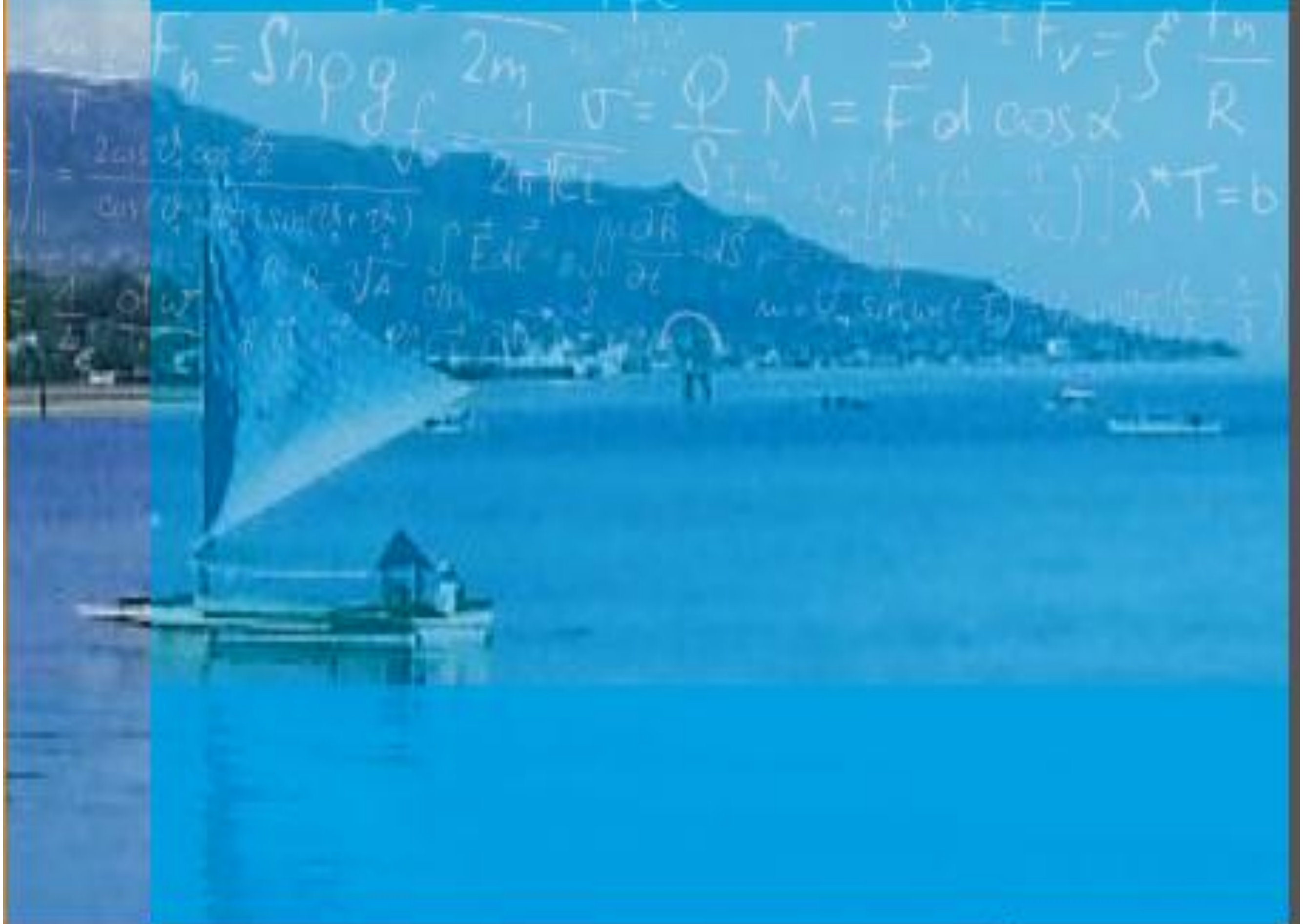
Basic Science
for Sustainable Marine Development

PROCEEDING
INTERNATIONAL SEMINAR 2015

Ambon, 3-4 June 2015



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Welcoming Address by The Organizing Committee

The honorable, the rector of Pattimura University
The honorable, the vice rector of academic affair, Pattimura University
The honorable, the vice rector of administration and financial affair, Pattimura University
The honorable, the vice rector of planning, cooperation and information affair, Pattimura University
The honorable, all the deans in Pattimura University
The honorable, the key note speakers and other guests.

We have to thank The Almighty God for the blessings that allow this International seminar can be held today. This is the first seminar about MIPA Science in which the Faculty of MIPA Pattimura University becomes the host. The seminar under the title Basic Science for Sustainable Marine Development will be carried out on 3 June 2015 at Rectorate Building, the second floor. There are 250 participants from lecturers, research institute, students, and also there are 34 papers will be presented.

This International seminar is supported by the amazing people who always give financial as well as moral supports. My special thanks refer to the rector of Pattimura University, Prof. Dr. Thomas Pentury, M.Si, and the Dean of MIPA Faculty, Prof. Dr. Pieter Kakissina, M. Si. I also would like to express my deepest gratitude to Dr. Kotaro Ichikawa, the director of CSEAS Kyoto University, Prof. Bohari M. Yamin, University of Kebangsaan Malaysia, Prof. Dr. Budi Nurani Ruchjana (Prisident of Indonesian Mathematical Society/Indo-MS), Dr. Ir. A. Syailatua, M.Sc (Director of LIPI Ambon), and Hendry Ishak Elim, PhD as the key note speakers. We expect that this international seminar can give valuable information and contribution especially in developing basic science for sustainable marine development in the future.

Last but not least, we realize that as human we have weaknesses in holding this seminar, but personally I believe that there are pearls behind this seminar. Thank you very much.

Chairman
Dr. Netty Siahaya, M.Si.

Opening Remarks
By Dean of Mathematic and Natural Science Faculty

I express my deepest gratitude to The Almighty God for every single blessing He provides us especially in the process of holding the seminar until publishing the proceeding of International Seminar in celebrating the 17th anniversary of MIPA Faculty, Pattimura University. The theme of the anniversary is under the title Basic Science for Sustainable Marine Development. The reason of choosing this theme is that Maluku is one of five areas in Techno Park Marine in Indonesia. Furthermore, it is expected that this development can be means where the process of innovation, it is the conversion of science and technology into economic value can be worthwhile for public welfare especially coastal communities.

Having the second big variety of biological resources in the world, Indonesia is rich of its marine flora and fauna. These potential resources can be treated as high value products that demand by international market. Basic science of MIPA plays important role in developing the management of sustainable marine biological resources.

The scientific articles in this proceeding are the results of research and they are analyzed scientifically. It is expected that this proceeding can be valuable information in terms of developing science and technology for public welfare, especially people in Maluku.

My special thanks refer to all researchers and reviewers for your brilliant ideas in completing and publishing this proceeding. I also would like to express my gratefulness to the dies committee-anniversary of MIPA Faculty for your creativity and hard working in finishing this proceeding, God Bless you all.

Dean of Mathematic and Natural Science Faculty

Prof. Dr. Pieter Kakisina, M.Si.

Contents

Rainfall and Rainy Days Prediction in Ambon Island Using Vector Autoregression Model

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ABSTRACT

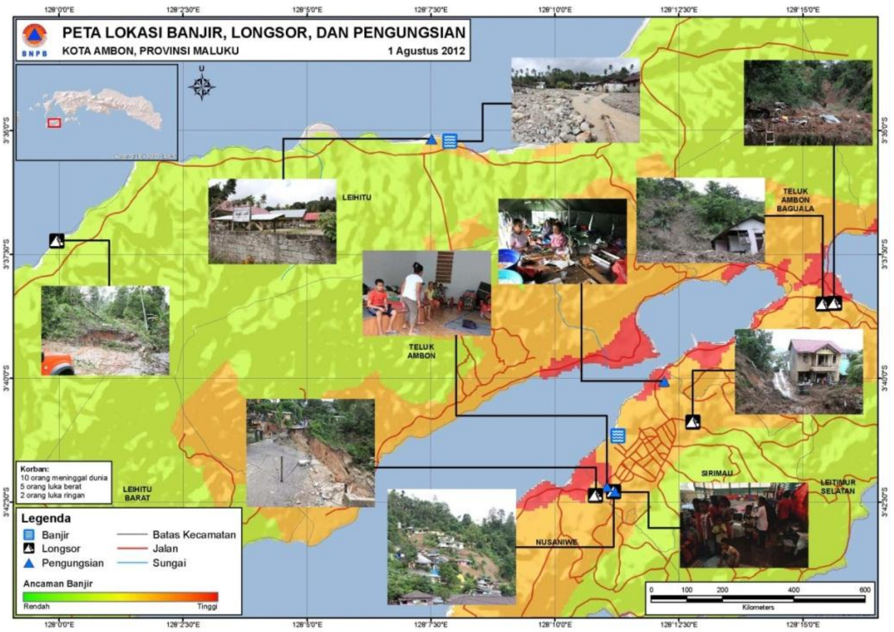
Ambon Island is one of the islands in Maluku Province, located in the eastern part of Indonesia. Ambon island is a tropical area with two seasons, namely rainy season and dry season. Geographically, Ambon island has a seasonal rainfall patterns with the high rainfall. The highest rainfall on the Ambon island occurred between May until July. In the last decade, the pattern of rainfall on the Ambon island become irregular. One of the indicator of this phenomenon was the extreme rainfall occured on the Ambon island. Extreme rain is the one of the factors that cause natural disasters in the Ambon island such as floods and landslides. Therefore, this study aimed to estimate rainfall model on the Ambon island using vector autoregression model (VAR) and to forecast rainfall and rainy days based on the best model of VAR. The data used in this research is time series data from January 2005 to December 2014. The data is monthly rainfall data ($rainfall$) and rainy days data for every month ($days$) on the Ambon island. The best of VAR models are based on the following analysis procedures: VAR lag order selection criteria, $R2$, residual test for autocorrelations, and MSE. In this study, we've gained the (7) as the best model. (7) derived from logarithmic transformation of the actual data. From this model, we've predicted the situation in 2015 that the mean value of monthly rainfall and rainy days is 171 mm and 16 days per month, respectively. MSE of this model was 0.499 for ($rainfall$) and 0.141 for ($days$). It is accurate because this model has the smallest MSE values.

Keywords: *Ambon island, time series, rainfall, rainy days, vector autoregression*, $VAR(7)$, *lag order selection criteria,* $R2$*, autocorrelations,* MSE*, forecasting*.

INTRODUCTION

Ambon island, one of the islands in Maluku Province is located in the Eastern part of Indonesia. In astronomical terms, Ambon island is located at 3° 29' - 3° 47' of South Latitude and 127° 54' - 128° 21' of East Longitude. Geographically, Ambon island is surrounded by the Banda sea and several islands such as Seram, the Lease islands (Haruku, Saparua and Nusa Laut), and other small islands. Based on the astronomical positions, Ambon island is a tropical climate region which has two seasons, namely dry season and rainy season. The geographical position of Ambon Island resulted in the occurrence of high rainfall. The highest rainfall on the Ambon Island occurs from May to July.

Since the last decade, climate in Ambon island has changed. These changes are assumed to be one of the consequences of global climate change. It has produced irregular patterns of rainy and dry seasons period in the island. The indicator of this phenomenon is the extreme rainfall that have been occured on the island. An extreme rainfall is the rainfall that excess 400 mm in short or long term. Based on data from Indonesian Agency of Meteorology, Climatology and Geophysics (BMKG) in Ambon, the phenomenon of extreme rainfall in the island occurred in May to August 2012 and June to August 2013. The extreme rainfall is one of the main factors that caused floods and landslides on the Ambon island (see Figure 1).



(Source: BNPB)

Figure 1. Map: Disaster and Evacuation in the Ambon island in 2012

Commonly, there is no right solution to the impact of extreme rainfall. One solution is to do rainfall forecast for a specific period of the future. This method can be used as an early warning method to anticipate disasters that might be caused by extreme rainfall (or extreme weather changes). By using Statistics, there are several available methods that can be used for estimation and forecasting of rainfall. The methods are chosen based on the type and pattern of the data, and the number of variables.

In this study, the data type in use is time series data. There are two variables of the data in use. These are the monthly rainfall level ($rainfall$) and the number of rainy days per month ($days$). Both of these variables are assumed to influence each other and have a correlation, i.e., if the number of rainy days increases then the rainfall will also increase, and vice-versa. Based on these assumptions, this study used the vector autoregression (VAR) model to estimate the pattern of rainfall and to produce the forecasting model. Thus, this study aims to estimate the best model of monthly rainfall level data and the number of rainy days per month on Ambon island using vector autoregression models.

PREVIOUS STUDY

VAR method was first introduced by Christopher A. Sims in 1980. This method was introduced as an alternative way in macroeconomic analysis (Lutkepohl, 2011). VAR is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on the system of variables (Eviews, 2009). VAR

model is non-structural models (Gujarati, 2004). VAR models have a simple structure with minimal number of variables (Sinay, 2014). VAR models are designed to analyse stationary variables, that is not contain a trend. The VAR approach sidesteps the need for structural modeling by treating every endogenous variable in the system as a function of the lagged values of all of the endogenous variables in the system (Eviews, 2009).

The commonly form of VAR models is:

$$y_t = A_t y_{t-1} + \cdots + A_p y_{t-p} + B x_t + \varepsilon_t$$

where y_t is a k vector of endogenous variables, x_t is a d vector of exogenous variables, $A_1, \ldots, A_p$ and B are matrices of coefficients to be estimated, and ε_t is a vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and uncorrelated with all of the right-hand side variables. (Eviews, 2009)

However, in 2014, Nugroho *et. al.* employs VAR methods for estimation models and forecasting of rainfall in Central Java. A VAR model of rainfall, temperature and humidity was obtained. From this study, the forecasting results using VAR model has better accuracy than the $ARIMA$ model, which was found by BMKG analysis.Generally, there are two steps to create and to generate an accurate forecasting. The first step is to collect the data that is relevant to the intended purpose of forecasting and related to information. The second step is to choose the right forecasting method to be implemented. (Henke & Reitch, 1998).

METHODS

This study employs a case study of monthly rainfall in the Ambon island. The data used in this research is a secondary data that was obtained from the Indonesian Meteorology and Geophysics Agency (BMKG). The data is the time series data of monthly rainfall level and the number of rainy days per month on the Ambon island. The data is the result of observation of Meteorological Station Pattimura BMKG Ambon from January 2005 to December 2014.

This study uses the VAR method to analysis the data. The VAR analysis procedure are shown as follows;

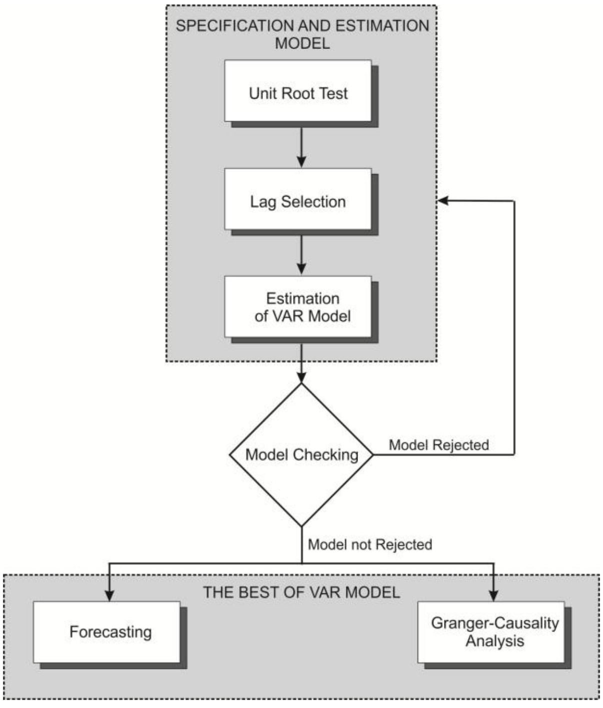


Figure 2. Flow Chart of VAR Analysis Procedure

The initial step in the analysis is an examination stasioneritas VAR data. To examine the stationary of the data that can be used as a unit root test. The unit root test used is based on the Augmented Dickey-Fuller (ADF) test. Mathematically, the form of ADF is shown as follows:

$$\Delta Y_t = \gamma + \delta t + \rho Y_{t-1} + \sum_{j=1}^{k} \phi_j \Delta Y_{t-j} + e_t$$

where $\Delta Y_t = Y_t - Y_{t-1}$ and $\rho = a - 1$.

The hypothesis of this test is

$H_0 : \rho = 0$ (a unit root exists)

At the significance level of $(1 - \alpha)100\%$, H_0 is rejected, if the ADF statistics is less than the critical value at the time of α, or $p\ value$ and less than the significance value of α. Meaning that, the data is stationary.

The next step is the selection of the lag order. The aims of this step is to obtain the optimal lag order of the VAR model. Lag order selection uses the following information criteria:

- Akaike Information Criterion (AIC)

$$AIC(p) = \log\det\left(\hat{\Sigma}_u(p)\right) + \frac{2}{T} pk^2$$

- Schwarz Information Criterion (SC)

$$SC(p) = \log\det\left(\hat{\Sigma}_u(p)\right) + \frac{\log(T)}{T} pk^2$$

- Hannan-Quinn Criterion (HQ)

$$HQ(p) = \log\det\left(\hat{\Sigma}_u(p)\right) + \frac{2\log\log(T)}{T} pk^2$$

Where, p is lag, $\hat{\Sigma}_u(p) = T^{-1} \sum_{t=1}^{T} \hat{u}_t \hat{u}_t$, T is the sample size, and k is the number of endogenous variable. Value of lag p chosen as the value of p^* which minimizes the information criteria in the observed intervals of 1, ..., p_{max}. Lag is optimal based on the smallest value of AIC, SC and HQ.

The sequential modified likelihood ratio (LR) test is carried out as follows. Starting with the maximum lag, followed by test of the hypothesis to check whether the coefficients on lag p are jointly zero using the χ^2 statistics:

- The Sequential modified likelihood ratio (LR)

$$LR = (T - m) + \left(\log\left|\Omega_{p-1}\right| - \log\left|\Omega_p\right|\right)$$

where is m the number of parameters per equation under the alternative. Note that Sims'(1980) small sample modification which uses $(T - m)$ was employed rather than T (Eviews, 2009). Lag is optimal which was based on the largest value of LR.

After the estimation of the model based on the optimal lag order, diagnostic checking for the residual was carried out. It aims to whether there is a serial correlation (autocorrelation) in lag h on residuals. The check employs the Portmanteau statistics test. The statistics of Portmanteau test is shown as follows:

$$Q_h = T \sum_{j=1}^{h} tr\left(\hat{C}_j' \hat{C}_0^{-1} \hat{C}_j \hat{C}_0^{-1}\right),$$

or

$$Q_h^* = T^2 \sum_{j=1}^{h} \frac{1}{T-j} tr\left(\hat{C}_j' \hat{C}_0^{-1} \hat{C}_j \hat{C}_0^{-1}\right)$$

where $\hat{C}_i = \frac{1}{T}\sum_{t=i+1}^{T} \hat{\boldsymbol{u}}_t \hat{\boldsymbol{u}}_{t-i}'$. The distribution of this statistics test is ${\chi^2}_{(k^2(h-n^*))}$, with the n^* is the number of coefficient other than constants in model of $VAR(p)$ that are estimated.
The hypothesis is

H_0: no residual autocorrelations up to lag h.

At the significance level of $(1-\alpha)100\%$, this study accepts the value of H_0, if $p\ value$ of the Q statistics for each lag h is greater than the significance value of α. Thus, there is no serial correlation.

VAR model is referred to the best model, if the model meets the VAR analysis procedures that is described above. The following step is forecasting of the future periods using the best of VAR model. Generally, Mean Square Error (MSE) value is used to determine the accuracy of forecasting results. The form of MSE is shown as

$$MSE = \frac{1}{n}\sum_{i=1}^{n}(Y_t - \hat{Y}_t)^2$$

where n is amount of data. A good model will produce smallest of MSE value which is related to the accuracy of a forecast. In several cases, the MSE values can be used to determine the performance of a model.

In this study, the relations between the variables in VAR models were analysed. In the analysis process, the Granger-Causality method was used to analyse the short-term causality of each variable in VAR models. The analysis also uses the Wald test, that is a chi-square distributon.

RESULTS AND DISCUSSION

The data are the monthly rainfall level ($rainfall$) and the number of rainy days per month ($days$), which was occured on the Ambon island in the period of January 2005 to December 2014. The number of observations of the data is 120 observations. From this data, the statistical description was derived. The maximum of $rainfall$, occurred in June 2006 with the level of rainfall is 1399.1 mm. That was occurred within 25 days. The minimum $rainfall$, occurred in November 2012 which is 10 mm within 3 days (see Figure 2). The average of $rainfall$ in Ambon island during the past 10 years is 267.53 mm and the average number of rainy $days$ is 18 days.

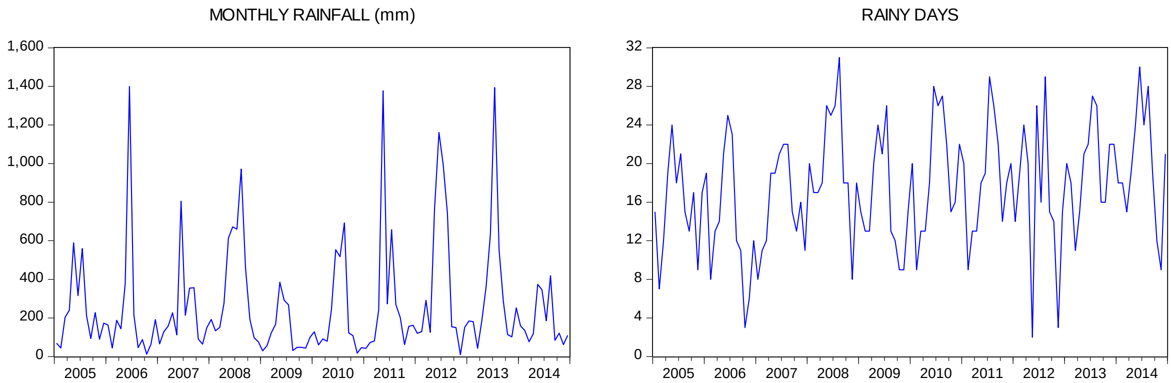


Figure 2. Plot of the Actual Data throughout 2005-2014

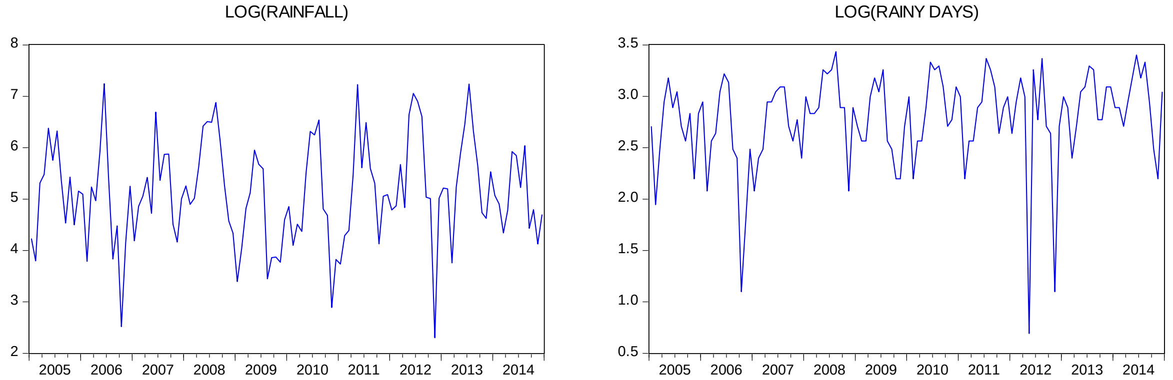


Figure 3. Plot of the Transformed Data (Log Tranformation) throughout 2005-2014

The statistical test for the normality of the data uses the Jarque-Bera test. It shows that the data of $rainfall$ is not normally distributed ($p\ value\ =$ 0.000000), and the data of $days$ is normally distributed ($p\ value\ =$ 0.703898). Normalization process of the data can be done using the logarithmic transformation (Box-Cox Transformations). Therefore, in this study, a comparison between the actual data and the data of logarithmic transformation (transformed data) is presented which aims to obtain the best VAR models. Logarithmic transformation of the data can be seen in Figure 3.

Figure 2 and Figure 3, show the pattern of the actual data and the transformed data which are not showing any trend component. This indicates that the data is already stationary. More details about the stationary characteristics of the data can be seen through the results of unit root test. This results are given in Table 1. Based on the table, it shows that $p\ values$ of ADF statistical analysis for each data component is 0. The $p\ values$ are less than $\alpha\ =$ 0.05. Thus, the hypothesis $H_0 : \rho = 0$ must be rejected (since there is a unit root). It means that the data is already stationary.

Table 1. Unit root test

	Critical value (α =5%)	**Level**	
		Stat. ADF	**$p\ value$**
Actual Data:			
$rainfall$	-2.885863	-6.886292	0.0000
$days$	-2.885863	-6.732931	0.0000
Transomred Data:			
$\log(rainfall)$	-2.885863	-6.082342	0.0000
$\log(days)$	-2.885863	-7.948556	0.0000

The results of data processing are shown in Table 2 which are VAR lag order selection criteria. The table, shows the optimum lags for the actual data for lag 1 and the optimal lags for the transformed data which are lag 1, lag 4 and lag 7. Thus, the actual data will be formed for the model of $VAR(1)$, and the transformed data will be established for the models $VAR(1)$, $VAR(4)$ and $VAR(7)$. These are the candidates for the best model.

Table 2. VAR Lag Order Selection Criteria

Lag	Actual Data				Transformed Data			
	LR	AIC	SC	HQ	LR	AIC	SC	HQ
0	-	20.37512	20.42367	20.39482	-	3.691537	3.740081	3.711233
1	41.13754*	20.06914*	20.21477*	20.12823*	43.01059	3.368373	3.514007*	3.427461*
2	1.264986	20.12875	20.37147	20.22723	2.914301	3.412565	3.655288	3.511045
3	8.698286	20.11733	20.45715	20.25521	7.627883	3.411347	3.751159	3.549220
4	5.573077	20.13466	20.57156	20.31192	12.63965	3.360060*	3.796962	3.537325
5	1.510296	20.19113	20.72512	20.40779	1.486172	3.416774	3.950765	3.633431
6	2.916340	20.23310	20.86418	20.48915	4.691121	3.440818	4.071898	3.696867
7	6.988951	20.23248	20.96065	20.52792	52.27610*	3.385689	4.113858	3.681130
8	3.973220	20.26208	21.08734	20.59692	3.510773	3.420162	4.245420	3.754995

*Indicates lag order selected by the criteria

The next step is to process the estimation and select the best model. Based on the VAR analysis procedures, the results were obtained as shown in Table 3. From the table, the $VAR(7)$ was obtained as the best model since it has the largest of R^2 for each component ($\log(rainfall)$ and $\log(days)$). Also, there is no serial correlation of residual for each lags based on the Portmanteau test. Finally, $MSE\ value$ of the $VAR(7)$ is small. Thus, the forecasting results using the $VAR(7)$ has better accuracy than the other models.

Table 3. Summary

	Actual	Tranformed		
	$\boldsymbol{VAR(1)}$	$\boldsymbol{VAR(1)}$	$\boldsymbol{VAR(4)}$	$\boldsymbol{VAR(7)}$
R^2 of				
$rainfall$	0.196036			
$\log(rainfall)$		0.294569	0.419716	0.480648*
$days$	0.235169			
$\log(days)$		0.182302	0.237102	0.314952*
Residual Tests for Autocorrelations ($\alpha = 0.05$):				
Portmanteau Tests	Rejected H_0: no residual autocorrelations up to lag 11	Rejected H_0: no residual autocorrelations up to lag 6	Accept* H_0: no residual autocorrelations	Accept* H_0: no residual autocorrelations
MSE of				
$rainfall$	66665.751			
$\log(rainfall)$		0.676	0.561	0.499*
$days$	28.547			
$\log(days)$		0.167	0.155	0.141*

* indicates best model by procedure of VAR analysis

Mathematically, $VAR(7)$ can be written as follows:

$$y = 0.51y_{t-1} + 0.207y_{t-2} + 0.018y_{t-3} - 0.396y_{t-4} - 0.073y_{t-5} - 0.079y_{t-6} + 0.097y_{t-7} - 0.173x_{t-1} - 0.266x_{t-2} - 0.105x_{t-3} + 0.461x_{t-4} - 0.0273x_{t-5} + 0.399x_{t-6} - 0.654x_{t-7} + 4.68$$

and

$$x = 0.168y_{t-1} - 0.015y_{t-2} + 0.058y_{t-3} - 0.139y_{t-4} + 0.012y_{t-5} - 0.101y_{t-6} + 0.108y_{t-7} + 0.159x_{t-1} + 0.0057x_{t-2} - 0.044x_{t-3} + 0.22x_{t-4} - 0.084x_{t-5} + 0.293x_{t-6} - 0.279x_{t-7} + 1.555$$

where $y = \log(rainfall)$ and $x = \log(days)$

The forecasting results for 2015 using $VAR(7)$ are given in Table 4. The table shows the mean value of monthly rainfall level is 171 mm and the mean value of rainy days is 16 days. For the year 2015, rainfall level in Ambon island is classified as a medium rainfall. The highest rainfall occurs in June with the amount of rainfall is 293.07 mm, within 19 days. While the lowest rainfall occurs in February with the amount of rainfall level is 124.16 mm, within 14 days.

Table 4. Forecasting results for 2015

Month	Rainfall	Days (Rainy Days)	Mean of Daily Rainfall	Rain Classification
January	136.35	18	7.76	Medium
February	124.16	14	8.66	Medium
March	133.12	16	8.32	Medium
April	159.22	15	10.60	Medium
May	184.82	16	11.82	Medium
June	293.07	19	15.17	Medium
July	212.29	18	12.09	Medium
August	181.85	16	11.36	Medium
September	180.43	17	10.73	Medium
October	145.14	15	9.40	Medium
November	145.67	15	9.52	Medium
December	154.19	16	9.83	Medium

Table 5. VAR Granger Causality/Block Exogeneity Wald Tests

Dependent variable	Excluded	Chi-sq	df	$p\ value$
$\log(rainfall)$	$\log(days)$	20.82424	7	0.0040
	All	20.82424	7	0.0040
$\log(days)$	$\log(rainfall)$	24.19589	7	0.0011
	All	24.19589	7	0.0011

The results of Granger-causality analysis of the $VAR(7)$ are given in Table 5. The table shows that $\log(rainfall)$ is the dependent variables, as the $p\ value$ of Granger-Causality test for $\log(days)$ is 0.0040. It means that, the hypothesis of H_0: is rejected since there is no

Granger-Causality relationship between the variables. Thus, there is a short term causality relationship, between the $\log(days)$ and $\log(rainfall)$. For $\log(days)$ as the dependent variables, $p\ value$ of Granger-Causality test obtained for $\log(rainfall)$ is 0.0011. It means that, the hypothesis H_0: is rejected since there is no Granger-Causality relationship between variables. Thus, there is a short term causality relationship, between the $\log(rainfall)$ to $\log(days)$.

CONCLUSIONS

The $VAR(7)$ was found to be the best model. The prediction for 2015 using the $VAR(7)$ produces the mean value of monthly rainfall level and number of rainy days of 171 mm and 16 days respectively per month. This results are accurate since the $MSE\ value$ of $VAR(7)$ is small. For a short-term forecasting, the model is better to be used based on the results of this study.

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