



АГЕНТСТВО МЕЖДУНАРОДНЫХ ИССЛЕДОВАНИЙ

ИННОВАЦИОННЫЕ ПОДХОДЫ К РЕШЕНИЮ СОВРЕМЕННЫХ ПРОБЛЕМ: КОМПЛЕКСНЫЙ АНАЛИЗ И ПРАКТИЧЕСКАЯ РЕАЛИЗАЦИЯ

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ГЕОЛОГО- МИНЕРАЛОГИЧЕСКИЕ НАУКИ



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FORECASTING MONTHLY RAINFALL IN BA DON, QUANG TRI USING ARIMA MODEL

Annotation

The study uses the ARIMA model to forecast the monthly rainfall in 2025 in the Ba Don area, Quang Tri province. Based on rainfall data from Ba Don station in the period of 2020 - 2024, the study has proposed 03 models ARIMA(12,0,11), ARIMA(12,0,12) and ARIMA(12,0,24). Based on the adjusted R^2 , Akaike info criterion (AIC), Schwarz criterion (SBIC), the number of significant variables in the model, the most suitable ARIMA(12,0,11) model was selected to forecast rainfall in the study area. The forecast results of average monthly rainfall in 2025 range from 12 to 716mm, peaking in September, October, and November, corresponding to the flood season in Quang Tri province.

Keywords

ARIMA, Rainfall, Ba Don

1. INTRODUCTION

Ba Don area is a ward in the north of Quang Tri province, in the coastal plain, located in a low - lying area on the southern bank of Gianh River, adjacent to the East Sea, and has a relatively dense river and stream system. Therefore, this is also an area with many potential risks during the storm season. According to research by Hoang Thi Ngoc Ha et al. (2020), the risks of natural disasters in the Ba Don area include storms, floods, heat waves, and saltwater intrusion [3]. According to the research program conducted in 2020 by the General Department of Disaster Prevention and Control and the United Nations Development Program, the Ba Don area is in the group with high and very high risk indexes due to storms and floods [9].

The Ba Don area is forecasted to have many fluctuations in natural disasters such as storms, landslides, droughts, and floods; high - risk areas are agriculture, aquaculture,

infrastructure, and residential safety [1]. Therefore, research on rainfall forecasting in the Ba Don area is of great significance in flood and disaster warning research.

The Arima model was researched and developed by George Box and Gwilym Jenkins, to forecast the fluctuations of the research object according to time series [2]. Currently, the Arima model is mainly applied in the economic field (forecasting GDP economic index, import - export situation...), agriculture (forecasting crop yield... [4,7], Hany F.abd - Elhamid et al. (2024) and S. Swain (2018) used the ARIMA model to forecast rainfall in arid regions to cope with climate change [5,8], H. N. Mahendra et al. (2023) used the ARIMA model to forecast air quality for the city of Surat in India [6].

The above studies show that, when there is a large enough historical data series, the ARIMA model can be used to forecast environmental problems reliably and effectively. The advantages of the Arima model are that it is simple, easy to use, can be run on different applications such as SPSS, R, Eviews and can forecast effectively in the short term. However, the ARIMA model also has disadvantages, such as requiring large historical data, and the forecast results do not take into account other influencing factors. In this study, the author uses monthly average rainfall data at the Ba Don gauging station from 2020 to 2024 to create a rainfall forecast model for 2025 as a reference document to develop a flood and natural disaster warning plan in the Ba Don area.

2. MATERIALS AND METHODS

2.1. Materials

The research data are the results of monthly average rainfall measurements at Ba Don meteorological station, Quang Tri province, from 2020 to 2024 (R series).

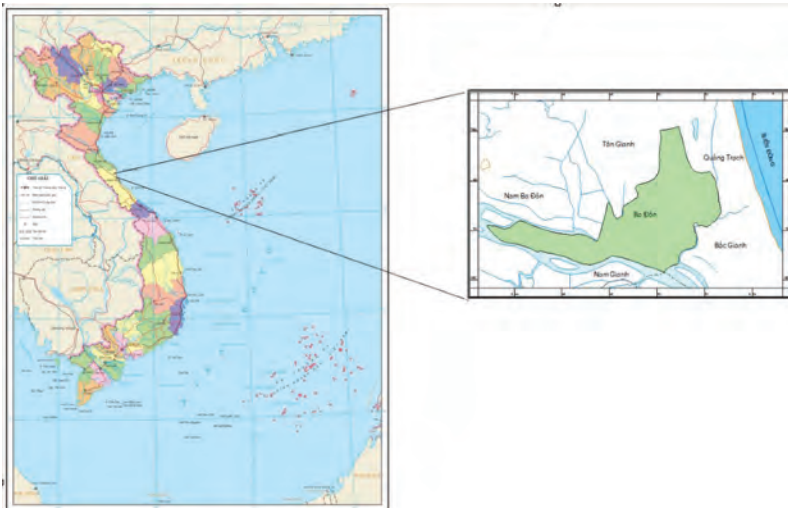


Figure 1. Study area

2.2. Research Methods

The Arima (AutoRegressive Inegrate Moving Average) model was first introduced by Box – Jenkins in 1974 [2]. The Arima model is a combination of 3 main components: AR – Auto - regressive component; I – Stationarity of the time series; MA – Moving average component. Arima is a quantitative forecasting model over time, the future value of the forecasted variable will depend on the movement trend of that object in the past. The Arima model analyzes the correlation between observed data to create a forecasting model through the stages of model identification, parameter estimation from observed data, and testing estimated parameters to find a suitable model. The forecast confidence limit is based on the variance of the forecast error.

The integrated autocorrelation model with ARIMA moving average (p,d,q) has the following general equation form:

$$Y_t = \phi_0 + \phi_1 Y_{t-1} + \dots + \phi_p Y_{t-p} + u_t + \theta_1 u_{t-1} + \theta_2 u_{t-2} + \dots + \theta_q u_{t-q}$$

u_t : White noise

ϕ, θ : Numerical parameter

p. Autoregressive order

q. Moving average order

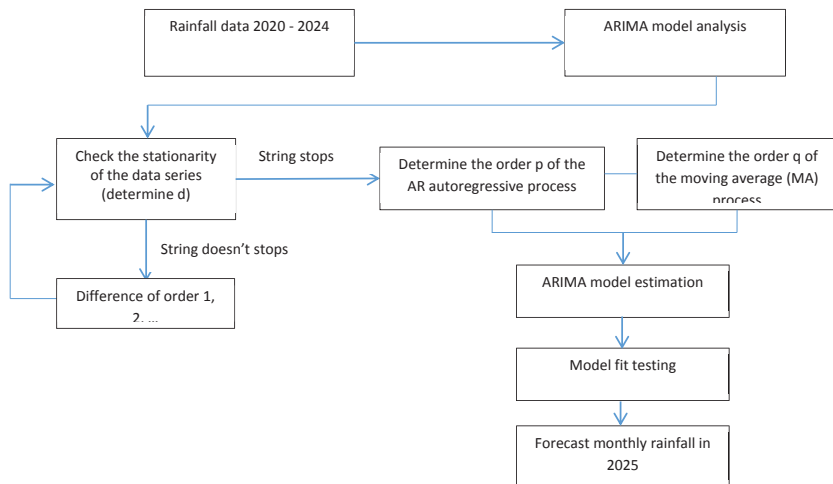


Figure 2. Rainfall forecast diagram for 2025 in Ba Don, Quang Tri using the ARIMA model

The process of building an ARIMA forecasting model to forecast rainfall using the Box–Jenkins method [2] includes 4 steps:

Step 1: Model identification

To use the ARIMA (p,d,q) model in forecasting, it is necessary to find suitable values of p,d, and q of the model (where d is the order of difference of the time series data under investigation, p is the order of autoregression, and q is the order of moving average).

These values are determined based on the autocorrelation diagram (ACF) and partial autocorrelation diagram (PACF). In which, the choice of the AR (p) model depends on the PCAF diagram if it has a high value at lags 1, 2, ..., p and suddenly decreases afterwards, at the same time the ACF function form gradually fades.

Step 2: Estimate the parameters of the ARIMA model (p,d,q)

Conduct parameter estimation for the identified suitable models using Eviews software based on comparison of criteria such as Coefficient of determination R^2 , AIC index, Schwarz criterion (SBIC) and number of significant variables (95 % level). The model with the largest R^2 index, smallest AIC and SBIC values and many significant variables is considered the most suitable model.

Step 3: Checking the model

The estimated model must then be checked to ensure that it is representative of the observed data series. This is done on the range of model error values to determine whether they are white noise. Here, the ACF plot of the residuals allows this criterion to be checked.

Step 4. Forecasting

Based on the equation of the ARIMA model, forecast the average monthly rainfall for the year 2025.

3. RESULTS AND DISCUSSION

3.1. Testing data stop

The condition for forecasting analysis using the ARIMA model is that the rainfall data series (R series) must be a stationary series. Therefore, before building a forecasting model, it is necessary to check whether the R series over time is a stationary series or not?

Testing the stationarity of a series R using the Augmented Dickey - Fuller (ADF) test is called the unit root test. The test results are shown in Table 2.

Table 2. ADF test results for rainfull data series

Kiểm định	t - Statistic	P - Value
ADF	- 5,904	0.000
Test critical values:		
1 % level	- 3,546	
5 % level	- 2,912	
10 % level	- 2,594	

The test results show that the t - Statistic values are all greater than the critical values, and the P - value is less than 0.05. Thus, it can be concluded that the R series is stationary, meets the conditions for ARIMA analysis and does not need to be differentiated. At that time, the ARIMA model will become an ARMA model.

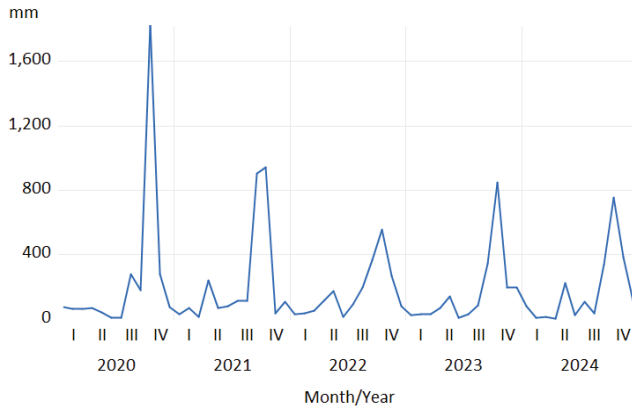


Figure 3. Average monthly rainfall in Ba Don area, Quang Tri from 2020 to 2024

3.2. Choosing a forecasting model

Step 1. Identification

As the test result above shows, the rainfall data series (R) is linear. Therefore, $d = 0$

Step 2. Model estimation

The p and q values are determined based on the autocorrelation coefficient (ACF) table and the partial correlation coefficient (PACF) table.

Table 3. Autocorrelation coefficient ACF
and partial correlation coefficient PACF of rainfall data series

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.242	0.242	3.6794	0.055
		2 -0.025	-0.089	3.7206	0.156
		3 -0.179	-0.161	5.8046	0.122
		4 -0.204	-0.134	8.8675	0.073
		5 -0.150	-0.094	10.083	0.073
		6 -0.098	-0.094	10.749	0.096
		7 -0.154	-0.200	12.422	0.088
		8 -0.175	-0.212	14.602	0.067
		9 -0.167	-0.240	16.834	0.055
		10 -0.034	-0.163	16.720	0.081
		11 0.342	0.204	25.576	0.008
		12 0.497	0.307	44.685	0.000
		13 0.161	-0.052	46.748	0.000
		14 -0.006	-0.000	46.750	0.000
		15 -0.146	-0.027	48.502	0.000
		16 -0.155	-0.018	50.522	0.000
		17 -0.114	-0.037	51.551	0.000
		18 -0.095	-0.035	52.446	0.000
		19 -0.079	0.038	53.011	0.000
		20 -0.145	-0.038	54.957	0.000
		21 -0.118	-0.002	56.289	0.000
		22 -0.036	-0.125	56.416	0.000
		23 0.108	-0.252	57.582	0.000
		24 0.329	0.073	68.745	0.000
		25 0.196	0.043	72.837	0.000
		26 0.004	-0.088	72.838	0.000
		27 -0.070	-0.017	73.395	0.000
		28 -0.113	-0.039	74.871	0.000

From Table 3, we use the ACF autocorrelation coefficients to choose order q for MA from the autocorrelation function and the PACF partial correlation function to choose

order p for AR. Based on the PACF chart, it shows that the partial correlation coefficients have large values at lags 12, equivalent to p receiving values $p = 12$. For the ACF chart, we have large autocorrelation coefficients at lags 11, 12 and 24, corresponding to q receiving values 11, 12 and 24. Thus, we will consider the models ARIMA(12,0,11), ARIMA(12,0,12), ARIMA(12,0,24).

The identified models are re - tested for suitability based on the following test parameters: adjusted R^2 index, Akaike info criterion (AIC), Schwarz criterion (SBIC), and the number of significant variables in the model. In which, The larger the R value, the more significant the model. The smaller the AIC and SBIC values, the more significant the model. The test results are summarized in Table 4.

Table 4. Statistical results of some criteria
of ARIMA models tested at 95 % significance level

Models	R^2	Akaike info criterion (AIC)	Schwarz criterion (SBIC)	Meaningful variables
ARIMA (12,0,11)	0,73	13,5	13,6	3
ARIMA (12,0,12)	0,56	13,8	13,9	3
ARIMA (12,0,24)	0,57	13,8	13,9	2

The statistical comparison results of some criteria of 4 models show that the ARIMA (12,0,11) model has a high R^2 coefficient of 0.73, the AIC and SBIC indicators are both smaller than the remaining models. Thus, the ARIMA (12,0,11) model is the most suitable model to forecast average monthly rainfall in Ba Don area, Quang Tri.

*** Step 3: Test the model**

After selecting the ARIMA (12,0,11) forecasting model, the above models were tested to see if they violated the assumptions of the regression model using the Breusch - Godfrey test and the White test. The results showed that there was no autocorrelation and the error variance did not change. Thus, it was concluded that the ARIMA (12,0,11) model was suitable for forecasting the average monthly rainfall in the study area.

3.3. Forecasting results

The results of the average monthly rainfall forecast in Ba Don area, Quang Tri province are summarized in the table 6.

Table 6. Rainfall forecast results for 2025 in Ba Don area, Quang Tri province

TIM E	202 5 MO 1	202 5 MO 2	202 5 MO 3	202 5 MO 4	202 5 MO 5	202 5 MO 6	202 5 MO 7	202 5 MO 8	202 5 MO 9	202 5 MO 10	202 5 MO 11	202 5 MO 12
Rainf ull (mm)	39,1	22,7	12,2	69,8	199, 6	68,2	15,2	82,1	340, 8	716, 0	271, 7	96,4

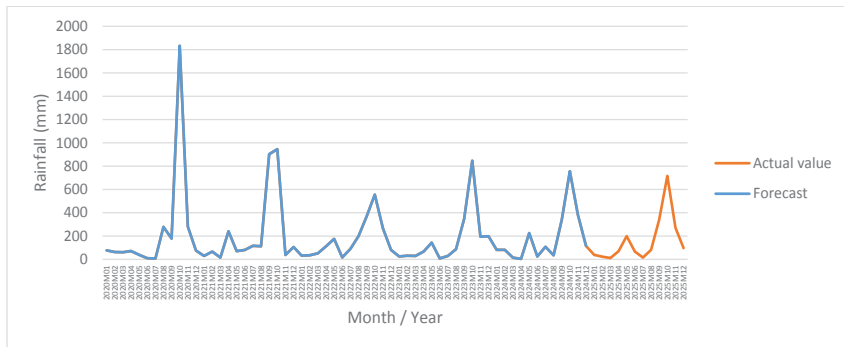


Figure 4. Long - term rainfall forecast for Ba Don

Forecast results for average monthly rainfall in Ba Don, Quang Tri in 2025 range from 12 to 716mm, peaking in September, October and November corresponding to the flood season in Quang Tri province. Forecast results are relatively consistent with historical data collected from 2020 to 2024.

4. CONCLUSION

Based on rainfall data in Ba Don area, Quang Tri province has built a model to forecast average monthly rainfall in 2025. The selected model is ARIMA (12,0,11) which has been tested by adjusted R2 index, AIC (Akaike info criterion), SBIC (Schwarz criterion) standard to ensure reliability in forecasting. The forecasted rainfall results in Ba Don area, Quang Tri in 2025 range from 12 to 716 mm, with high rainfall concentrated in September, October and November during the rainy season.

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