Khulna University Studies Special Issue ICSTEM4IR: 904-916, 2022

ORIGINAL ARTICLE

SCIENCE & ENGINEERING

TIME SERIES ANALYSIS OF AQUACULTURE AND CAPTURE FISH PRODUCTION AND PROJECTION OF FUTURE TREND IN BANGLADESH

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KUS: ICSTEM4IR-22/0184

Manuscript submitted: July 20, 2022 Accepted: September 28, 2022

Abstract

This study is conducted to identify the trends in aquaculture and capture fish production in Bangladesh from 1960 to 2018 using Sen's slope estimator and Mann Kendall test and apply time series modeling to forecast aquaculture and capture fish production (in metric tons). The data is retrieved from World Bank (WB). To forecast, ARIMA models are used and optimum models are selected by simulating several candidate models with AIC, BIC, mean squared error, and white noise error as selection criteria. Co-integration between two time series (aquaculture and capture fish) had been tested to establish a vector error correction model (VECM). Sen's slopes for both aquaculture and capture fish production are positive and significant (*p*-value<0.01). This study found that the ARIMA (1,2,1) and ARIMA(1,1,0) are the best models to forecast aquaculture fish production and capture fish production in Bangladesh. The estimated aquaculture fish production will be 47,17,014 metric tonnes, and capture fish production will be 25,15,141 metric tonnes in the year 2028. The co-integration test confirms that there is no long-run association between aquaculture and capture fish production. Since increasing fish production will mitigate the necessity of adequate food and nutrition for the growing population, this study will assist policymakers in setting a sustainable and prospective hunger-free Bangladesh.

Keywords: Aquaculture, capture fish, Mann-Kendall, ARIMA, AIC, BIC, Ljung–Box test, co-integration.

Introduction

Captured fisheries refer to capturing aquatic animals (fin and shellfish) from natural water bodies like the Sea, River, Lake, Pond, Estuary, etc. for human food, decorative, and other uses. Humans have no control over the breeding, spawning, and recruitment of juvenile fish to the fishing industry. Cultivating aquatic organisms under constant surveillance is known as aquaculture, like agriculture, but with fish as the primary product instead of plants or animals. The aquaculture industry provides food for half of the world's fish consumption.

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DOI: https://doi.org/10.53808/KUS.2022.ICSTEM4IR.0184-se

Aquaculture is conducted everywhere, including in tanks on land, freshwater ponds, rivers, and Marine boundary. Inland open water capture fisheries, inland closed water culture fisheries, and marine fishing contributed 35 percent, 44 percent, and 21 percent, respectively, to produce 2.1 million tonnes of fish (Hussain, 2010).

In Bangladesh, fisheries is crucial for export value, employment, income, and nutrition. Fish consumption accounted for 63% of animal protein, 5% of the GDP, and 5% of export earnings nearly ten years ago. In addition, 1.4 million people actively participated in fishing, 11 million occasionally, and 3 million operated in aquaculture (Hussain, 2010).

In many developing nations, fisheries and aquaculture are an essential aspect of agri-food systems, providing fish and other aquatic foods as well as a more environmentally sustainable animal-source food to satisfy the national and global target of food and nutrition security (Hallström et al., 2019; Willett et al., 2019). The growth of aquaculture and faltering capture fisheries has significantly changed developing countries' fisheries and aquaculture systems over the last four decades (Belton & Thilsted, 2014; Tran et al., 2020). In addition, the growth of global aquaculture has positively contributed to global food and nutrition security, boosting world fish supplies and mitigating fish output reduction from capture fisheries to meet the increasing demand for fish (Tran et al., 2022). The fishery sector in Bangladesh plays an increasingly significant role in the national economy through foreign exchange earnings, animal-sourced protein and food supply, food security, employment opportunities, and supporting overall socio-economic development and sustainable livelihoods (Islam & Shamsuddoha, 2018; Rashid & Zhang, 2019).In 2018, Bangladesh ranked one of the largest fish producers in the world, 3rd after China and India in inland capture fishery production, 5th in terms of world aquaculture production after China, India, Indonesia, and Vietnam (FAO, 2020), and became self-sufficient in fish production (FRSS, 2018). The sector contributed 3.50% of the national gross domestic product (GDP), more than one-fourth (25.72%) of the agricultural GDP, and 3% of Bangladesh's total foreign exchange earnings in 2017 (FRSS, 2018). In this industry, 12% of Bangladesh's 165 million people with full-time work and part-time jobs were generated. (FRSS, 2018). Fish is one of the essential foods in the Bangladeshi diet, contributing 60% of total animal-source foods, while per capita fish consumption in Bangladesh reached 62.58 grams/day in 2017 (BBS, 2018).

The main sources of domestic fish supply in Bangladesh are inland culture, inland capture, and marine capture. The total fish production in Bangladesh has increased six-fold and its steadily growing trend has been maintained over the past 36 years (total output increased from 754,000 metric tons (MT) in 1983-84 to 4,384,000 MT in 2018-19). The majority of fish supply in Bangladesh comes from inland culture and capture fisheries (accounting for 84.53% of total production) (FRSS, 2020), of which aquaculture has been playing a crucial role to boost inland fisheries production to meet the increasing fish demand of Bangladesh population (Finegold, 2009). Aquaculture in Bangladesh is practiced in freshwater and brackish water environment with diverse production systems ranging from extensive, improved and semi-intensive to intensive aquaculture. Inland aquaculture in freshwater is mainly comprised of fish farming of Indian major carps (Rohu, Mrigal, Catla), exotic and other carps (Silver carp, Bighead carp, Grass carp, and Common carp), pangasius, and tilapia. Coastal aquaculture mainly includes brackish water shrimp farming in ghers. The contribution of aquaculture to Bangladesh's total fish production has remarkably increased from 15.53% in 1983-84 to 56.76% in 2018-19 (FRSS, 2020). Landings from inland capture and marine fisheries in Bangladesh have been increasing at average growth rates of 1.58% and 0.80% over the 1983/1984- 2018/2019 period, respectively, contributing 28.19% (1,235,000 MT) and 15.05% (660,000 MT) to total fish production in 2018-19 (FRSS, 2020). Of captured fish species, Hilsa, the national fish of Bangladesh accounted for the highest share (12.15%) in the country's total fish production in 2018-19 (FRSS, 2020). The majority of Bangladesh's total catch fish of Hilsa (65% of total Hilsa fish production) currently originated from marine capture resources (FRSS, 2017). After ten years, during FY 2019–20, the nation produced more fish: more than 1.2 million (12.48 lakh) tonnes of fish that were captured, more than 2.5 million (25.84 lakh) tonnes of fish that were produced in captivity, and 0.67 million (6.71 lakh) tonnes of marine fish (FRSS, 2021).

Due to their inherent nutritious levels, fish and other aquatic products are classified as "inimitable" animal-source foods, supporting food and nutrition security in many developing nations (Bogard et al., 2015). In Bangladesh, among animal-source foods, fish is the cheapest source and the most crucial multiple nutrient-rich foods in the diet. It provides a wide range of micronutrients, protein, and fatty acids essential for the human brain, bone, and nervous system development, growth, cognition, and disease prevention (Ezzati & Riboli, 2013; Nestel et al., 2015; Tacon & Metian, 2013). Several species from inland capture, typically consumed whole with head and bones, are rich in essential fatty acids and could contribute more than 25% of the recommended nutrient intakes including iron, zinc, calcium, iodine, vitamin A and vitamin B12, for pregnant and lactating women and infants (Tran et al., 2022).

Aquaculture and fishing have a long history in Bangladesh. They are significant parts of everyday lives as food sources and nourishment, employment, earnings, and a diversity of cultural and social activities. As per production, Bangladesh has the third-largest inland fishery and is the fifth-largest exporter of crustacean and fish species in the world (FAO, 2018).

Aquaculture is a fairly diversified industry with 14 commercial and subsistence aquaculture systems spread around the country. (Belton et al., 2018; Hernandez et al., 2018; Jahan, 2015). Shrimp farming with an eye forward into export has increased since the 1970s, resulting in the displacement of privately owned agricultural land and open land, accelerated soil and water salinization, disrupted local labor markets, and widened power and wealth gaps, particularly in the southwest. (Akber et al., 2018; Mukhopadhyay et al., 2018). Less focus has been placed on the vast majority of fish farmers, also known as aquaculture's "missing middle." (Belton et al., 2018). Commercial beel aquaculture, combined rice-fish farming, homestead and commercial pond and gher aquaculture are a few. Many of these systems center on low- and medium-value species, produce at different scales using different production technologies and were created in response to the increased demand for fish and fish products from lower- and middle-class consumers in rural and urban regions (Pokrant, 2019).

Autoregressive Integrated Moving Average (ARIMA) models are used extensively to forecast time series data and ARIMA (1,1,1) model was used to forecast marine fish production in Tamil Nadu (Anuja et al., 2017). In Pakistan, Mehmood et al. (2020) used ARIMA(2,1,3) to forecast fisheries production from 633.974 to 720.196 tons for the year 2017-2026. In Bangladesh, the total fish was predicted 60,13,331 tons in 2028. Using ARIMA (0,2,1)(Voumik, 2021). Patle et al. (2015) mentioned that a lot of techniques are used for trend analysis of time series data from simple linear regression to advanced parametric and non-parametric methods (Helsel & Hirsch, 1992; Hirsch & Slack, 1984). Among all, the Mann-Kendall test (Kendall, 1975; Mann, 1945) is the most popular non-parametric method to analyze the trend in the time series data. The current paper not only attempts to forecast aquaculture and capture fish production in Bangladesh; but also analyzes the trend. This study also attempts to investigate the long-run relationship between aquaculture and capture fish production.

Due to the great significance of fisheries on livelihood, food security, nutritional fulfillment, economic development, and national revenue; study about ongoing fish production, future trend, and projection of both aquaculture and capture fish production is in demand. Therefore, the major goals of this study are-

(i) to explore the long-run trend of aquaculture and capture fish production in Bangladesh;

(ii) to forecast aquaculture and capture fish production in Bangladesh;

(iii) to investigate whether there is any long-run relationship between aquaculture and capture fish production.

Methodology

To detect monotonic trends if any, Mann-Kendall (Mann, 1945) is used. To measure the magnitude of the trend, Sen's slope is applied (Sen, 1968). For time series modeling and prediction, the non-seasonal Auto-Regressive Integrated Moving Average (ARIMA) model (Box & Jenkins, 1976) is used. To explore the long-run relationship between two time series variables, Johansen co-integration test is applied (Johansen, 1988). The whole analysis is carried out using statistical package R(R Core Team, 2022).

Data source

For this study, the data set comprises annual time series data over the period 1960-2018 for aquaculture and capture fish production. The data are taken from the World Development Indicators (WDI) of the World Bank (WB) [1].

Mann-Kendall test

The Mann-Kendall test is a non-parametric method used to detect a trend in time series data (Mann, 1945). The null hypothesis (H_0) of this test is that there is no serial correlation or monotonic trend against the alternative hypothesis (H_A) is that the data follow monotonic trend.

Sen's slope trend estimator

Sen's slope estimates both the slope and intercept (Sen, 1968). A positive slope indicates a positive trend and a negative slope indicates a negative trend. For autocorrelated data, linear trend gives biased results. In that case, Sen's slope gives a more reliable trend estimate.

ARIMA model

In 1970, Box and Jenkins developed the Auto-Regressive Integrated Moving Average (ARIMA) model (Box & Jenkins, 1976). If a time-series data $(\{Y_t\})$ is stationary and has p^{th} auto regressive order with q^{th} moving average order then the model is known as ARMA (p,q) or ARIMA(p,d,q) with d=0. Here d stands for the degree of first difference. The ARIMA (p,d, q) model is written as:

$$\Delta^d Y_t = c + \beta_1 \Delta^d Y_{t-1} + \beta_2 \Delta^d Y_{t-2} + \cdots + \beta_p \Delta^d Y_{t-p} + \epsilon_t - \theta_1 \epsilon_{t-1} - \theta_2 \epsilon_{t-2} - \ldots - \theta_{t-q} \epsilon_{t-q} \quad (1)$$

where, $\Delta^d Y_t$ is the differenced series of order d. Delta notation is used for differenced series i.e., for first difference, $\Delta Y_t = Y_t - Y_{t-1}$. A level series with no differencing is also denoted as I(0) and a first differenced series is denoted as I(1) and so on.

To understand whether the series is stationary or not time series plot, ACF (Autocorrelation function), and PACF (Partial autocorrelation function) plot will be used. If the original series is found as non-stationary; mathematical transformation (for example log transformation) and differencing will be applied. Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test(Kwiatkowski & Shin, 1992) would be used to examine the series' stationarity. Since the KPSS test often gives a high rate of Type I errors, the Augmented Dickey-Fuller Test (ADF) (Dickey & Fuller, 1979) is also used. After obtaining the stationary series, the order of AR and MA will be determined from ACF and PACF plots. After estimating a model, its residual will be examined whether they are white noise or not. Ljung-Box statistic will be used to verify whether the residuals are auto correlated or not. Since there may be many candidate models; so the most appropriate model will be selected by using the Akaike information criterion (AIC), Bayesian information criterion (BIC), the sum of the square of error(SSE), and *p*-value of the Ljung-Box test for model residuals. The best model will be used to forecast the future value of a series.

Co-integration test

To investigate the long-run association between aquaculture and capture fish production series,

[1] (https://www.worldbank.org)

Johansen Test is applied (Johansen, 1988). This test considers a Vector Auto-Regressive (VAR) model. The general of the VAR(p) model is

$$\mathbf{y}_t = \boldsymbol{\mu} + \mathbf{A}_1\mathbf{y}_{t-1} + \ldots + \mathbf{A}_p\mathbf{y}_{t-p} + \boldsymbol{\epsilon}_t \tag{2}$$

Where μ is the mean vector of the series, $\mathbf{A}_i$ are the coefficients matrices at each lag and ϵ_t is a multivariate Gaussian noise with a mean of zero. The Vector Error Correction Model (VECM) is the first difference series.

$$\boldsymbol{\Delta y_t} = \boldsymbol{\mu} + \mathbf{A_1 y_{t-1}} + \boldsymbol{\Pi_1 \Delta y_{t-1}} \ldots + \boldsymbol{\Pi_p \Delta y_{t-p}} + \boldsymbol{\epsilon_t} \tag{3}$$

where, $\boldsymbol{\Delta} y_t = \mathbf{y}_t - \mathbf{y}_{t-1}$. If, the series are not co-integrated A will be zero. If r is the rank of matrix A, the Johansen test sequentially checks whether this rank $r = 0$, 1 through to $r = n - 1$, where n is the number of time series in the test. The null hypothesis, $r = 0$ implies there is no co-integration at all. A rank r greater than 0 indicates that there are one or more co-integrating relationships among the time series.

Results

The aquaculture fish production and captured fish (in metric tons) from 1960 to 2018 are analyzed. The Mann-Kendall statistic is used to determine the trend of both time-series data. Both series exhibit approximately exponential growth. So, to stabilize variation logarithmic transformation (with base 10) is taken. Fish productions are forecasted using ARIMA models, which also depict stochastic patterns. To examine the long-run relationship between aquaculture and capture fish production, a co-integration test is applied.

The trend of aquaculture and capture fish production

The estimated Sen's slope for the aquaculture series ($l_k = 25292.1$) and capture fish series ($l_k = 22209.53$) are found positive. This indicates that in both aquaculture and capture fish production is increasing. However, the increasing trend of aquaculture fish production is notable ($Z_S = 11.13, p < 0.01$) and the increasing trend of capture fish production is also significant ($Z_S = 9.33, p < 0.01$) (Table 1).

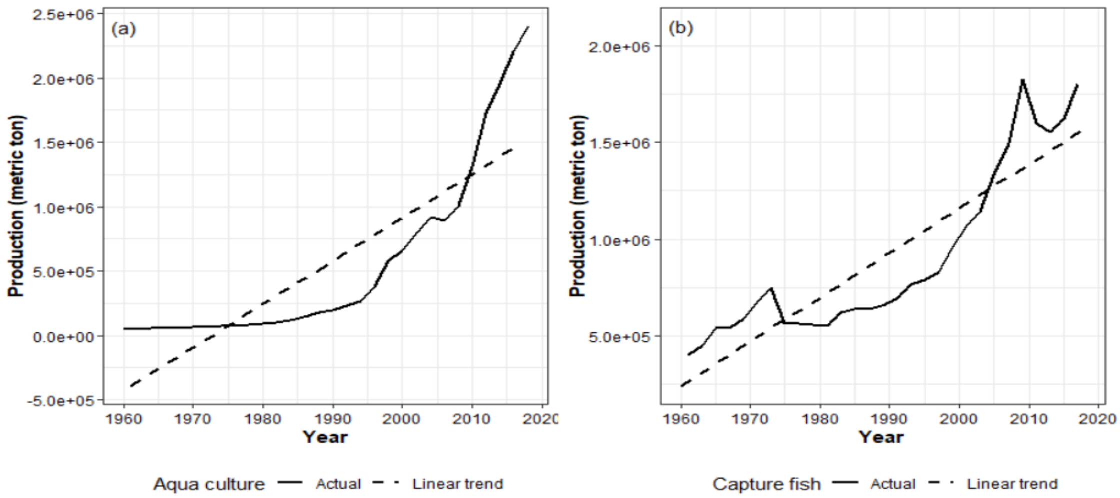

Figure 1. Time series plot with linear trend :(a) Aquaculture fish production (metric ton), (b) Capture fish production (metric ton).

Capture fish production was at its peak in the year 2009 (1821579 metric tons), then decreased until 2012. After 2012, the trend of captured fish production began to increase. No notable change is found in the aquaculture fish production series. The time series plots with linear trends of both fish production are shown in Figure 1.

Table 1. Results of Mann-Kendall test and Sen's slope estimators for aquaculture and capture fish series

Series	Z_S	Sen's Slope, l_k	Mann-Kendall test statistic, S (σ_S^2)
Aqua culture	11.13***	25292.1	1703 (23383.67)
Capture fish	9.325***	22209.53	1427(23383.67)

(**** Statistically significant at 1% level of significance*)

KPSS and ADF stationary test

To assess the stationary of aqua and capture fish series, KPSS and ADF tests are performed. For KPSS test a *p*-value greater than 0.05 would indicate that the data is stationary. On the contrary, for ADF test a *p*-value less than 0.05 would indicate that the data is stationary. Both log-aquaculture and log-capture fish series are not stationary at level (KPSS=1.540, p<0.05; ADF=-2.31, p>0.05 for aquaculture and KPSS=1.417, p<0.05; ADF=-1.678, p>0.05 for capture fish series). While, KPSS=0.482, p<0.05 indicates that I(1) series of log-aquaculture is stationary; but ADF test reject it (ADF=-3.10, p>0.129). But, I(2) series of log-aquaculture is found stationary from both test (KPSS=0.0579, p>0.05; ADF=-4.83, p<0.05). Meanwhile, the KPSS test support that, the I(1) series of log-capture fish became stationary at a 5% level of significance (KPSS=0.107, p>0.05 and the ADF test support that the I(1) series is stationary at 7% level of significance (Table 2).

Table 2. KPSS and ADF test for stationary of aqua and capture fish series

Series	log(Aquaculture)		log(Capture fish)	
	KPSS	ADF	KPSS	ADF
Level, I(0)	1.540(0.010)	-2.31(0.449)	1.417(0.01)	-1.678(0.705)
1^{st} difference, I(1)	0.482(0.046)	-3.10(0.129)	0.107(0.10)	-3.375(0.069)
2^{nd} difference, I(2)	0.0579(0.1)	-4.83(0.01)	-	-5.024(0.01)

(*p-value are reported in bracket*)

Selection of appropriate model for aquaculture and capture fish production with ACF and PACF plot

The ACF and PACF plot of the I(0) series of log-aquaculture and log-capture fish are presented in Figure 2. Since both series show an almost strong trend. So, the ACF of both series decays slowly and PACF at the first lag is almost 1, indicating both series are non-stationary (Shumway & Stoffer, 2017). The ACF and PACF plot of the I(2) series of log-aquaculture and I(1) series log-capture fish are presented in Figure 3. ACF of I(2) log-aquaculture did not show any significant spike, but only a spike close to the confidence limit at lag 1 suggests a MA(1) model.

While PACF showed no significant spike below lag 5 (only a significant spike at lag 12); a spike near the confidence limit at lag 1 suggests AR(1) model. ACF of I(1) log-capture fish also did not show any significant spike, but a spike close to the confidence limit at lag 1 suggests MA(1) model. No significant spike is found from the PACF plot for the I(1) log-capture fish series, but a spike close to the confidence limit at lag 1 snuggest AR(1). ACF and PACF help to realize the plausible ARIMA models for a stationary series; but not the best ones. To find the best model for both series, different ARIMA models are simulated. Candidates' models with different parameters for I(2) log-aquaculture and I(1) log-capture fish are presented in Table 3 and Table 4 respectively.

Khulna University Studies Special Issue (ICSTEM4IR): 904-916:2022
DOI: https://doi.org/10.53808/KUS.2022.ICSTEM4IR.0184-se

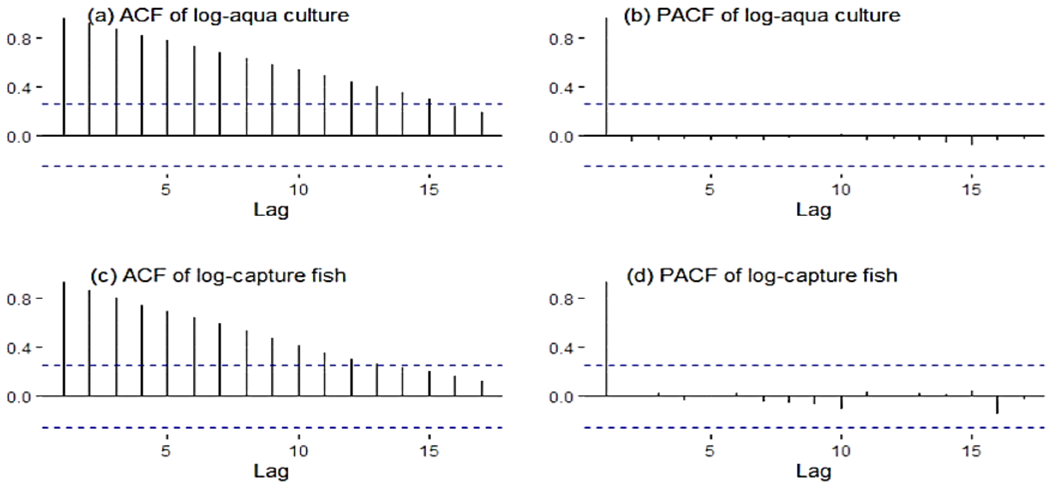

Figure 2. (a) ACF and (b) PACF of log-aqua culture fish production; (c) ACF and (d) PACF of log-capture fish production.

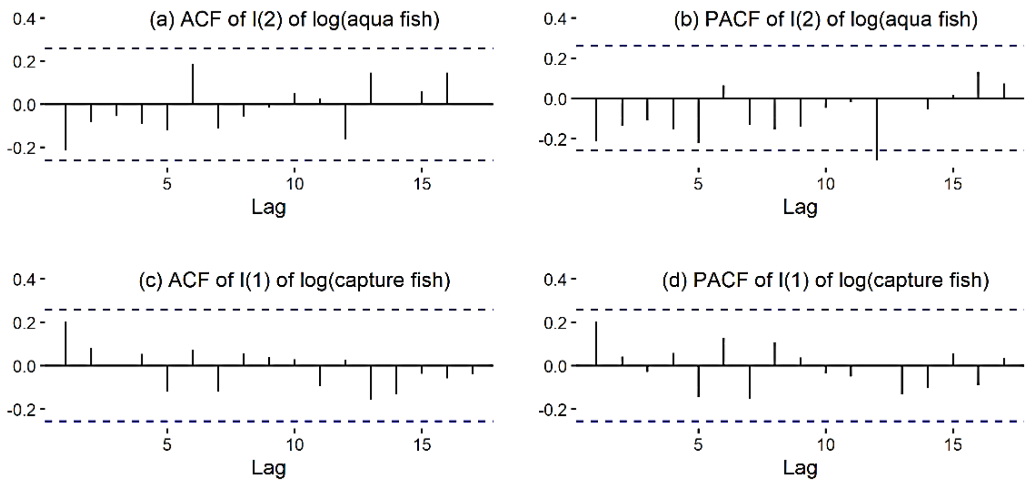

Figure 3. (a) ACF , (b) PACF of I(2) series of log-aqua culture and (c) ACF , (d) PACF of I(1) series of log-capture fish.

Simulation results of different ARIMA models

Four ARIMA models are found comparatively with smaller AIC, BIC, SSE, and greater *p*-value of Ljung-Box test for I(2) log-aquaculture series. ARIMA(1,2,1) is selected with lowest AIC=-281.609, BIC=-275.480, SSE=0.02117 and with the highest insignificant auto correlated residual, $p>0.05$ (Table 3). Candidate ARIMA models with comparatively smaller AIC, BIC, SSE, and greater *p*-value of Ljung-Box test for I(1) log-capture fish series are presented in Table 4.

Table 3. Candidate ARIMA models with selection criteria for I(2) log-aqua culture series

Model	AIC	BIC	SSE	p-value of Ljung-Box test
0 2 0	-275.652	-273.609	0.02562	0.4452
0 2 1	-277.318	-273.232	0.02399	0.4996
1 2 0	-276.256	-272.170	0.02446	0.5410
1 2 1	-281.609	-275.480	0.02117	0.9700 (selected)

Table 4. Candidate ARIMA models with selection criteria for I(1) log-capture fish series

Model	AIC	BIC	SSE	p-value of Ljung-Box statistic
0 1 0	-251.078	-246.957	0.041811	0.536
0 1 1	-251.268	-245.087	0.04024	0.906
1 1 0	-251.604	-245.423	0.039999	0.955(selected)
1 1 1	-249.715	-241.474	0.03992	0.975

ARIMA(1,1,0) is selected with lowest AIC=-251.604, and BIC=-245.423, SSE=0.04 and with insignificant auto correlated residual, *p*=0.955 (**Table 4**).

Table 5. Parameter estimation of the ARIMA(1,2,1) model for log-aquaculture fish production

Coefficients	Estimates	Std. error
AR(1)	0.555	0.149
MA(1)	-0.932	0.081

with estimated $\sigma^2 = 0.0004$

Table 6. Parameter estimation of the ARIMA(4,1,2) model for log-capture fish production

Coefficients	Estimates	Std. error
Drift	0.0129	0.0045
AR(1)	-1.5627	0.3175

with estimated $\sigma^2 = 0.0007$

Model validation

The selected model ARIMA(1,2,1) for log-aquaculture and ARIMA(1,1,0) for log-capture fish production is validated by comparing the predicted and observed values from 2004 to 2018. The validation tools-root-mean-squared error (RMSE), mean absolute percentage error (MAPE) and mean absolute error (MAE) are found very low for both models (Table 7). Comparison of observed versus forecast log series of aquaculture and capture fish production from fitted ARIMA models are presented in Figure 4. It is seen that observed predicted log-aquaculture and log-capture fish are in close agreement with $R^2 = 98.26\%$ and $R^2 = 81.89\%$ respectively.

Table 7. Model validation parameters for forecasting aquaculture and capture fish production (log-series)

Series	RMSE	MAPE	MAE
log-aquaculture	0.022	0.002	0.012
log-capture	0.024	0.003	0.016

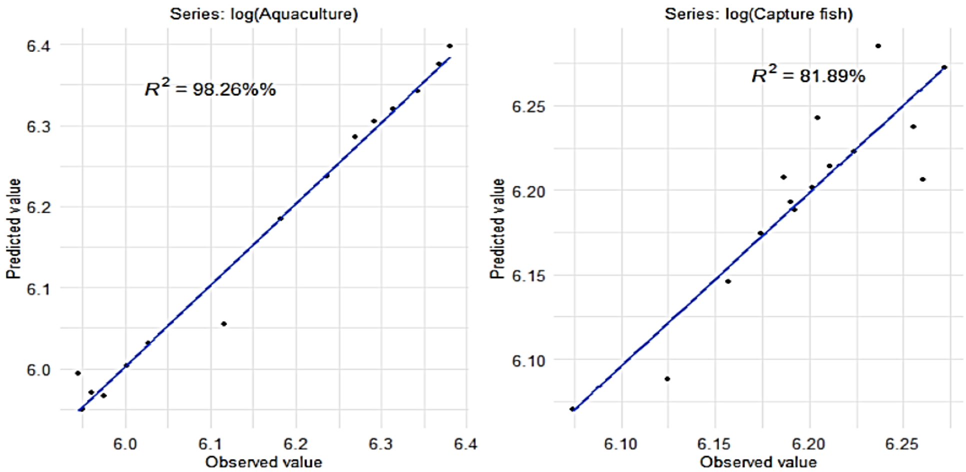

Figure 4. Comparison of observed versus forecast log series of aqua and capture fish production.

Visualizing actual vs. predicted series and forecasting fish production

The best-fitted ARIMA models for log-aquaculture and log-capture fish production are used to forecast future fish production in Bangladesh. To observe how the actual series and predicted series are tied, graph actual versus predicted log-series are shown in Figure 5(a,b). The figure exhibits that, for both series predicted values are so much close to actual observations. Aquaculture fish production and capture fish production are predicted from ARIMA (1,2,1) and ARIMA(1,1,0) respectively for the next ten years after 2018. The ten years prediction is shown in Table 8 and also visualize with a 95% confidence interval in Figure 5(c,d).

Table 8. Ten years of fish production

Year	log(Aqua fish)	log(Capture fish)	Aquaculture fish production (metric ton)	Capture fish production (metric ton)
2019	6.402544	6.285675	2526643	1930522
2020	6.428421	6.298585	2681768	1988774
2021	6.456812	6.311362	2862936	2048153
2022	6.486598	6.324111	3066183	2109169
2023	6.517160	6.336854	3289727	2171973
2024	6.548152	6.349596	3533071	2236641
2025	6.579384	6.362338	3796507	2303233
2026	6.610749	6.375079	4080834	2371807
2027	6.642188	6.387821	4387201	2442423
2028	6.673667	6.400562	4717014	2515141

Con-integration test of two series

Since the log-aquaculture series is I(2) and the log-capture fish series is I(1), so the two series may not be co-integrated. However, Johansen's co-integration test confirms this fact (Table 6). In addition, the original series is also tested for co-integration.

The test statistic for zero rank does not exceed the 1% level of significance for the aquaculture and

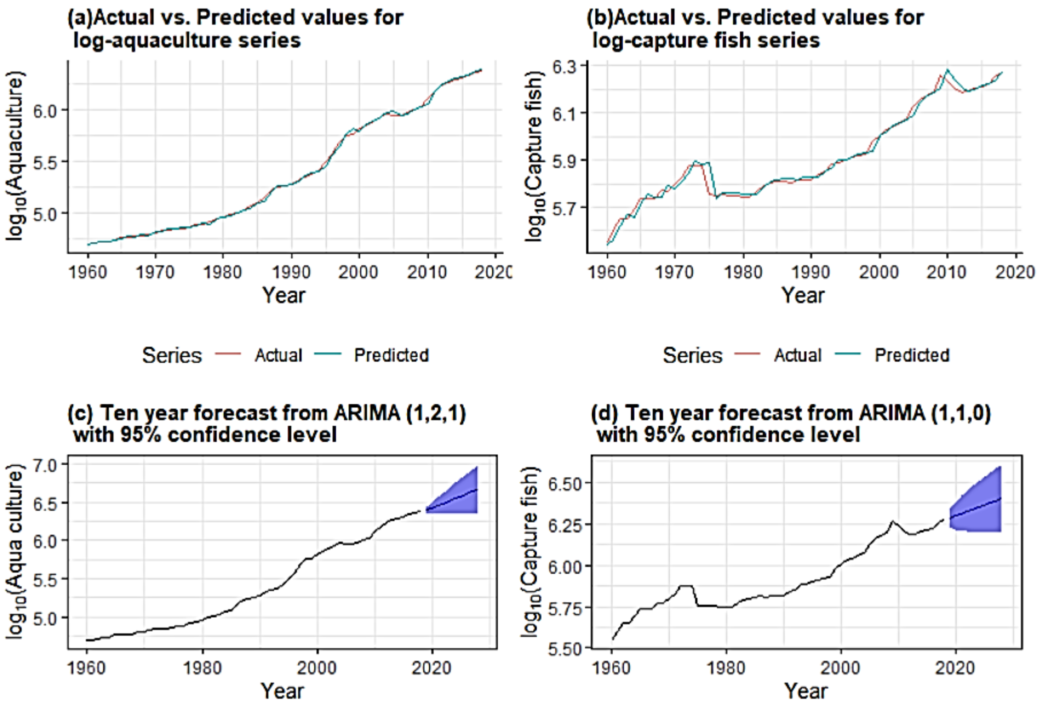

Figure 5. (a) Actual vs. predicted values of log-aquaculture series, (b) Actual vs. Predicted values for log-capture fish series and (c)Ten year forecast from ARIMA (1,2,1)with 95% confidence level, (d) Ten year forecast from ARIMA (1,1,0)with 95% confidence level

Table 9. Johansen co-integration test for aquaculture and capture fish along with log series

Series	Rank	Test	10%	5%	1%
Aquaculture and Capture	r<=1	8.85	6.50	8.18	11.65
	r=0	20.84	15.66	17.95	23.52
log-aquaculture and log-capture	r<=1	0.46	6.50	8.18	11.65
	r=0	12.15	15.66	17.95	23.52

capture fish series (20.84<23.52). So, the null hypothesis of no co-integration cannot be rejected. But, at a 5% level of significance, the test value (20.84) is greater than the critical value (17.95) implies that the two series are co-integrated. To avoid spurious relationships, co-integration at 5% is ignored. On the contrary, the claim of no co-integration cannot be rejected for log-series of aquaculture and capture fish at a 10% level of significance (test value 12.15<15.66). This result concludes that there is no long-run association between the series.

Discussion

In this paper, trend analysis from Sen's slope estimates showed that both aquaculture fish production and capture fish production are increasing on average from 1960 to 2018 in Bangladesh. However, the Mann-Kendall test confirmed that the positive trend is significant for both series. Due to a strong trend, actually exponential trend, log-transformed series are found non-stationary. To forecast the log-aquaculture series

ARIMA(1,2,1) is selected and the forecasted production of aquaculture fish in 2028 is 47,17,014 metric tonnes. While ARIMA (1,1,0) is used to forecast log-capture fish and forecasted capture fish in 2028 is 25,15,141 metric tonnes. So, increasing the rate of both aquaculture and captured fish can contribute to great economic growth in Bangladesh. During FY 2019-2020, By exporting around 70.95 thousand tonnes of fish and fisheries items, Bangladesh made TK 39,851.50 million (Habib, 2022). However, the fishery sector is directly or indirectly engaged in employment (Béné, 2006). Enhancing the fishery sector would lead to reducing the unemployment rate. Beyond the contribution to economic growth, fishery resources can mitigate malnutrition. As stated earlier, several species of both inland capture fish have high nutritional value (Bogard et al., 2015). Hence, the Bangladesh government may take steps to enhance all kinds of fish production to boost the economy, prevent malnutrition and ensure food security.

Conclusion

Time series forecasting analysis utilized the secondary data of the World Bank from 1960 to 2018. The trend analysis of capture fish production showed an increasing production but a falling growth rate trend due to overexploitation. However, the Aquaculture production trend rate is rising due to new techniques and technology introduced in this sector. In this study, the ARIMA models are fitted to Bangladesh's annual aquaculture production and capture fish production. ARIMA (1,2,1) and ARIMA(1,1,0) are selected as the most appropriate models for log series of aquaculture and capture fish production based on some goodness of fit measures. Both models show that production of aquaculture and capture fish production will increase next years. By 2028, aquaculture fish production has been estimated to reach 47,17,014 metric tonnes, and capture fish production has reached 25,15,141 metric tonnes. Fish production forecasting, both capture, and aquaculture are required for planning purposes, and fish import policy should be based on such projections. To achieve a sustainable development goal (SDG) it is important to utilize the fisheries resource.

Conflict of interests

The authors have declared that there are no conflicting interests.

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