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FORECASTING MARINE AND TOTAL FISH PRODUCTION IN INDIA USING ARIMA MODELS

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Abstract: Fish has a significant role in resisting hunger and malnutrition. Fish supplies protein and healthy fats to our diet and is also the unique source of essential nutrients like long-chain omega-3 fatty acids, iodine, vitamin D, and calcium. India is the second-largest producer of Fish after China. The fisheries production division is one of the most important divisions of the Indian economy; it gives more than 5% to the agricultural GDP. The Box-Jenkins model was used in this study to estimate the trend and growth rate of Inland and Total Fish production in India from 1978-2018. The secondary data was used in this study, collected from the Ministry of Agriculture and Farmers Welfare, Govt. of India. Between 1978 to 2018, Total fish production in India increased about 2306 thousand tons to 12606 thousand tons and Marine fish production about 1490 thousand tons to 3688. The result showed that ARIMA (0, 2, 1) and ARIMA (0, 2, 1) were the best-fitted models for Marine and Total fish production in India. Moreover, we used the developed model to forecast the Marine and Total fish production in India for the next 20 years up to 2038. It concluded that the production rate of Total fish was found higher than the Production rate of Marine fish in India.

Keywords: Forecasting, Autoregressive Integrated Moving Average (ARIMA), Fish Production.

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1. Introduction:

The demand for food production has significantly increased with the growth of the human population. Since fish are an outstanding protein supplier, the demand for fish has been substantially increased. According to the 2020 State of the World Fisheries Report, per capita fish consumption has risen from 9.0 kg in 1961 to 20.5 kg in 2018. India is the world's second-largest producer of fish, aquaculture production, and inland capture fisheries. Fish production plays a key role in providing nutritional security, food security, and employment in India. Over 14.5 million people are engaged at the primary level and many more along the value chain in the fisheries sector of India [1].Mangrove's influence is essential to increase the production of fish in India. It has a positive impact on commercial fish production and the technical efficiency of fish production [2]. India is a tropical country, and it has almost 2.02 million square kilometers of the exclusive economic zone due to its highly diverse nature

[3]. Despite such increment, India is at the lower stage of using aquatic resources and fish for protein and nutritional security [4]. The production forecast of fish plays a vital role in meeting the future demand for fish in India. In India, marine fish production has increased from 5149 thousand tons in 1950-51 to 3688 thousand tons in 2017-18 while; the Total fish production had increased from 2306 thousand tons in 1950-51 to 12606 thousand tons in 2017-18. In 1950-51 marine fish production accounted for 28.98%, and inland fish production accounted for 71.01% of the total fish production in India. However, in 2017-18marine fish production accounted for 29.26%, and inland fish production accounted for 70.73% of the country's total fish production. In 2017-18 compared to 2016-17, the average growth rate in fish production is10.14%. In India, Andhra Pradesh is the largest producer of inland fish, and Gujarat is the largest marine fish producer.The export of fish and fish products is also increasing in India. India exported 13 77,243.70 tons fish worth 45,106.90 crores in 2017-18. Time series modeling is an important tool for managers and scientists [5].

Autoregressive Integrated Moving Average (ARIMA) technique is better than Regression Analysis for predicting the significance of any variable [6].[7] in his paper forecasting and modeling India's marine and inland fish production through the ARIMA models. He had concluded by suggesting ARIMA (0, 1, 0) model was appropriate for both marine and inland food production in India. By using ARIMA, Holt’s Linear, BATS, and TBATS models[8]estimated the fish production in India. His study based on minimum goodness of fit values 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. Similarly, the Box-Jenkins methodology [9] tried to forecast fish production in Pakistan for the year 2017-2026. He found ARIMA (2, 1, 3) was the most suitable model with minor forecast error. From 2017-2026 he observed a significant increment, from 619.624 to 724.750 tons.Further, [5] tried to forecast the fresh water and marine fish production in Malaysia using ARIMA and ARFIMA models. However, in this study, both ARIMA and ARFIMA models were inadequate to forecast the production because the absolute values were found outside the 95 percent forecast interval. An effort was made by [10] to compare the ARIMA, Holt-Winters, and NNAR models, for forecasting fish production on the northeast coast of India.His study concluded that Holt-Winter’s model has better forecasting capability than ARIMA and NNAR models. In Tamil Nadu (INDIA), [6] applied the ARIMA and Regression model to study fish production trends and forecast upcoming years. He developed ARIMA (1, 1, 1) model for marine fish production in Tamil Nadu. [11] also, use the ARIMA model for forecasting fish production in Assam (INDIA). Furthermore, found ARIMA (1, 1, 0) was the best model for forecasting fish production in Assam. Similar studies have been done by [12] for forecasting the fish production in Odisha (INDIA) using the Seasonal ARIMA models. Also, the Time Series forecasting model has been used by [13] for forecasting fish production in Chilika lagoon, Odisha (INDIA). Besides fisheries, ARIMA modeling was also used in cotton production[14], rice production[15], wheat production[16], and onion production[17], etc.

Against this background, an attempt was conducted to examine the increasing trend and forecast the Marine and Total fish production in India using ARIMA models.

2. Data and Methodology:

The time-series data on marine and total fish production in India is taken from the Department of Animal Husbandry, Dairying and Fisheries (DAHD), Ministry of Agriculture and Farmers Welfare, Govt. of India. Corresponding data set covering 40-year data from 1978-79 to 2017-18.

The Box-Jenkins (ARIMA) model is used in this study. When we differenced a time series, it follows both Auto-Regressive (AR) and Moving Average (MA) models. It is known as Autoregressive Integrated Moving Average (ARIMA) model [18]. In the Agriculture sector, researchers extensively used the

ARIMA model. This is an extrapolation method and requires past data set to fit this model [6]. There are four steps required in this model fitting- Identification, Estimation, Diagnostic Checking, and Forecast. The R software package is used to estimate the parameters and fit the ARIMA model.

Before performing these four steps, we first ensure that the data are stationary. In this study, we use the Augmented Dickey-Fuller (ADF) unit root test (1979) to check the stationarity of the data.

2.1 Identification: It is the first step in ARIMA modeling. Here, to identify the potential models, we observe the ACF and PACF pattern of the given time series data. Various models near the proposed order are acknowledged, and estimation is performed.

2.2 Estimation: In general, the nonlinear least-square method is used in the ARIMA model for parameter estimation[19]. There are various software packages available for fitting ARIMA models. The R software package is used in this paper to calculate Akaike Information Criteria (AIC), Bayesian Information Criteria (BIC), Mean Absolute Percentage Error (MAPE), and Mean Absolute Error (MAE) to consider the best model. In 1978, Schwartz introduced Akaike Information Criteria (AIC) and Bayesian Information Criteria (BIC). AIC and BIC equations are-

$$\text{AIC} = T^{/}\log(\sigma^2) + 2(p+q+1) ---------------------------(i)$$

$$\text{BIC} = T^{/}\log(\sigma^2) + (p+q+1)\log T^{/} -------------------------(ii)$$

Here, σ^2 it indicates the Mean Square Error and $T^{/}$ indicates the number of observations used. The model with the lowest AIC or BIC value will be the best[20].

2.3 Diagnostic Checking: By monitoring the ACF and PACF of the residuals, we can say whether the residuals follow white noise or not. Another model is needed to select if this model does not follow white noise. Again, by plotting the "Normal Q-Q" plot, we checked the normality of the residuals; we can also check the normality by considering the One-sample Kolmogorov Smirnov test. We can pick another model if we get a satisfactory result and proceed with the analysis.

2.4 Forecast: Forecasting is the last step in ARIMA modeling. Before forecasting, we comparethe model's accuracy with all the competing models. For comparing accuracy, we calculate some statistics such as Mean Error (ME), Root Mean Square Error (RMSE), Mean Absolute Error (MAE), Mean Percentage Error (APE), and Mean Absolute Percentage Error (MAPE). There are two types of forecast-sample period forecast and post-sample period forecast [7]. A sample period forecast is used to generate the confidence of the model, and a post-sample period forecast is used to generate precise forecasts for policymaking and other purposes.

Autoregressive Integrated Moving Average (ARIMA):

Box and Jenkins (1970) introduced this ARIMA model. The forecast error of this model is very low. The mathematical form of the ARIMA model is given by ARIMA (p, d, q). Here, 'p' denotes the order of the AR model, 'q' denotes the order of the MA model and '' denotes the differencing order.

$$\phi(B)\nabla^d x_t = \mu + \theta(B)e_t ---------------------------(iii)$$

$\phi(B)$ & $\theta(B)$ are given by-

$$\phi(B) = 1 - \phi_1 B - \phi_2 B^2 - .... - \phi_p B^p ---------------------(iv)$$

$$\theta(B) = 1 - \theta_1 B - \theta_2 B^2 - .... - \theta_q B^q ---------------------(v)$$

And the difference operator is given by-.

$$\nabla = (1 - B)^d \text{ ---------------------------------- } (vi)$$

3. Results and Analysis:

In this study, we examine India's Marine and Total fish production data from 1978-79 to 2017-18. The basic descriptive statistics of both the data sets are shown in Table-1. The maximum and the minimum marine fish productions were 3688 and 1427 thousand tons found in 2017-18 and 1982-83. Moreover, India's maximum and minimum total fish productions were 12606 and 2306 thousand tons found in 2017-18 and 1978-79.

Table 1: Basic Descriptive Statistics of Marine and Inland fish Production data.

Measures	**Observations (Marine fish)**	**Observations (Total fish)**
Minimum Observation	1427 (Year= 1982-83)	2306 (Year=1978-79)
Maximum Observation	3688 (Year=2017-18)	12606 (Year=2017-18)
1st Quartile	1791.75	3103.75
3rd Quartile	2998.5	7249.25
Mean	2592.95	5713.125
Median	2795.00	5368
SE Mean	111.692590	438.8844
LCL Mean	2367.030413	4825.397
UCL Mean	2818.869587	6600.853
Standard Deviation	706.405961	2775.749
Skewness	-0.340823	0.6409810
Kurtosis	-1.176223	-0.4869010

Table 2: JarqueBera Test for Normality Check.

	Hypothesis	**Test Statistic**	**Degrees of Freedom**	**P-value**
Marine Fish	H_0: The data is normally distributed H_1: The data is not normally distributed	JarqueBera = 2.7849	2	0.2485
Total Fish	H_0: The data is normally distributed H_1: The data is not normally distributed	JarqueBera = 3.1669	2	0.2053

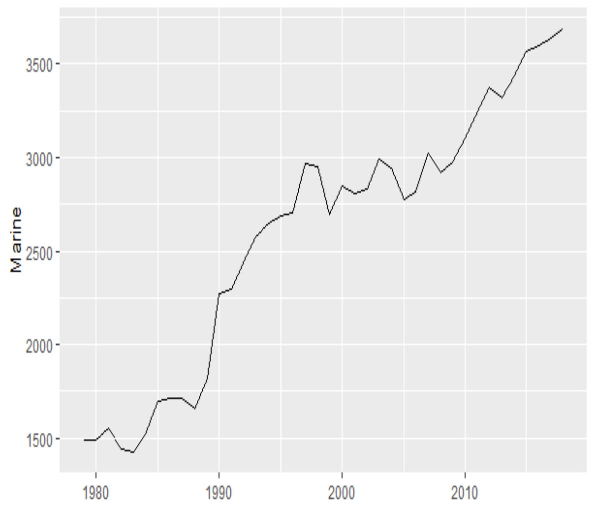


Fig1: Plotting original data of Marine fish Production in India (1978-2018).

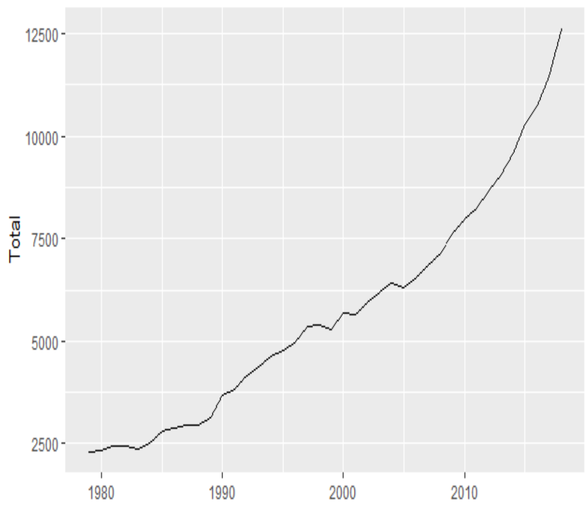


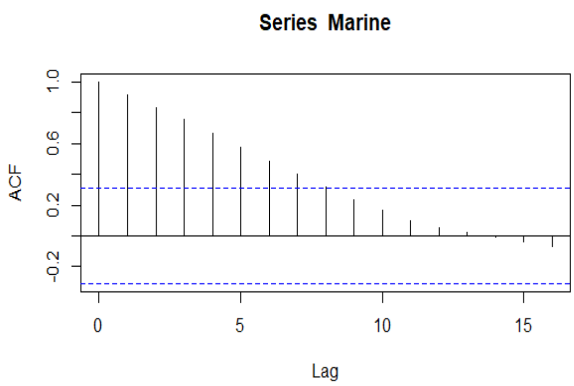
Fig2: Plotting original data of Total fish production in India (1978-2018).

Table 3: F-test results for Structural Break Points.

	Hypothesis	Test Statistic	p-value
Marine Fish	H_0: Absence of Structural Break Points H_1: Presence of Structural Break Points	F=141.58	p-value $< 2.2 \times 10^{-16}$
Total Fish	H_0: Absence of Structural Break Points H_1: Presence of Structural Break Points	F=83.107	p-value $< 2.2 \times 10^{-16}$

Table 4: Structural Break Points of both Inland and Marine Fish Production Data.

Marine Fish			**Total Fish**		
Observation no.	**Year**	**Production**	**Observation no.**	**Year**	**Production**
11	1987-1988	1658	11	1987-1988	2959
17	1993-1994	2649	18	1994-1995	4789
32	2008-2009	2978	28	2004-2005	6305
			34	2010-2011	8231



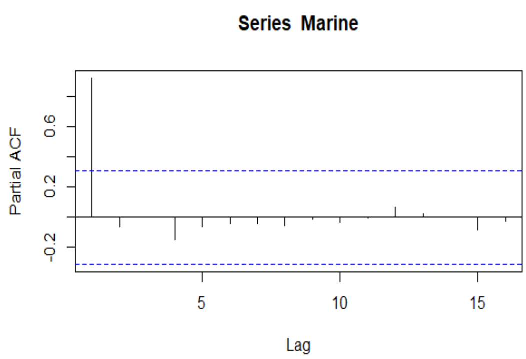


Fig3:ACF of marine fish production.**Fig4:** PACF of marine fish production.

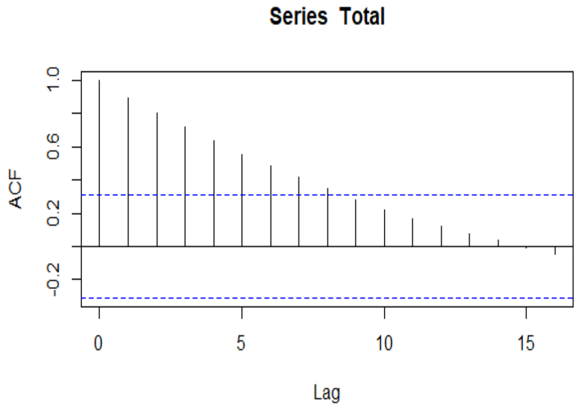


Fig5: ACF of total fish production.

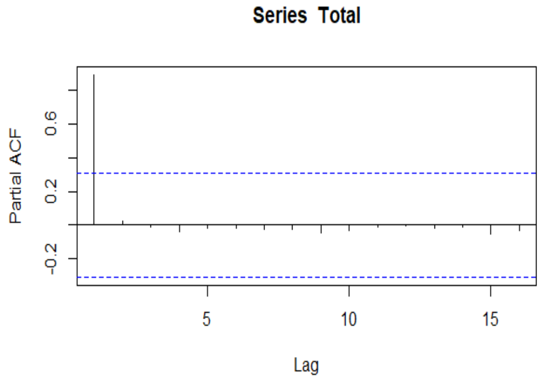


Fig6: PACF of total fish production.

The original data of marine and total fish production in India used for modeling is plotted in Fig1 and Fig2. Here we used F-test to find the structural breakpoints of the data set. To check the normality of the data set, we use the JarqueBera test.We found three structural breakpoints for marine fish data and four structural breakpoints for total fish production data using R software. In the model specification, we check the ACF and PACF of the given data set. The Autocorrelation Function (ACF) and Partial autocorrelation function (PACF) of marine fish production are shown in Fig3 and Fig4. Also, the Autocorrelation Function (ACF) and Partial autocorrelation function (PACF) of total fish production are shown in Fig5 and Fig6. The Auto-correlation function (ACF) and Partial autocorrelation function of both the testing data set reveala significant trend in the data set. Further, to make the series stationary, we take the first difference of both the data series to remove the trend.

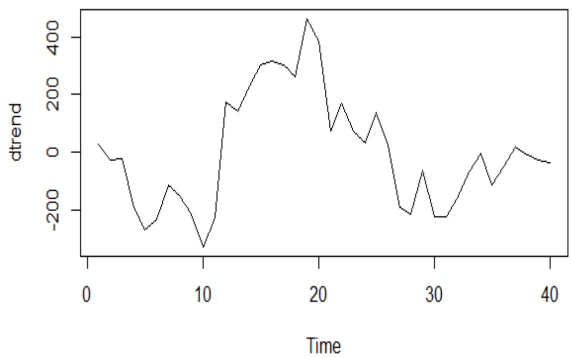


Fig7: First difference of the fitted Marine fish production data.

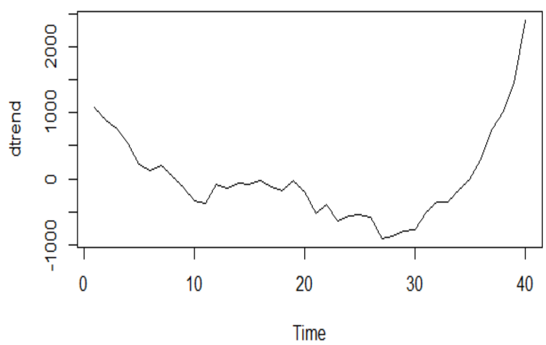
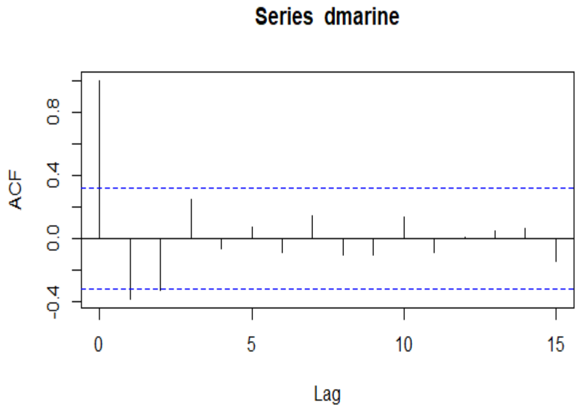


Fig8: First difference of the fitted Total fish production data.



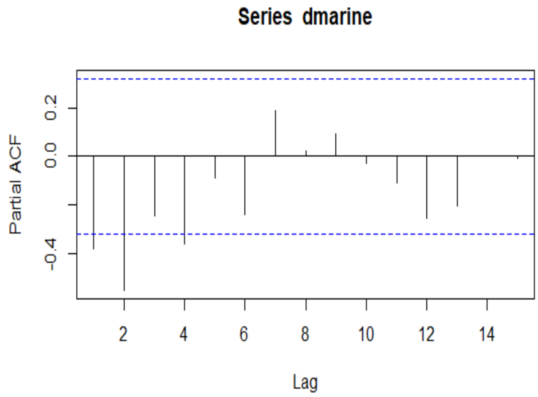
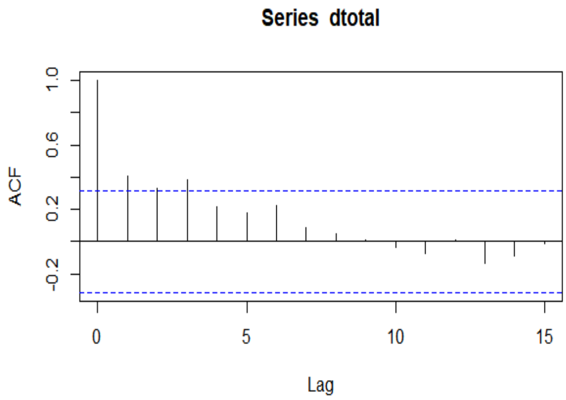


Fig9: ACF of first difference of marine data. **Fig10:** PACF of first difference marine data.



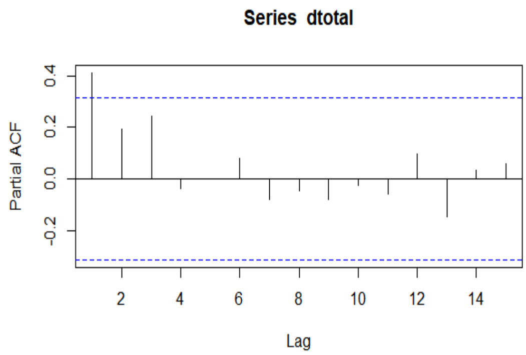
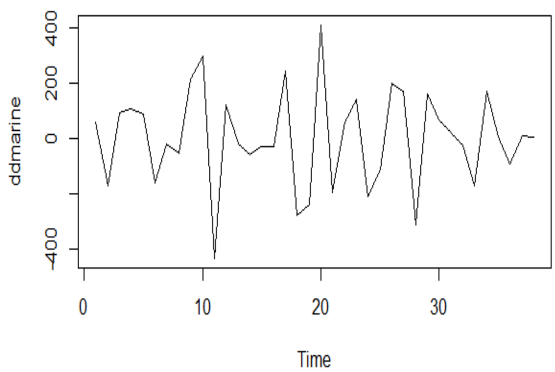


Fig11: ACF of first difference of total fish data. **Fig12:** PACF of first difference total fish data.



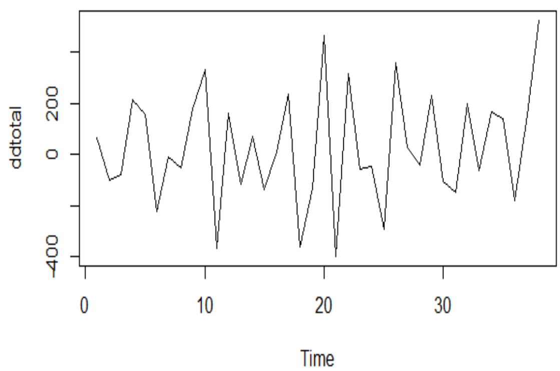


Fig13: Second difference of the fitted marine fish production data.

Fig14: Second difference of the fitted total fish production data.

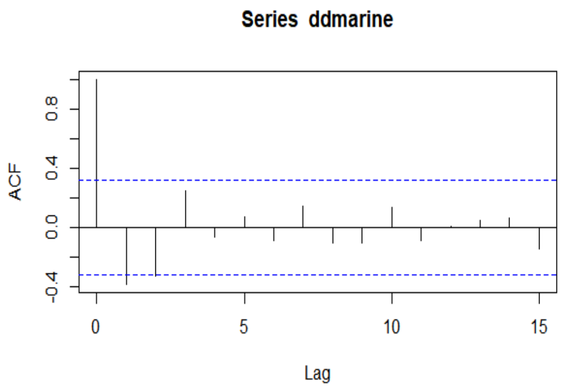


Fig15: ACF of the 2nd differencing of the marine fish.

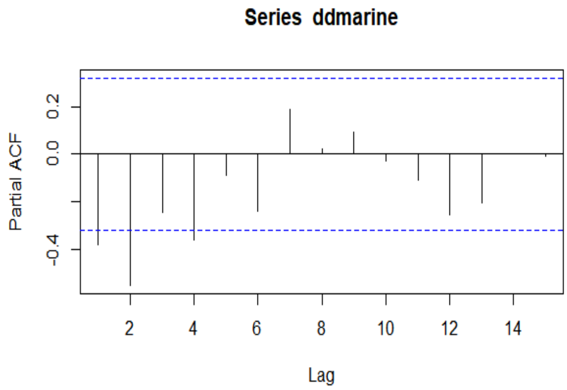


Fig16: PACF of the 2nd difference of the marine fish.

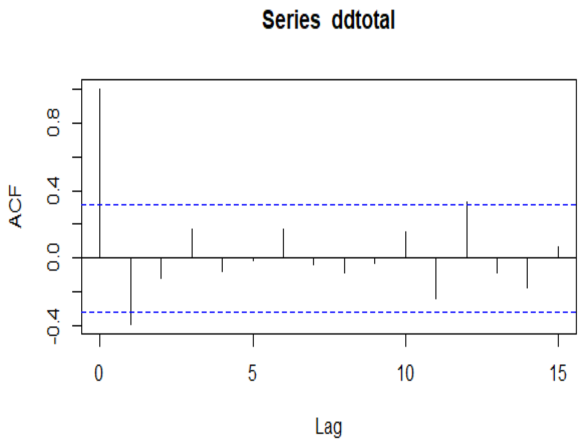


Fig17: ACF of the 2nd differencing of the total fish.

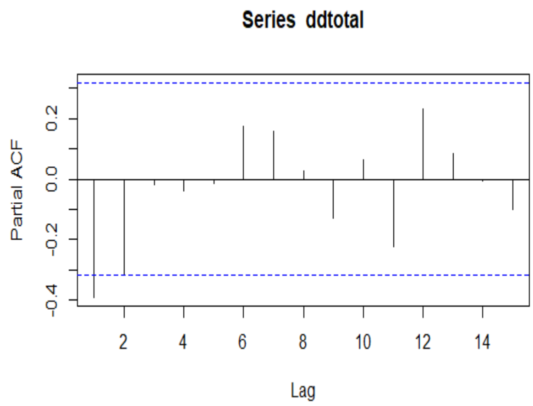


Fig18: PACF of the 2nd difference of the total fish.

The first difference of both the data series is plotted in Fig7 and Fig8. In Fig7, we have seen a slight decreasing pattern, and in Fig8, we have seen a slight increasing patternof the first differenced data. Here we also used the Augmented Dickey-Fuller test to check the stationarity. It is found that p-value > 0.05; so it cannot reject the null hypothesis, i.e., the first difference is still non-stationary. To make the data stationary, we again differentiate the data. The second difference of both the data series is plotted in Fig13 and Fig14. Moreover, the ACF and PACF of the second difference of the testing data are plotted in Fig15, Fig16, Fig17, and Fig18. From these figures, we have seen that the second difference of both the testing data series behaves stationary. Further, we apply the Augmented Dickey-Fuller test to check the stationarity of the second differenced data statistically. Moreover, we found a p-value<0.05 for both the data series, so we reject the null hypothesis, i.e., the second difference of both the data series is stationary.

Model Selection and Estimation of parameters:

The data sets became stationary after differencing. Then we suggest some probable models for further analysis. The proposed models for marine fish production in India are- ARIMA (1, 2, 0), ARIMA (0, 2, 1), ARIMA (1, 2, 1), ARIMA (2, 2, 0), and ARIMA (0, 2, 2). The proposed models for total fish production in India are- ARIMA (0, 2, 1), ARIMA (1, 2, 0), ARIMA (1, 2, 1), ARIMA (0, 2, 2), and ARIMA (2, 2, 0). The proposed ARIMA models, corresponding Standard errors (S. E.), Z-values, and p-Values for both the series are presented in Table7 and Table8. The AIC and Log-Likelihood of the fitted ARIMA models for marine fish production are given in Table5. Similarly, the AIC and Log-Likelihood of the fitted ARIMA models for total fish production are given in Table6. From Table5, it is observed that the AIC value for Model-2: ARIMA (0, 2, 1) is slightly lower compared to other fitted models for marine fish production series. Also, from Table6, the AIC value for Model-2: ARIMA (0, 2, 1) is slightly lower than other fitted models for the total fish production series. Hence, we used these two models for forecasting the data.

Table 5: AIC and Log-Likelihood of the fitted ARIMA models of marine fish production.

Model	ARIMA order	AIC	Log Likelihood
Model 1	ARIMA(1,2,0)	499.14	-247.57
Model 2	ARIMA(0,2,1)	481.55	-238.78
Model 3	ARIMA(1,2,1)	483.55	-238.78
Model 4	ARIMA(2, 2, 0)	487.93	-240.96
Model 5	ARIMA(0, 2, 2)	483.55	-238.78

Table 6: AIC and Log Likelihood of the fitted ARIMA models of Total fish production.

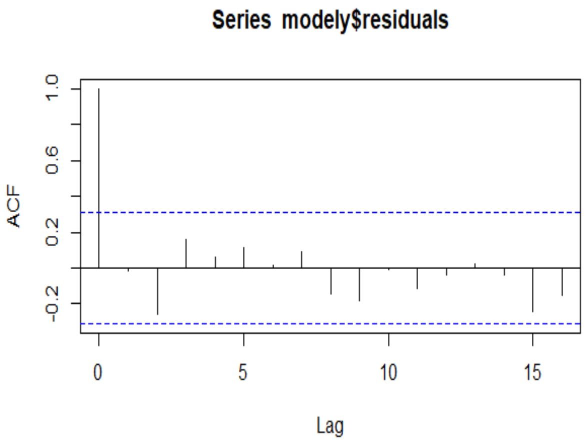
Model	ARIMA order	AIC	Log Likelihood
Model 1	ARIMA(0, 2, 1)	512.3	254.15
Model 2	ARIMA(1, 2, 0)	516.3	-256.15
Model 3	ARIMA(1,2,1)	514.07	-254.03
Model 4	ARIMA(0, 2, 2)	513.75	-253.87
Model 5	ARIMA(2, 2, 0)	512.37	-253.19

Table 7: Parameter estimation of the ARIMA (0, 1, 1) model for Inland Fish Production.

Coefficients	Estimates	Std. Error	Z-value	Pr(> |z|)
MA1	-0.41451	0.16545	-2.5054	0.01223

Table 8: Parameter estimation of the ARIMA (2, 1, 4) model for Marine Fish Production.

Coefficients	Estimates	Std. Error	Z-value	Pr(> |z|)
AR1	-0.019408	0.576975	-0.0336	0.9732
AR2	0.609482	0.389912	1.5631	0.1180
MA1	0.166118	1.621120	0.1025	0.9184
MA2	-0.931508	1.202507	-0.7746	0.4386
MA3	0.321107	0.426833	0.7523	0.4519
MA4	0.424409	0.843350	0.5032	0.6148



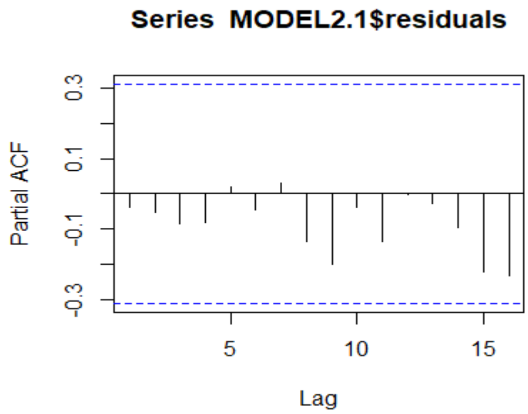
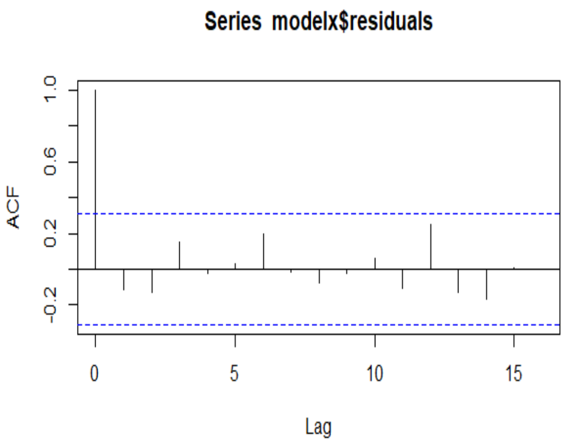


Fig19: ACF of the residuals of marine fish.

Fig20: PACF of the residuals of marine fish.



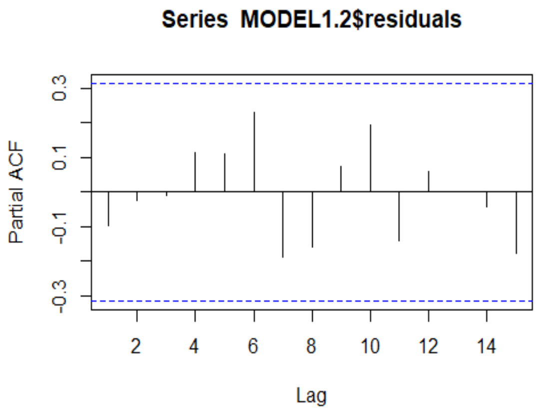
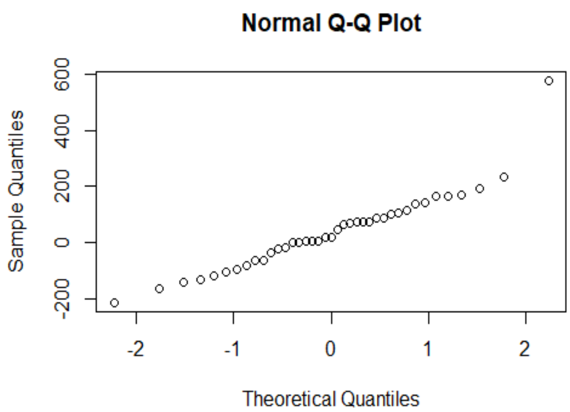


Fig21: ACF of the residuals of total fish.

Fig22: PACF of the residuals of total fish.



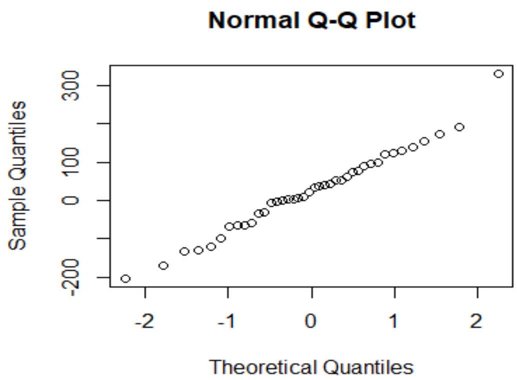


Fig23: Normal Q-Q Plot of the residuals of marine fish. **Fig24:** Normal Q-Q Plot of the residuals of total fish.

Auto-correlation function and Partial auto-correlation function of residuals of both the data set were plotted in Fig19, Fig20, Fig21, and Fig22. The ACF of the residuals is used to indicate the goof fit of the models. Model parameters were estimated using the R software package, and results are presented in Table7 and Table8.The selected ARIMA models with error measures are shown in Table9. Here Mean error (ME), Root mean square error (RMSE), Mean absolute error (MAE), Mean percentage error

(MPE), Mean absolute percentage error (MAPE), Mean absolute scaled error (MASE), and (ACF1) are presented in this table. The best-fitted ARIMA models for Inland and Marine fish production are ARIMA (0, 2, 1) and ARIMA (0, 2, 1). The minimum absolute percentage error (MAPE) of Marine fish data is 3.544109, and for Total fish, data is 2.822063. Next, we carried out the forecasting for both the data set. To check the normality, we plotted the Normal Q-Q plot for both the data set as shown in Fig23 and Fig24.

Table 9: Error measures for the selected ARIMA models for Marine and Total fish production.

Models	ME	RMSE	MAE	MPE	MAPE	MASE	ACF1
ARIMA (0, 2, 1))	6.888326	120.4007	86.97808	0.3637124	3.544109	0.8640206	-0.016026
ARIMA (0, 2, 1)	47.69343	188.298	144.6848	0.6647086	2.822063	0.5195862	-0.118597

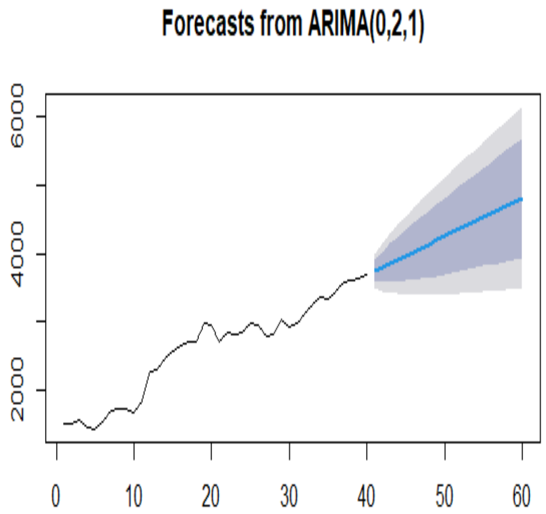
Table 10: Forecasted values of Marine Fish Production along with 80% and 95% confidence intervals for the upcoming 15 years.

Year	Point Forecast	80%CI		95% CI	
		Lower	Upper	Lower	Upper
2018-2019	3744.359	3584.037	3904.681	3499.167	3989.551
2019-2020	3800.718	3571.172	4030.265	3449.657	4151.779
2020-2021	3857.077	3572.533	4141.621	3421.905	4292.250
2021-2022	3913.436	3580.985	4245.888	3404.996	4421.877
2022-2023	3969.795	3593.806	4345.785	3394.770	4544.821
2023-2024	4026.154	3609.625	4442.684	3389.127	4663.182
2024-2025	4082.514	3627.639	4537.388	3386.842	4778.185
2025-2026	4138.873	3647.334	4630.412	3387.129	4890.617
2026-2027	4195.232	3668.359	4722.105	3389.449	5001.014
2027-2028	4251.591	3690.463	4812.719	3393.419	5109.762
2028-2029	4307.950	3713.459	4902.441	3398.754	5217.146
2029-2030	4364.309	3737.205	4991.413	3405.236	5323.382
2030-2031	4420.668	3761.589	5079.747	3412.694	5428.642
2031-2032	4477.027	3786.523	5167.531	3420.993	5533.061
2032-3033	4533.386	3811.936	5254.837	3430.023	5636.750

Table 11: Forecasted values of Total Fish Production along with 80% and 95% confidence intervals for the upcoming 15 years.

Year	Point Forecast	80%CI		95%CI	
		Lower	Upper	Lower	Upper
2018-2019	13433.79	13186.20	13681.37	13055.14	13812.43
2019-2020	14261.57	13833.38	14689.77	13606.70	14916.44
2020-2021	15089.36	14467.36	15711.36	14138.09	16040.63
2021-2022	15917.15	15084.91	16749.39	14644.35	17189.95
2022-2023	16744.93	15686.03	17803.84	15125.48	18364.39

2023-2024	17572.72	16271.35	18874.09	15582.44	19563.00
2024-2025	18400.51	16841.59	19959.42	16016.35	20784.66
2025-2026	19228.29	17397.46	21059.12	16428.28	22028.31
2026-2027	20056.08	17939.60	22172.56	16819.21	23292.95
2027-2028	20883.87	18468.60	23299.13	17190.03	24577.70
2028-2029	21711.65	18984.97	24438.34	17541.55	25881.75
2029-2030	22539.44	19489.19	25589.69	17874.48	27204.40
2030-2031	23367.23	19981.68	26752.78	18189.47	28544.98
2031-2032	24195.01	20462.82	27927.21	18487.12	29902.91
2032-2033	25022.80	20932.97	29112.63	18767.95	31277.65



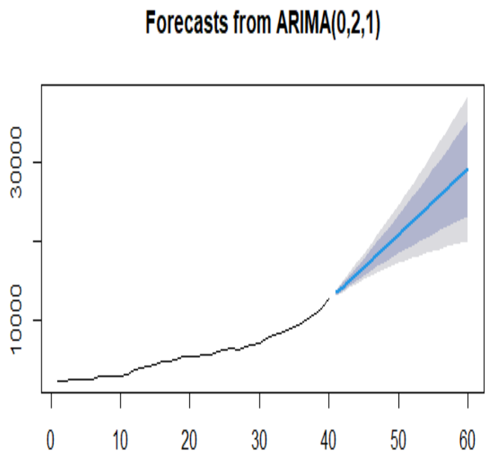


Fig25: Trends of marine fish production in India next 15 years.

Fig26: Trends of total fish production in India for the next 15 years.

Table10 and Table11 the forecasted values of marine and total fish production in India for the upcoming 15 years. The forecasted values are also observed within 80% and 95% confidence limits. Moreover, the trends of marine and total fish production in India using the ARIMA (0, 2, 1) model for both the data set are shown in Fig25 and Fig26. From Table10, the trend of marine fish production in India is decreasing slowly. FromTable11, it is observed that total fish production in India will increase in the upcoming 15 years. The marine fish production of India in 2033 will be 4533.386 thousand tons, and the total fish production of India in 2033 will be 25022.80 thousand tons.

4. Conclusion:

Fish is an essential source of food and nutrition in India. The fisheries sector generates income and employment for millions of people in India. In this study, the ARIMA models were fitted to India's annual marine and total fish production.Based on minimum goodness of fit values, ARIMA (0, 2, 1) and ARIMA (2, 1, 4) models are acknowledged as the best-fitted models for India's marine and total fish production. Using these two models, we forecasted the marine and total fish production for the next ten years. The best-fitted models show that the production will increase in both areas for the next years. By 2033, the total fish production has been estimated to reach 25022.80 thousand tons, and marine fish production has reached 4533.386 thousand tons. Marine fish production has decreased from 71.01% in 1951 to 29.26% in 2018 of the total fish production. The production pattern has been shifted from marine to inland. Since the population of India is still growing, to meet the future demand for fish, we need to focus on more advanced methods of fish production. The findings of this study are significant for fish farmers and policymakers for better future planning regarding the production of fish in India.

References:

[1] ICAR-Central Institute of Freshwater Aquaculture and M. Ss, “Present Status of Fish Disease Management in Freshwater Aquaculture in India: State-of-the-Art-Review,” *AAF*, vol. 1, no. 1, pp. 1–9, Nov. 2017, doi: 10.24966/AAF-5523/100003.

[2] L. R. Anneboina and K. S. Kavi Kumar, “Economic analysis of mangrove and marine fishery linkages in India,” *Ecosystem Services*, vol. 24, pp. 114–123, Apr. 2017, doi: 10.1016/j.ecoser.2017.02.004.

[3] T. V. Sathianandan, “MARINE FISH PRODUCTION IN INDIA – PRESENT STATUS,” p. 5.

[4] N. K. Barik, “Freshwater fish for nutrition security in India: Evidence from FAO data,” *Aquaculture Reports*, vol. 7, pp. 1–6, Aug. 2017, doi: 10.1016/j.aqrep.2017.04.001.

[5] P. J. W. Mah, N. A. M. Ihwal, and N. Z. Azizan, “FORECASTING FRESH WATER AND MARINE FISH PRODUCTION IN MALAYSIA USING ARIMA AND ARFIMA MODELS,” *MJoC*, vol. 3, no. 2, p. 81, Dec. 2018, doi: 10.24191/mjoc.v3i2.4887.

[6] A. Anuja, V. K. Yadav, V. S. Bharti, and N. R. Kumar, “Trends in marine fish production in Tamil Nadu using regression and autoregressive integrated moving average (ARIMA) model,” *JANS*, vol. 9, no. 2, pp. 653–657, Jun. 2017, doi: 10.31018/jans.v9i2.1252.

[7] P. Borkar, “Forecasting and Modelling of Marine and Inland Fish Production in India,” vol. 4, no. 4, p. 6, 2017.

[8] P. Mishra, S. Ray, S. Tiwari, A. Badr, and R. Balloo, “Estimation of Fish Production in India using ARIMA, Holt’s Linear, BATS and TBATS Models,” p. 9.

[9] aisar Mehmood, M. H. Sial, S. Sharif, A. Hussain, M. Riaz, and N. Shaheen, “Forecasting the Fisheries Production in Pakistan for the Year 2017-2026, using Box-Jenkin’s Methodology,” *PJAR*, vol. 33, no. 1, 2020, doi: 10.17582/journal.pjar/2020/33.1.140.145.

[10] K. G. Mini, S. Kuriakose, and T. V. Sathianandan, “Modeling CPUE series for the fishery along northeast coast of India: A comparison between the Holt- Winters, ARIMA and NNAR models,” vol. 57, p. 8, 2015.

[11] A. K. Yadav, K. K. Das, P. Das, R. K. Raman, J. Kumar, and B. K. Das, “Growth trends and forecasting of fish production in Assam, India using ARIMA model,” *JANS*, vol. 12, no. 3, pp. 415–421, Sep. 2020, doi: 10.31018/jans.v12i3.2353.

[12] R. K. Raman, T. V. Sathianandan, A. P. Sharma, and B. P. Mohanty, “Modelling and Forecasting Marine Fish Production in Odisha Using Seasonal ARIMA Model,” *Natl. Acad. Sci. Lett.*, vol. 40, no. 6, pp. 393–397, Dec. 2017, doi: 10.1007/s40009-017-0581-2.

[13] R. K. Raman *et al.*, “Time series forecasting model for fisheries in Chilika lagoon (a Ramsar site, 1981), Odisha, India: a case study,” *Wetlands Ecol Manage*, vol. 26, no. 4, pp. 677–687, Aug. 2018, doi: 10.1007/s11273-018-9600-4.

[14] M. K. Debnath, K. Bera, and P. Mishra, “Forecasting Area, Production and Yield of Cotton in India using ARIMA Model,” vol. 2, no. 1, p. 6, 2013.

[15] M. A. Hamjah, “Rice Production Forecasting in Bangladesh: An Application Of Box-Jenkins ARIMA Model,” p. 11, 2014.

[16] B. Nath, D. Dhakre, and D. Bhattacharya, "Forecasting wheat production in India: An ARIMA modeling approach," p. 9.

[17] P. Mishra and C. Sarkar, "Instability and forecasting using ARIMA model in the area, production and productivity of onion in India," p. 7.

[18] T. J. Sankar and C. Vijayalakshmi, “Implementation of Stochastic Model for Fish Production Forecasting,” p. 7, 2017.

[19] R. K. Paul and M. K. Das, “STATISTICAL MODELLING OF INLAND FISH PRODUCTION IN INDIA,” p. 8.

[20] B. Dutta, M. P. Barman, and A. N. Patowary, “APPLICATION OF ARIMA MODEL FOR FORECASTING ROAD ACCIDENT DEATHS IN INDIA,” p. 9.