Eco. Env. & Cons. 30 (July Suppl. Issue) : 2024; pp. (S62-S69)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2024.v30i04s.011

Forecasting of Fish Production of India using ARIMA Models

M. Rajani*[1], A. Balasubramanian[2] and O. Sudhakar[3]

[1, 2] College of Fishery Science, Andhra Pradesh Fisheries University, Muthukur, Nellore Dt. 524 344, Andhra Pradesh, India
[3]Officer on Special Duty, Andhra Pradesh Fisheries University, Vijayawada 521 134, Andhra Pradesh, India.

(Received 29 October, 2023; Accepted 21 December, 2023)

ABSTRACT

Fish is an essential component of the diet of the most popular in India. Fish production in India has increased at a higher rate compared to other food items. The most widely used time series models ARIMA was applied for modelling and forecasting of total, inland and marine fish production in India for a period from 1978-79 to 2021-22. The collected data during the third decade was found highly consistent and stable with less variability. The lowest mean fish production growth rate was observed in all three categories viz., Inland, Marine and Total fish production, in the fourth decade of study period, i.e., 2003-2012. Present study revealed that the model ARIMA (0,1,3) was best fit for forecasting marine fish production of India while ARIMA (0,2,1) was best model for both inland and overall fish production. The model forecasted that the fish production in all three categories would be in increasing trend for the next five years from 2022-23 to 2026-27 with highest estimated marine, inland and total fish production of 42.18 lakh tonne 162.78 lakh tonne and 211.64 lakh tonnes respectively during the year 2026-27.

Key words : *ARIMA, Fish Production, Growth, Forecasting.*

Introduction

India is vested with extensive fisheries resources accounting both marine and inland sector. These two sectors are the significant systems for the food production of the country that contribute to food and nutrition safety. Apart from that they act as a major source of livelihood for the coastal population and economy of the country. The inland fisheries resources of the country include a length of 191,024 kms of rivers and canals and 8.34 million ha area of reservoirs, ponds and tanks, beels, brackish water lakes, backwaters, floodplain lakes and derelict waters (CEBPOL, NBA, 2018). The marine water bodies are mainly used for capture fisheries resources while the inland water bodies are widely used for both culture and capture fisheries. The large network of inland water masses provides great potential for economic capture fishery. Fishery sector provides direct employment in the producing units (primary level) and indirect employment through its ancillaries and associated activities (Yadav *et al*., 2020).

Fish production plays a significant role in providing nutritional security, food security and employment in India. The demand for food production has significantly increased with the growth of the human population. The fish production from capture fisheries is declined drastically despite the demand for fish consumption is rising significantly since the fish are an excellent protein supplier having other

nutritional values and awareness among the public about the health benefits of fish consumption (Pradeep *et al.,* 2021). The additional demand for fish consumption can be fulfilled only through increasing the aquaculture practices (Saroj *et al.*, 2022). The decline in marine stocks worldwide has provided momentum for rapid growth in aquaculture which in-turn perches as one the fastest growing food producing sectors. At present, more than 40% of the total global fish production is contributed by aquaculture by farming more than 220 species of finfish and shellfish. India has also emerged as a one of the major fish producers through inland aquaculture and ranks second position in the world. The inland fish production has reached to the tune of 10.74 MMT in the country and more than 80% of production is from aquaculture sector only (Das *et al.,* 2022).

The global per capita fish consumption has risen from 9.0 kg in 1961 to 20.5 kg in 2019 and a slight decline to 20.2 kg in 2020 (FAO, 2022). The increase of global per capita fish consumption is due to increase of fish production. The present per capita consumption of India is only 6.31kg (Kritika *et al.,* 2023). The fish production forecast plays a imperative role in assessing the future demand of fish in India. In India, marine fish production has increased from 5.34 lakhs tons in 1950-51 to 41.27 lakhs tons in 2021-22, while the Inland fish production was from 2.18 lakhs tons in 1950-51 to 121.21 lakhs tons in 2021-22. In 1950-51 marine fish production accounted for 71.01%, and inland fish production accounted for 28.99% of the total fish production in India. However, in 2021-22 marine fish production accounted for 25.40%, and inland fish production accounted for 74.60% of the country's total fish production (Anon, 2022). The export of fish and fish products is also increasing in India accounting 13,69,264 MT of marine fish products worth Rs 57,586.48 crores (US$ 7.76 billion) during FY 2020-21(Anon, 2023).

Time series forecasting is a very useful technique for forecasting production and prices of aquaculture commodities. Autoregressive Integrated Moving Average (ARIMA) is one of the most traditional methods of non-stationary time series analysis. The ARIMA technique is better than regression analysis for predicting the significance of any variable (Anuja *et al.,* 2017). Paul *et al*., (2010) forecasted inland fish production of India using the ARIMA (1,2,1) model. Further, Yadav *et al.,* (2020) was estimated forecasting of fish production in Assam, India through the ARIMA models and suggested ARIMA (1, 1, 0) model was good and amenable to capture the trend of fish production in Assam. Similarly, Pradeep *et al.,* (2021) studied estimation of fish production in India using ARIMA, Holt's Linear, BATS and TBATS Models applying minimum goodness of fit values and found that ARIMA (2, 2, 1) and ARIMA (3, 2, 0) were the best-fitted models for forecasting inland and total fish production in India. Against this background, present study is attempted to analyze the increasing growth trend and for forecasting the inland, marine and total fish production in India using ARIMA models.

Materials and Methods

Data Collection: The time series data on fish production of marine and inland for a period of 50 years from 1950-51 to 2021-22 were collected from Hand Book on Fisheries Statistics, Department of Fisheries, Ministry of Fisheries, Animal Husbandry & Dairying Government of India, New Delhi (Anon, 2022). These data sources are authentic and reliable and time series data are mostly stationary in nature.

Statistical Tools: Out of five major forecasting techniques viz., exponential smoothing method, single equation regression models, simultaneous equation regression models, vector auto regression and ARIMA, the ARIMA model is more suitable for precise and accurate forecasting of any kind of production (Chaudhari and Tingre, 2013; Pal, *et al.,* 2007; Sagar *et al.,* 2016).

ARIMA: It is popularly known as Box – Jenkins (1970) methodology. The ARIMA model was used in this study for predicting upcoming marine and inland production in India. By using various ARIMA models, the best appropriate fitting model was identified.

While differentiating the time series data, the data follows both Auto Regressive (AR) and Moving Average (MA) models and thus it is known as autoregressive integrated moving average. In ARIMA (p, d, q) time series, 'p' denotes the number of autoregressive terms, 'd' refers integration, which means the number of times the series has to be altered before it becomes stationary, and 'q' is the number of moving average terms (MA).

Auto Regressive Process of order (p) is,

$$Y_t = \mu + \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots + \phi_p Y_{t-p} + \varepsilon_t;$$

Moving Average Process of order (q) is,

$$Y_t = \mu - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots - \theta_q \varepsilon_{t-q} + \varepsilon_t;$$

and the general form of ARIMA model of order (p, d, q) is

$$Y_t = \phi_1 Y_{t-1} + \phi_2 Y_{t-2} + \ldots\ldots + \phi_p Y_{t-p} - \theta_1 \varepsilon_{t-1} - \theta_2 \varepsilon_{t-2} - \ldots\ldots - \theta_q Y_{t-q} + \varepsilon_t$$

Where, Y_t is marine/Inland production, ε_t are independently and normally distributed with zero mean and constant variance for t = 1, 2,….., n; ϕ_p and θ_q are also estimated.

There are four steps required in this model fitting such as Model Identification, Estimation, Diagnostic Checking, and Forecast. The R software package was used in this study to estimate the parameters and fit the ARIMA model.

ARIMA model includes following steps

Model Identification: At first, the data were checked for stationarity with the help of the autocorrelation function (ACF) and partial autocorrelation function (PACF). The next step in the identification process was to find the initial values for the orders of non-seasonal parameters 'p' and 'q', which are obtained by looking for significant correlations in the ACF and PACF plots.

Estimation: Generally, this calculation is done by simple least squares but sometimes it has to be resorted to nonlinear (in parameter) estimation methods. Since software packages are available for easy and convenient usage, statistical R- software 4.2.2 Version was used for modelling and predicting marine and inland fish production in India.

Diagnostic Checking: For the adequacy of the model, the residuals were examined from the fitted model and alternative models were also considered whenever required. If the first identified model appeared to be inadequate then other ARIMA models were tried until a satisfactory model fits to the data. Different models were obtained for various combinations of AR and MA individually and collectively, the best model was obtained based on minimum value of Akaike Information Criteria (AIC) given by;

AIC= -2 log L+2m, where, m=p+q and L is the likelihood function.

The performances of different approaches were evaluated on the basis of Bayesian Information Criterion (BIC), Mean Absolute Percentage Error (MAPE) and Root Mean Square Error (RMSE).

Forecasting: Forecasting is the ultimate step in ARIMA modelling. As a first step of forecasting, the model's accuracy with all the competing models was compared followed by five-year forecast from 2022-2023 to 2026-2027 was done as forecasting errors increase rapidly if go too far out in the future.

Results and Discussion

The enhancement of fisheries sector in India can be classified into three phases. During the first phase 1950 – 66, fish landings were remained below one million tonnes obtained mainly from non-mechanized indigenous crafts and gears. The second phase spanning from 1967- 86 was featured with increased mechanization, improved gear materials, introduction of motorized country crafts, expansion in export trade, etc. The third phase during 1987 – 2022 was witnessed with an intensification of mechanization as well as motorization of country crafts, modification of gears, multi-day voyage fishing and expansion of fishing grounds (Anon, 2021). All India data of marine, inland and total fish production collected from 1950-51 to 2021-22 for the present study are presented in Figure 1.

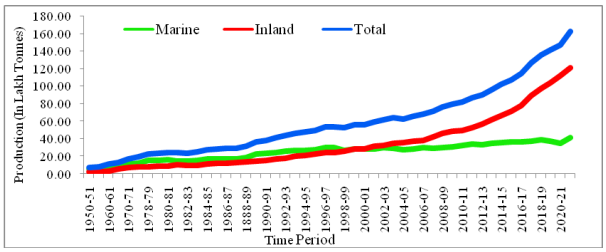


Fig. 1. Marine, Inland and Total Fish Production of India.

It is evident from the Figure 1 that, increasing trend was observed in all three cases of marine, inland and total fish production during the period of 50 years from 1950-51 to 2021-22 despite the trend in marine fish production did not raise heavily unlike inland fish production and total fish production. Fish production in India has witnessed a tremendous growth by showcasing a production increase from 7.52 lakh tonnes (total production), 5.34 lakh tonnes (marine) and 2.18 lakh tonnes (inland) during 1950-51 to 162.48 lakh tonnes (total production), 41.27 lakh tonnes (Marine) and 121.21 lakh tonnes (Inland) in 2021-22.

A remarkable average production has been witnessed in Indian marine and inland fisheries in the past five decades by rising from 1.11 MMT in marine and 0.62 MMT in inland during period 1951-82

to 3.65 MMT in marine and 8.60 MMT in inland during period 2013-2022 (Table 1).

The coefficient of variation in marine fish production during 1951-1982 was 34.74% which reduced to 4.63% during the period 1993-2002 and later increased to 6.31% during 2013-2022. Similarly, the CV for inland fisheries production declined from 1951-1982 to 1993-2002 from 44.64% and 17.27% respectively showing high fluctuation in the fish production. CV value for both inland and marine and total fish production decreased from first decade to third decade and found least during the third decades in all three categories which indicated that the production data were consistent and high stable with less variability.

During the second decade 1983-1992, mean fish production growth increased significantly with maximum growth rate of 67.09% in marine fisheries and 80.46% in total fish production, which could be attributed to the introduction of motorized country crafts, modification of gears, multi-day voyage fishing and expansion of fishing grounds. However, the mean growth rate in all three categories of fish production gradually declined upto fourth decade i.e. 2003-2012. The reduced production might be depletion of wild fish stocks due to sudden development in mechanization which led to overexploitation, natural calamities, environmental and disease problems. Nevertheless the mean fish production in all three categories increased in fifth decade, i.e. 2013-2022 and during this period the inland fisheries increased significantly compared to marine production with maximum growth 105.67%, which could be due to introduction of increment in fish seed production, adoption of new technology, culture activities, species, and also through the holistic approach adopted (Paul *et al.*, 2015; Hemant, 2017). It indicated that production could be increased inland fisheries as it offers immense opportunity and potential to enhance production through optimal utilisation of fisheries, technology infusion and capacity building.

ARIMA Models

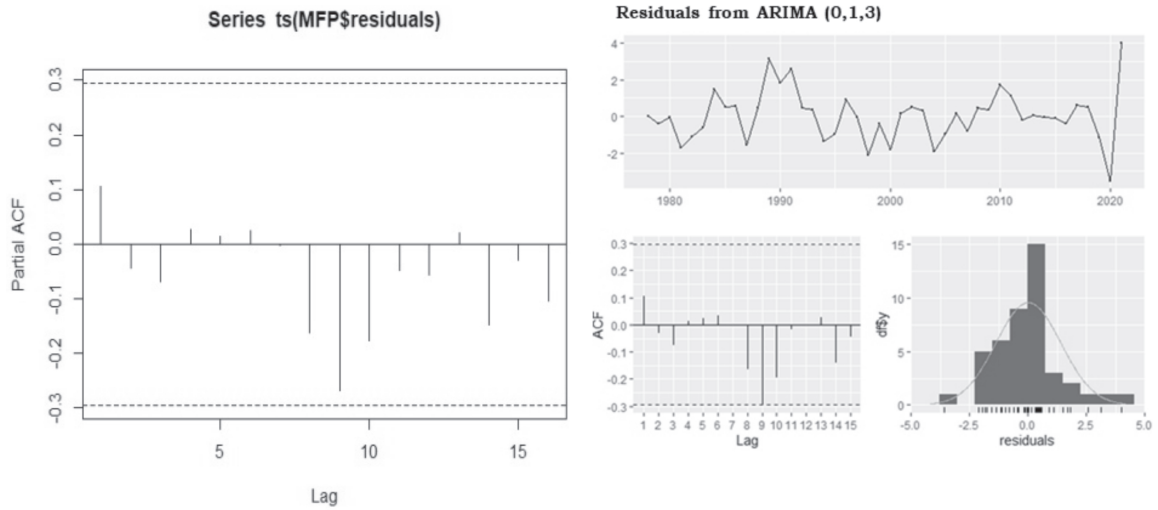
The dataset contains time series data from 1950-51 to 2021-22 about the inland, marine and total fish production in India. However, the fish production data from 1978-79 to 2021-22 was utilized for this study. The stationarity of data is checked with the help of ACF and PACF and presented in Fig. 2. The observed values of ACF and PACF from the figure, it could be understood that the observed values fall between -0.3 to 0.3 which indicates that the data are stationary. In R software all ARIMA models were tested for determining accurate fit based on the criteria of minimum AIC values and the values are given in Table 2.

Among the comparison of ARIMA models, the best fitted ARIMA models for marine, inland, and total production are ARIMA (0, 1, 3), ARIMA (0,2,1) and ARIMA (0,2,1) respectively. As shown in the residual plot, the individual autocorrelation coefficient at lag 15 is within the 95 percent confidence limit, confirming good fit of the selected models (Figure 2). The model which had minimum value of BIC, RMSE and MAPE among the chosen models was selected as best-fit model.

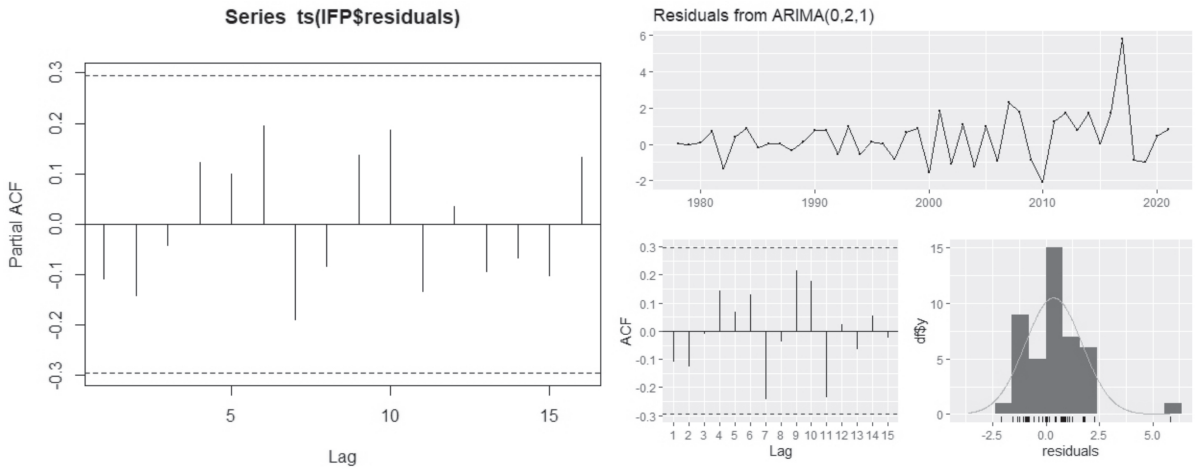
The ARIMA (0, 1, 3) has least AIC (162.2887) value and thus model was considered for best fit ARIMA Model for marine fish production in India. On further analysis, the other diagnostic parameters BIC (171.09), RMSE (1.38) and MAPE (3.95) also endorsed that the chosen ARIMA (0,1,3) model is a good fit and can be used for forecasting (Table 2). Similarly ARIMA (0,2,1) was selected as a best fitted model for both inland and total fish production as it had minimum value of AIC goodness of fit criteria. The ARIMA (0,2,1) yielded minimum AIC value of 151.14 for Inland fish production and thus the model was selected as best fit ARIMA Model for

Table 1. Decade wise mean production, coefficient of variation and growth rate for Indian fish production from 1950-51 to 2021-2022

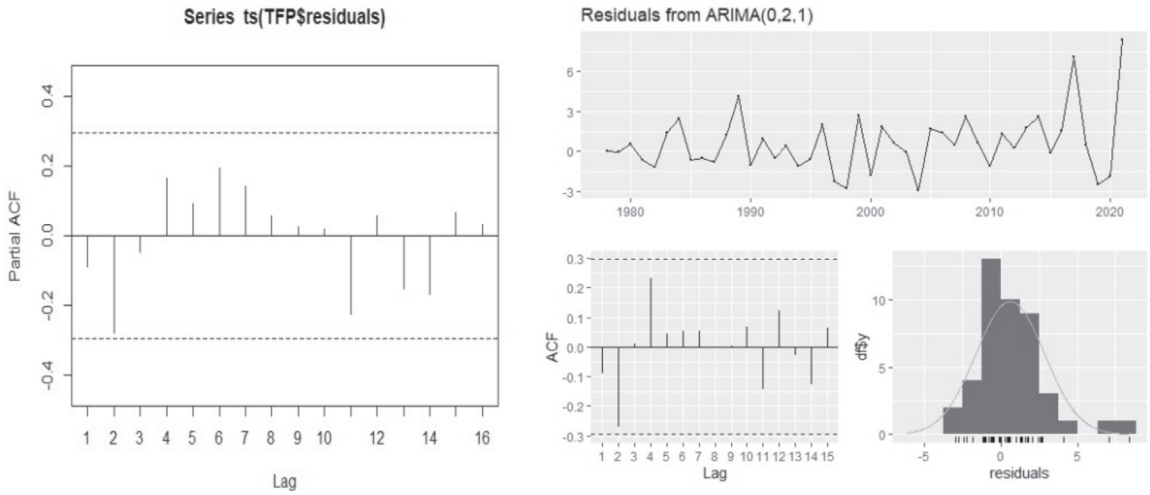
Period	Average landings Production (In Tonnes)			CV(%)			Growth (%)		
	Marine	Inland	Total	Marine	Inland	Total	Marine	Inland	Total
1951-1982	1111400	621600	1733000	34.74	46.64	38.51	-	-	-
1983-1992	1857000	1270300	3127300	19.04	18.88	18.65	67.09	104.36	80.46
1993-2002	2771000	2433800	5204800	4.63	17.27	9.69	49.22	91.59	66.43
2003-2012	3017400	4180900	7198300	6.07	17.44	12.23	8.89	71.78	38.30
2013-2022	3649700	8598900	12248600	6.31	25.97	19.63	20.96	105.67	70.16



a. Residuals from ARIMA (0, 1, 3) - Marine Fish Production



b. Residuals from ARIMA (0, 2, 1) – Inland Fish Production



c. Residuals from ARIMA (0, 2, 1) - Total Fish Production

Fig. 2. ACF, PACF and residuals for best fit ARIMA model

inland fish production. On further analysis of the model, the other diagnostic parameters BIC (154.61), RMSE (1.36), MAPE (3.03) also indicated that model is good fit and could be used for forecasting. As described earlier, the same, the ARIMA (0,2,1) model was found as best fit model for total fish production also as it yielded minimum AIC value of 195.52. Further analysis also proved that ARIMA (0,2,1) was best fit for total fish production by evaluating other diagnostic parameters like BIC (199.00), RMSE (2.30) and MAPE (0.48). It indicated that ARIMA (0,2,1) is the best accurate forecasting model compared with other ARIMA models (Table 2) and all these parameters differed significantly ($P<0.01$). The finding of the present study is concurrent with the finding of Boruah *et al.,* (2020) and Mahalingaraya (2018) who forecasted the total fish production of India using the same ARIMA models.

Forecasting

After development of the best fit time series model, forecasting was carried out for all the data series of fish production. With respect to all time series, the residuals of the chosen models were determined to be stationary. Using the best-fit models, the anticipated values of fish production for inland, marine and total for the next five years from 2022-2023 to 2026-2027 were forecasted (Figure 3). All the forecast points lie in-between the confidence interval of upper and lower limit of 80% and 95% level (Table 3). All the information about the forecasting from best fit model is given in Figure 3. The blue colour line indicates the forecast values which lie within the confidence limit of upper 95 % and lower 80% level and confirmed that the selected models yielded good prediction of fish production for the next five years.

On overall forecasted values of inland, marine and total fish production for the next five years from 2022-23 to 2026-27, it can be interpreted that there is a possibility of increasing trend in the fish production of all three categories. In the marine fish production, it can be estimated as 42.74 lakh tonne in the year 2026-27 despite a fall seems to be appeared in production during the year 2023-24. However, in the case of inland fish production, a steady increment can be observed with the predication of highest production of 162.78 lakh tonne in 2026-27.

Similarly, a steady increasing trend of total fish production can be anticipated with the maximum production of 211.64 lakh tonne in 2026-27. The forecast indicates the positive growth in the country's fish production with good scope and possibility of improving the fish production in the country

Table 2. Diagnostic Checking and Model Fit

Marine Fish Production ARIMA Model Identification		Inland Fish Production ARIMA Model Identification		Total Fish Production ARIMA Model Identification	
Models	AIC	Models	AIC	Models	AIC
ARIMA(2,1,2)	166.0118	ARIMA(2,2,2)	Inf	ARIMA(2,2,2)	Inf
ARIMA(0,1,0)	164.8615	ARIMA(0,2,0)	158.9408	ARIMA(0,2,0)	205.0531
ARIMA(1,1,0)	165.8423	ARIMA(1,2,0)	153.9326	ARIMA(1,2,0)	203.0480
ARIMA(0,1,1)	164.4278	ARIMA(0,2,1)	151.1384	ARIMA(0,2,1)	195.5253
ARIMA(0,1,0)	168.9 621	ARIMA(1,2,1)	153.0732	ARIMA(1,2,1)	197.4870
ARIMA(1,1,1)	Inf	ARIMA(0,2,2)	153.0242	ARIMA(0,2,2)	197.1470
ARIMA(0,1,2)	163.7176	ARIMA(1,2,2)	152.0265	ARIMA(1,2,2)	199.3050
ARIMA(1,1,2)	164.3378				
ARIMA(0,1,3)	162.2887				
ARIMA(1,1,3)	162.5632				
ARIMA(0,1,4)	162.2913				
ARIMA(1,1,4)	164.2669				

Model fit statistics of the fitted ARIMA model for marine, inland and total fish production in India (1978-79 to 2021-22)

Variables	Best fitted ARIMA Model	AIC	BIC	MAPE	RMSE
Marine	ARIMA(0,1,3)	162.29	171.09	3.95	1.38
Inland	ARIMA(0,2,1)	151.14	154.61	3.03	1.36
Total	ARIMA(0,2,1)	195.53	199.00	0.48	2.30

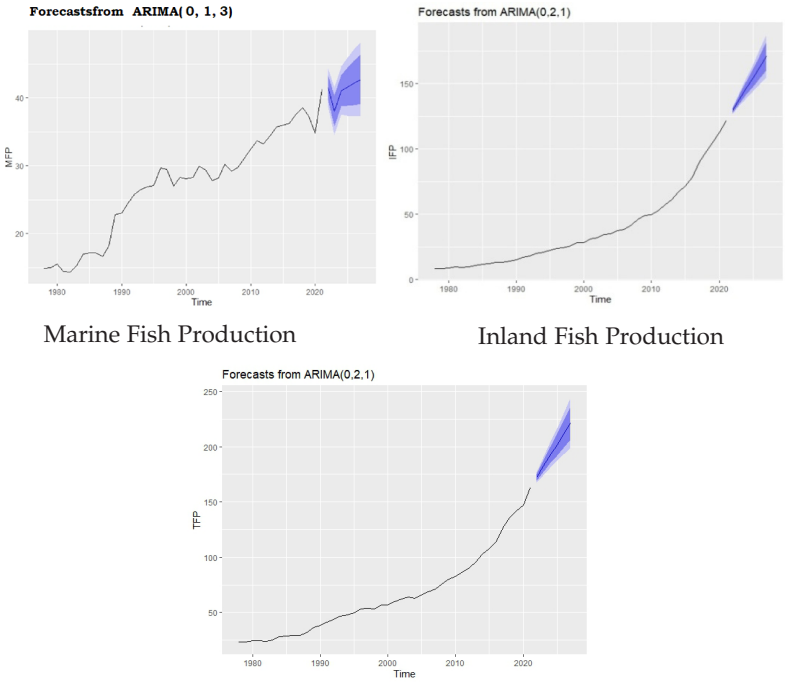


Fig. 3. Actual and forecast values from best fit ARIMA model

through adopting various management strategies and technical advancement. The forecast of increasing trend of all three categories of fish production could be achieved by expanding aquaculture area in both inland and marine region, converting wetlands into production site, adopting new technology, introduction of new species for culture, maintaining the wild fish resources in sustainable manner and preventing IUU fishing in Indian waters.

Conclusion

The maximum average growth of 105.67% in inland production was observed during 2013-2022 while

Table 3. Forecasting of Marine, Inland and Total Fish Production by ARIMA (in Lakh Tonnes)

S.No	Year	Forecast	Lo 80	Hi 80	Lo 95	Hi 95
		Marine Production - Fitted ARIMA (0,1,3) Model for Forecasting				
1	2022-2023	41.50	39.63	43.37	38.63	44.36
2	2023-2024	41.06	38.75	43.38	37.52	44.61
3	2024-2025	41.62	38.81	44.43	37.32	45.92
4	2025-2026	42.18	38.95	45.41	37.24	47.12
5	2026-2027	42.74	39.14	46.34	37.24	48.24
		Inland Production- Fitted ARIMA (0,2,1) Model for Forecasting				
1	2022-2023	129.52	127.72	131.33	126.77	132.28
2	2023-2024	137.84	134.57	141.11	132.84	142.84
3	2024-2025	146.15	141.25	151.06	138.66	153.65
4	2025-2026	154.47	147.76	161.17	144.21	164.72
5	2026-2027	162.78	154.11	171.46	149.51	176.05
		Total Production- Fitted ARIMA (0,2,1) Model for Forecasting				
1	2022-2023	172.31	169.26	175.36	167.65	176.98
2	2023-2024	182.14	177.00	187.29	174.28	190.01
3	2024-2025	191.97	184.64	199.31	180.75	203.20
4	2025-2026	201.81	192.12	211.49	186.99	216.62
5	2026-2027	211.64	199.44	223.84	192.98	230.30

minimum average growth of 8.89% in marine production was observed during 2003-2012. Among different models tested, ARIMA (0,1,3) was chosen as the best fit model for marine fish production while ARIMA (0,2,1) was selected as the best fit model for both inland and total fish production based on their minimum goodness of fit values. In the coming next five years from 2022-23 to 2026-27, the projected values based on the best fit models in all areas like's marine, inland and total fish production will steadily be increased. The forecasted marine fish production during the year 2026-27 for Marine, Inland and Total fish production would be 42.18 lakh tonnes, 162.78 lakh tonnes and 211.64 lakh tonnes respectively. It indicated that there would be possibility of increasing production through advancement of technical skills and adoption of new management strategies in sustainable manner.

Acknowledgements

The authors thank to an anonymous reviewer and the journal editor for their helpful and valuable comments.

Conflicts of Interest

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

References

Anon, 2021. Trend analysis of Marine Fisheries of India. Posted by vikaspedia. https://vikaspedia.in/agriculture/fisheries/marine-fisheries/capture-fisheries/trend-analysis-of-marine-fisheries-of-india.

Anon, 2022. *Hand Book on Fisheries Statistics*, Department of Fisheries Ministry of Fisheries, Animal Husbandry & Dairying Government of India, New Delhi. https://dof.gov.in/sites/default/files/2021-02/Final_Book.pdf.

Anon, 2023. Ministry of Commerce & Industry, Posted On 2023 by PIB Delhi. https://pib.gov.in/PressRelese Detailm.aspx?PRID=1898018.

Anuja, A., Yadav, V.K., Bharti, V.S. and Kumar, N.R. 2017. Trends in marine fish production in Tamil Nadu using regression and autoregressive integrated moving average (ARIMA) model. *Journal of Applied and Natural Science*. 9(2): 653-657, doi: 10.31018/jans.v9i2.1252.

Boruah, B.B., Pinky, R., Anupam, D. and Bidyutt, B.H. 2020. Forecasting Marine And Total Fish Production In India Using ARIMA Models. *Indian Journal of Economics and Business*. 19(2): 161-174.

Box, G.E.P. and Jenkins, G.M. 1970. Time Series Analysis, Forecasting and Control. Holden Day, *San Francisco*. 46-87.

CEBPOL, NBA. 2018. Mainstreaming Biodiversity: Inland Fisheries and Aquaculture - A key for food and nutritional Security, Published by the *Centre for Biodiversity Policy and Law, National Biodiversity Authority*, 5p.

Chaudhari, D.J. and Tingre, A.S. 2013. Forecasting of milk production in India: An application of ARIMA model. *Indian J. Dairy Sci*. 66: 72-78.

Das, P.C and Shajahan Ferosekhan, S. 2022. Recent Advances in Carp Culture in India. *Director, ICAR-CIFRI; Convener, 1st Indian Fisheries Outlook; President, PFGF*.73-83.

FAO. 2022. The State of World Fisheries and Aquaculture 2022. Towards Blue Transformation. Rome, FAO. https://doi.org/10.4060/cc0461en.

Hemant, S. 2017. Growth and Instability of Inland Fish Production in India. *Fishery Technology*. 54: 155–161.

Kritika, P., Manoj, K.J. and Babita, S. 2023. Understanding the systematics and ecology of freshwater fish Clarias batrachus: A first step towards its Conservation. *International Research Journal*. 10(9): a870-a878.

Mahalingaraya, Santosha, R, Kanchan, S., Shekhawat, R.S and Shashikala, C. 2018. Statistical Modeling and Forecasting of Total Fish Production of India: A Time Series Perspective. *International Journal of Current Microbiology and Applied Sciences*. 7(3): 1698-1707.

Pal, S., Ramasubramanian, V. and Mehata S.C. 2007. Statistical Models for Forecasting Milk Production in India. *J. Ind. Soc. Agril. Statist*. 61: 80–83.

Paul, P. and Nilay, K.B. 2015. Present Scenario, Problems and Prospects of Inland Fishing of West Bengal, India. *Geography*. 5(7): 128-130.

Paul, R.K. and Das, M.K. 2010. Statistical modelling of inland fish production in India. *Journal Inland Fish. Soc. India*. 42(2): 1-7.

Pradeep, M., Ray, S., Tiwari, S., Badr, A. and Balloo, R. 2021. Estimation of Fish Production in India using ARIMA, Holt's Linear, BATS and TBATS Models. *Indian Journal of Ecology*. 48(5): 1254-1261.

Sagar, S.D. and Paramasivam, R. 2016. Forecasting of milk production in India with ARIMA and VAR time series models. *Asian J. Dairy & Food Res*. 35(1): 17-22.

Saroj, K.S. and Ferosekhan, S. 2022. Present Status and Future Scope of Freshwater Aquaculture Sector in India, Director, ICAR-CIFRI; Convener, 1st Indian Fisheries Outlook; President, PFGF.84-99.

Yadav, A.K., Kishore, K.D., Pronob, D., Rohan, K.R., Jeetendra, K. and Basanta, K.B. 2020. Growth trends and forecasting of fish production in Assam, India using ARIMA model. *Journal of Applied and Natural Science*. 12(3): 415 - 421. https://doi.org/10.31018/jans.v12i3.2353.