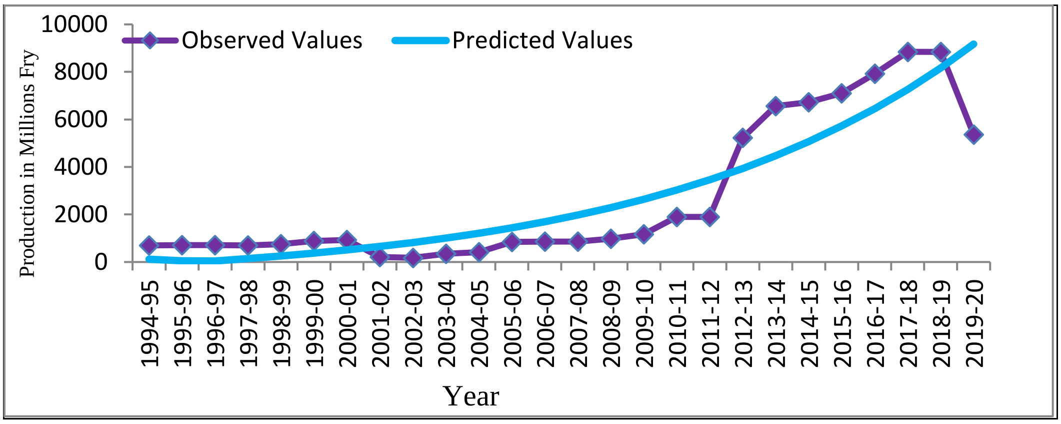

Fig. 13. Observed and Predicted values of fish seed production in Andhra Pradesh using Monomolecular model.

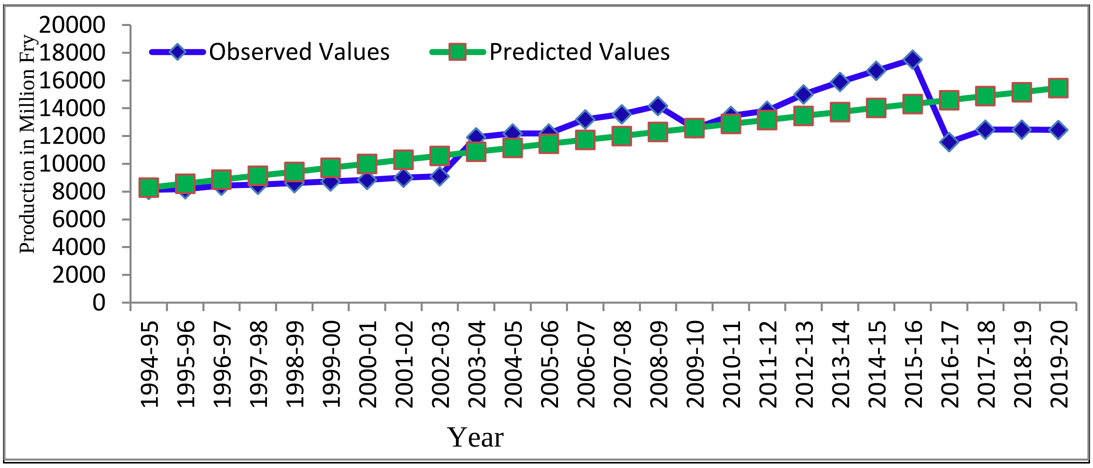

Fig. 14. Observed and Predicted values of fish seed production in West Bengal using Monomolecular model

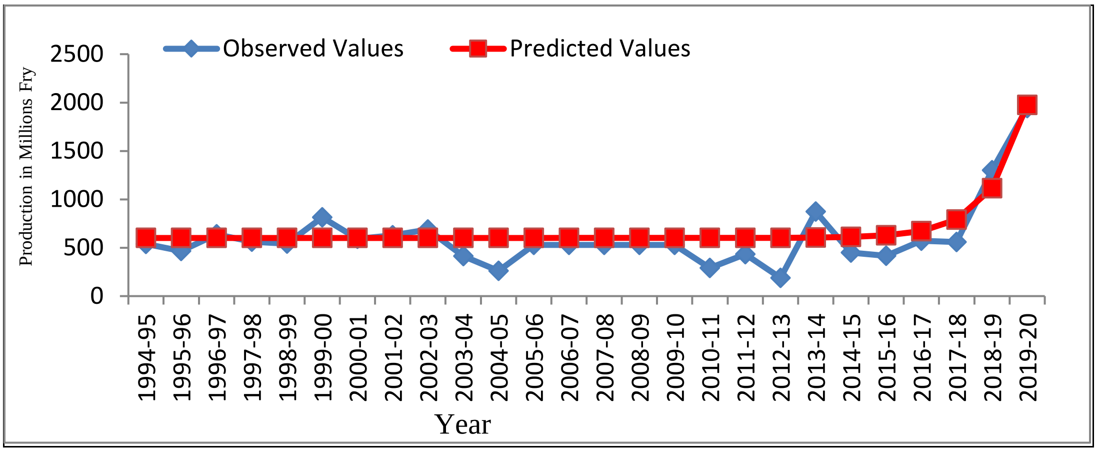

Fig. 15. Observed and Predicted values of fish seed production in Tamil Nadu using Monomolecular model

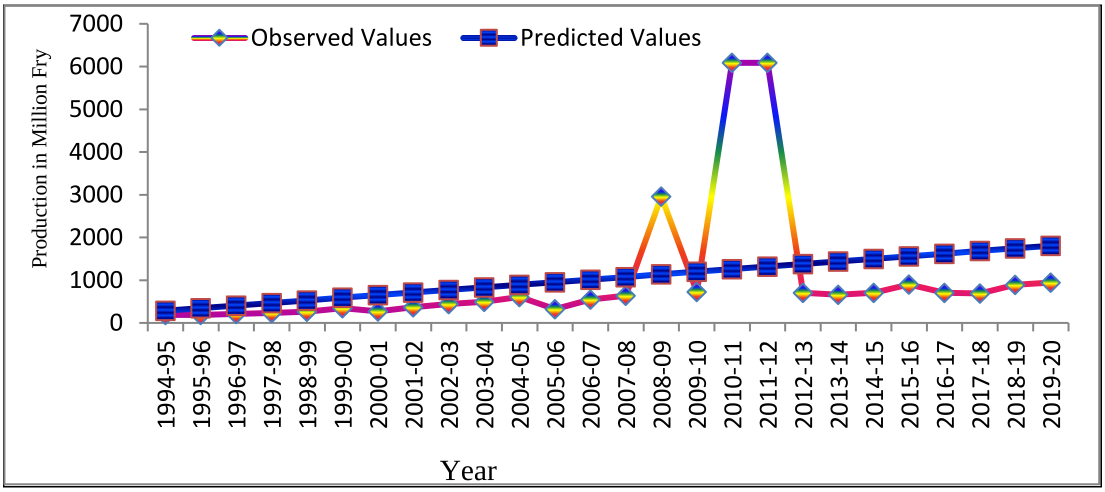

Fig. 16. Observed and Predicted values of fish seed production in Odisha using monomolecular model

In Odisha state, it was observed that the maximum increasing trend was observed in the year 2019-20 followed by 2013-14 and 1999-2000 respectively (Fig. 15). The increase of seed production might be due to demand for fish seed within the state. Maximum decline in the fish seed production was observed in the year 2004-05 followed by 2012-13 and 2010-11 respectively. The decline in the production might be due to poor weather an climate in the region during such periods.

In case of Tamil Nadu state, the maximum increasing trend was observed in the year 2010-11 and 2011-2012 followed by 2008-09 respectively (Fig.16). Similarly, maximum decline in the production was observed in the year 2005-06. The increase and decline in the production might be due to undulated demand and so their technical issues persist during such periods. However, the fish seed production was almost uniform from 1994-95 to 2004-05 and 2012-13 to 2019-20.

Instability index was calculated for the time series data of fish seed production for 26 years from 1994-95 to 2019-20 for the four state and India. The statistics calculated related to instability analysis are represented in Table 4 & Fig. 11. The linear model could be able to fit the data of fish seed production in India, Andhra Pradesh, Tamil Nadu, Odisha and West Bengal against time trend. The R^2 values for India, Andhra Pradesh, Tamil Nadu, Odisha and West Bengal are 91%, 69%, 10%, 9% and 62 % respectively.

Table 4. Instability index for fish seed production

Particulars	Instability Index	Production
India	C.V	42.66
	CDI	13.13
	R^2	0.91
Andhra Pradesh	C.V	110.73
	CDI	63.41
	R^2	0.69
Tamil Nadu	C.V	81.95
	CDI	79.30
	R^2	0.10
Odisha	C.V	150.68
	CDI	146.94
	R^2	0.09
West Bengal	C.V	23.58
	CDI	14.93
	R^2	0.62

Table 5. Forecasted values of fish seed production using monomolecular model

Year	India	Andhra Pradesh	West Bengal
2020-21	53363	10395	15746
2021-22	56359	11652	16033
2022-23	59522	13048	16320
2023-24	62860	14601	16607
2024-25	66383	16328	16894
2025-26	70101	18247	17182
2026-27	74026	20382	17469
2027-28	78169	22755	17756
2028-29	82541	25393	18043
2029-30	87156	28326	18330

The instability indices CV and CDVI indicated high instability in Odisha, Tamil Nadu and Andhra Pradesh during the study period whereas low instability was observed in West Bengal and India as a whole. The high instability in fish seed production in these three states might be due to problems related to technological development as well as infrastructural facilities which include availing credit, marketing, leasing and ownership of ponds etc [33,34]. Thus the appraisal study indicated obviously that demand for fish seed and fish culture practices are always undulating in the states of Tamil Nadu, Andhra Pradesh and Odisha compared to West Bengal.

The forecasted values were computed by using the best fit Monomolecular model and presented in Table 5. In which, the fish seed productions for the next 10 years from 2020-21 to 2029-30 for the states of Andhra Pradesh, West Bengal and India were forecasted. Monomolecular model reveals absolutely that the state of Andhra Pradesh will take over the West Bengal from the year 2025-26 onwards due to the expansion of aquaculture areas and increase in establishment of number of fish seed hatcheries [35-39].

4. CONCLUSIONS

The collected data on fish seed production from the Eastern Costal States of India for the period of last 26 years from 1994–95 to 2019–20 could be fit appropriately in the non linear model of Monomolecular compared to logistic and Gombertz model. Statistics of Run-test and Shapiro-Wilk described vividly that the difference between predicted and observed value of fish seed production for the period studied were normally and randomly distributed for the states of Andhra Pradesh, West Bengal and India. The CDV Instability index for Andhra Pradesh, Tamil Nadu and Odisha for the period of study revealed high instability in fish seed production while low instability in West Bengal and India as a whole. It is predicted that in the coming years, the state of Andhra Pradesh will produce more fish seed compared to other states.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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