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Stochastic modelling and forecasting of relative humidity and wind speed for different zones of Kerala

GOKUL KRISHNAN K. B., VISHAL MEHTA* and V. N. RAI

Department of Agricultural Statistics, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology (ANDUAT), Kumarganj – 224 229, Ayodhya, Uttar Pradesh, India

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e mail : visdewas@gmail.com

सार — **जलवायु परिस्थितियों में विविधता वर्ष भर होने वाले ऋतुनिष्ठ परिवर्तनों पर निर्भर करती है। जलवायु परिस्थितियों की मॉडलिंग और पूर्वानुमान एक विशिष्ट अवधि में जलवायु में ऋतुनिष्ठ परिवर्तनों के प्रभावों को निर्धारित करने में मदद कर सकती है। जलवायु परिवर्तन हमारे समाज में कृषि, औद्योगिक, भौगोलिक और तकनीकी क्षेत्रों को प्रत्यक्ष और अप्रत्यक्ष रूप से प्रभावित कर सकता है। जलवायु परिवर्तन से कृषि और संबद्ध क्षेत्र गंभीर रूप से प्रभावित होते हैं जिससे इससे खेती की गई फसलें पूरी तरह नष्ट हो जाती हैं। इस अध्ययन में, केरल के उत्तरी, मध्य और दक्षिणी क्षेत्रों के लिए सापेक्ष आर्द्रता और पवन गति का मॉडल तथा पूर्वानुमान करने के लिए,** SARIMA (**सीज़नल ऑटोरेग्रेसिव इंटीग्रेटेड मूविंग एवरेज**) **मॉडल का उपयोग करके प्रसंभाव्य दृष्टिकोण को नियोजित किया गया। केरल के उत्तरी क्षेत्र और मध्य क्षेत्र के लिए मासिक मौसम डेटा** 39 **वर्षों** (1982-2020) **की अवधि के लिए आरएआरएस पिलीकोड और** RARS **पट्टांबी से लिया गया, जबकि दक्षिणी क्षेत्र के लिए,** 36 **वर्षों** (1985-2020) **की अवधि के लिए** RARS, **वेल्लयानी से डेटा एकत्र किया गया। मॉडल का सत्यापन** MSE (**माध्य वर्ग त्रुटि**), RMSE (**मूल माध्य वर्ग त्रुटि**), MAE (**माध्य निरपेक्ष त्रुटि**) **और** MAPE (**माध्य निरपेक्ष प्रतिशत त्रुटि**) **का उपयोग करके किया गया। केरल के विभिन्न क्षेत्रों में सापेक्ष आर्द्रता और पवन गति का** MAPE **मान** 10 **प्रतिशत से कम था जो दर्शाता है कि फिट मॉडल सटीक निष्पादन कर रहा है। सर्वोत्तम चयनित** SARIMA **मॉडल का उपयोग अगले** 5 **वर्षों के लिए सापेक्ष आर्द्रता और पवन गति के अनुमानित मूल्यों को प्राप्त करने में किया जाता है।**

ABSTRACT. The variations in climatic conditions depend on seasonal changes throughout the year. Modelling and prediction of climatic conditions can help to determine the impacts of seasonal changes in climate over a specific period of time. Climate change can directly and indirectly affect agricultural, industrial, geographical and technological sectors in our society. Agriculture and the allied sector are seriously affected by changes in climate since it leads to complete destruction of cultivated crops. In this study, in order to model and forecast relative humidity and wind speed for northern, central and southern zones of Kerala, stochastic approach using SARIMA (Seasonal Autoregressive Integrated Moving Average) model was employed. The monthly weather data for the northern zone and the central zone of Kerala was taken from the location of RARS Pilicode and RARS Pattambi for a period of 39 years (1982-2020) whereas for southern zone, data was collected from the location of RARS, Vellayani for a period of 36 years (1985-2020) with the help of data access viewer. The model validation was done using MSE (mean square error), RMSE (root mean square error), MAE (mean absolute error) and RMAPE (relative mean absolute percentage error). The RMAPE values of relative humidity and wind speed in different zones of Kerala was less than 10 per cent which indicated that fitted model is showing accurate performance. The best selected SARIMA model is used in attaining anticipated values of relative humidity and wind speed for the next 5 years.

Key words – SARIMA, RARS, Kerala, Northern zone, Central zone, Southern zone.

1. Introduction

The forecasting of weather parameters with maximum precision is one of the main objectives of different scientists who undergo research in climatology. Scientists developed several methodologies over the years for forecasting the weather parameters. The stochastic approach is one of the main methods employed by the scientists for projecting future values of weather parameters. The modelling and predicting of weather parameters using stochastic methods has significant impacts on people living around the world since it directly and indirectly influence agriculture policies adopted in the entire world which depends on the specific climate in a particular area. Especially, the countries like India, where more than 58% of people depend on agriculture as the main source of income, the prediction of weather parameters can play a crucial role since farmers can take necessary precautions measures to overcome the damage caused due to extreme variations in climatic conditions.

The relative humidity and wind speed are extremely important factors in the growth of many agriculture crops. The crop water relationship directly impacted by relative humidity and also indirectly affects photosynthesis, leaf development, yield and incidence of diseases (Grange and Hand, 1987). Some crops need a humid climate for better development, whereas other crops may show their maximum potential in a low-humid area. Most of the diseases are also affected by changes in relative humidity such that too humid conditions are favourable for both fungi and bacteria and might cause the death of cultivated crops. Humans also get affected by relative humidity, if the atmosphere surrounding people consists of high moisture content, the human body undergoes sweating (Tsutsumi *et al*., 2007), the rate of respiration and blood circulation is increased. The relative humidity also influences other weather parameters like rainfall and temperature in such a way that the higher the relative humidity the more the water vapour is present in the atmosphere, the greater will be the rainfall covering that area, whereas the temperature decreases with an increase in water vapour content of the air (Jamaludin, 2009). Even though, there is a drop in temperature due to a rise in relative humidity, the climate of the surrounding area is warmer due to the presence of water vapour in the air. Wind speed is an important weather parameter which is used as a renewable source of energy and it is also noted that production of energy using wind has very lower side effects on the surrounding environment. In various locations throughout the world, wind power produced using wind is rapidly expanding sources of renewable energy. Wind speed showed a direct impact on the growth and development of plants. Wind speed affects photosynthesis by regulating the amount of carbon dioxide available in the air and it also shows a significant impact on reproduction of plants since wind is one of the main agents which help in pollination (Chakraborty *et al*., 2015). Wind speed plays a crucial role in human life since it can provide a huge amount of energy and also give comfort to the human body in a warm climate by keeping the body temperature down. The wind speed indicated an influence on both rainfall and temperature, the greater the wind speed the higher the evaporation, which results in increased rainfall (Shukla and Misra, 1977) whereas temperature falls.

The modelling and forecasting of weather parameters are carried out over the years using different methods. Methods employed by various researchers for forecasting are SARIMA, exponential smoothing (ETS), multiple linear regression (MLR), general autoregressive conditional heteroscedasticity (GARCH), support vector machines (SVM), artificial neural network (ANN) etc., over the years. Compare to other methods, stochastic approach using SARIMA gained more popularity due to exceptional potential in detection of the trend for weather parameters (Lee and Sohn, 2007). Partheepan *et al*. (2005) investigated the annual climatic trend and transition in temperature and precipitation using the ARIMA model. Time series modelling using a stochastic approach was carried out (Hansen *et al*., 2006; Rahmstorf *et al*., 2007) for forecasting temperature data. Shiri *et al*. (2011) undergo a study about predicting relative humidity using the ARIMA model for the data collected from the North-West of Iran and the results concluded that there was an increasing trend in the months of May, June and September whereas other months does not reveal any significant trend. Weekly rainfall was predicted using the ARIMA model by Zakaria *et al.* (2012) showed a falling trend in the semi-arid region. The monthly average surface temperature was forecasted using the ARIMA model by Afrifa-Yamoah (2015) in the Brong Ahafo region of Ghana and results indicated that there was a decreasing trend over the years. Jamaludin *et al*. (2015) investigated temporal dynamics in relative humidity by collecting the data from 13 research stations in Malaysia using the SARIMA model and the results helped the officials to initiate necessary actions to control the effects of climate change. Hossain (2016) investigated about forecasting humidity using the SARIMA model by collecting data from different research stations in Bangladesh mainly for determining statistical properties of fitted model and also humidity for 2 years was predicted using the same model.

The stochastic approach for forecasting wind speed was done by employing the SARIMA model in South-East Nigeria (Igboekwe and Omekara, 2002) and the result conveyed that wind speed values predicted have the capacity of starting a new wind power generating plant at the location. A comparison study for evaluating ARIMA and ANN models for forecasting wind speed (Cadenas and Rivera, 2007) on the south coast of Oaxaca, Mexico and the outcomes of the study conveyed that the ARIMA model outperformed with higher precision. Palomares-Salas *et al*. (2009) did a comparison study for forecasting wind speed in southern Andalusia using the ARIMA and the neural network with back propagation algorithm and results indicated that ARIMA model outperformed the neural network with more accuracy. Grigonytė and Butkevičiūtė (2016) undergo projection of future wind speed using the ARIMA model, which helped to build an optimal model structure that improved the accuracy of forecasting. Current conditions and future aspects of

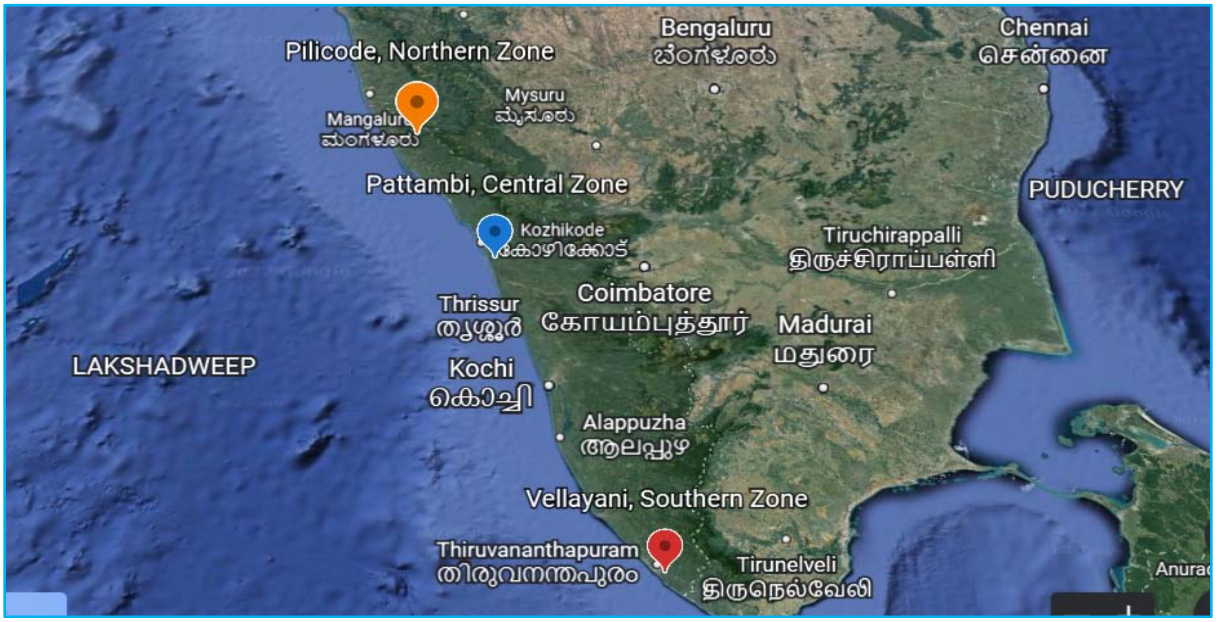


Fig. 1. Study area map of northern, central and southern zone of Kerala (*Source* : Google Earth)

modelling and forecasting of weather parameters are reviewed by Jeong *et al*., (2017) and suggested that for maximising precision of forecasting weather parameters, sufficient improvements in methodologies are necessary. Li *et al*. (2020) conducted a comparison study for forecasting relative humidity using SARIMA, Holt-Winters exponential smoothing model and XGBoost model for the data collected from Sichuan province and results revealed that the XGBoost model gave more accurate prediction. Dimri *et al*. (2020) undergo a study related to examine variations in precipitation, minimum and maximum temperature using the SARIMA model to ascertain the dynamic structure of climate. Thus, prediction of weather parameters are very crucial for managing the effects of climate change, unexpected severe rainfall, lack of proper rainfall or drought, a sudden increase in wind speed, industrial activities, agricultural production, proper communication, rise in global temperature, a sudden increase or decrease in humidity, energy sources, etc.

Different complex environmental processes are fitted with the help of continuous-time, continuous-space statistical models (Hartfield and Gunst, 2003). Tsiotas and Argiriou (2011) suggested that in order to undergo modelling of time series data consisting of large complex data sets, selection and application of statistical approaches are necessary. The primary focus of current research was to employ SARIMA model for estimating anticipated values of relative humidity and wind speed for northern, central and southern zones of Kerala.

2. Materials and methods

2.1. *Study area and data collection*

The monthly weather data was accessed through data access viewer from respective locations. The weather data consists of relative humidity and wind speed for the northern zone of Kerala was collected from the location of research station RARS, Pilicode over a period of 39 years (1982-2020). The research station is located at 1997° N latitude and 75.1633° E longitude in Kasaragod, northern-most district of Kerala with 15m elevation above sea level. The average wind speed of Pilicode lies in between, 3m/s to 4m/s whereas the annual average relative humidity is 78%.

The weather data for the central zone of Kerala, including relative humidity and wind speed, was collected from the location of RARS, Pattambi for a period of 39 years (1982-2020). It is located in the Palakkad district, which is known as the rice bowl of Kerala. The research station situated at 10.8057° N latitude and 76.1957° Elongitude with an altitude of 63m. The annual average wind speed of Pattambi ranges from 2m/s to 3m/s and average relative humidity is 78%.

The relative humidity and wind speed for the southern zone of Kerala was collected from the location of research station RARS, Vellayani, situated in Trivandrum, southern-most district of Kerala. The data was collected for a period of 36 (1985-2020) years. Trivandrum is known as the capital city of Kerala. The geographical location of Vellayani is at 8.4316° N latitude and 76.986° Elongitude with a height of 8m from mean sea level. The average annual relative humidity of this region is 74% with a constant warm, humid climate throughout the year. The wind speed of the location ranges between 1m/s to 5m/s. The locations of research stations in the northern, central and southern zones are indicated in Fig. 1. The data analysis was completed using R software with packages tseries (Trapletti and Hornik, 2018) and forecast (Hyndman and Khandakar, 2008; Hyndman *et al*., 2020).

2.2. *Methodology*

2.2.1. *Seasonal Autoregressive Integrated Moving Average (SARIMA)*

The stochastic modeling of relative humidity and wind speed was carried out using the SARIMA model. The seasonal ARIMA is an extension of ARIMA which completely deals with the time series data consisting of seasonal components (Goswami *et al*., 2017). Let Y_t is considered as the recorded values of weather parameter (relative humidity or wind speed). The Box & Jenkins (1976) SARIMA model was represented as (*p*, *d*, *q*) (*P*, *D*, *Q*)$_s$. The SARIMA model is made up of two parts, non-seasonal (*p*, *d*, *q*) and seasonal (*P*, *D*, *Q*)$_s$. The mathematical expression of the SARIMA model (Ken *et al*., 1998) expressed as the following:

$$\Psi_P\left(B^s\right)\varphi_p(B)\nabla_S^D\nabla^d Y_t = \mu + \theta_Q\left(B^s\right)\Theta_q(B)e_t \qquad (1)$$

In the above equation, the small letters *p*, *d* and *q* indicate autoregressive, number of differentiation to make data stationary and moving average order of the non-seasonal part of the SARIMA model. Similarly, the letters *P*, *D*, *Q* and *S* represent the autoregressive order, the number of differentiation to make data stationary and moving average order and periodicity of the data for the seasonal part of the SARIMA model (Murthy *et al*., 2019).

$\Psi_P\left(B^S\right) = 1 - \Psi_1(B) - \Psi_2\left(B^{2S}\right) - \ldots - \Psi_P\left(B^{PS}\right)$ imply the seasonal autoregressive operator of order *P*

$\varphi_P(B) = 1 - \varphi_1(B) - \varphi_2\left(B^2\right) - \ldots - \varphi_P\left(B^P\right)$ express the non-seasonal autoregressive operator of order *P*

$$\nabla_S^D\left(1 - B^S\right)^D; \nabla^d = (1 - B)^d; B^k Y_t = Y_{t-k}$$

μ is the intercept term or mean term.

$\theta_Q\left(B^S\right) = 1 - \theta_1 B^S - \theta_2 B^{2S} - \ldots - \theta_Q B^{QS}$ express the seasonal moving average operator of order *Q*

$\Theta_q(B) = 1 - \Theta_1 B^1 - \Theta_2 B^2 - \ldots - \Theta_q B^q$ imply the non-seasonal moving average operator of order *q*

e_t assigned as the error terms having mean zero and variance σ_e^2 which are distributed identically and independently. *S* is the periodicity of the data and *B* is the back shift operator.

The stationary of data is checked before undergoing the fitting of a model using ADF (Augmented Dickey-Fuller) test. If the data is not stationary, differentiation of the data is necessary; otherwise, data can be used for the fitting of the SARIMA model (Said and Dickey, 1984). The fitting of SARIMA model is divided in to four iterative stages, identification of the model, estimation of parameter, diagnostic checking and forecasting. The different stages of fitting the SARIMA model take a lot of time in to past years, but due to the development of different software, the procedure has become less hard. In the past, identification of the model was done with the help of ACF (Auto-Correlation Function) plot and parameters were estimated using maximum likelihood estimate (Banerjee *et al*., 1993).

2.2.2. *Model Selection Criteria*

The selection of the model was done based on the least value for AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) and AICc (Modified Akaike Information Criterion) values (Jain and Mallick, 2017).

$$AIC = -2 \times ln(L) + 2 \times k \qquad (2)$$

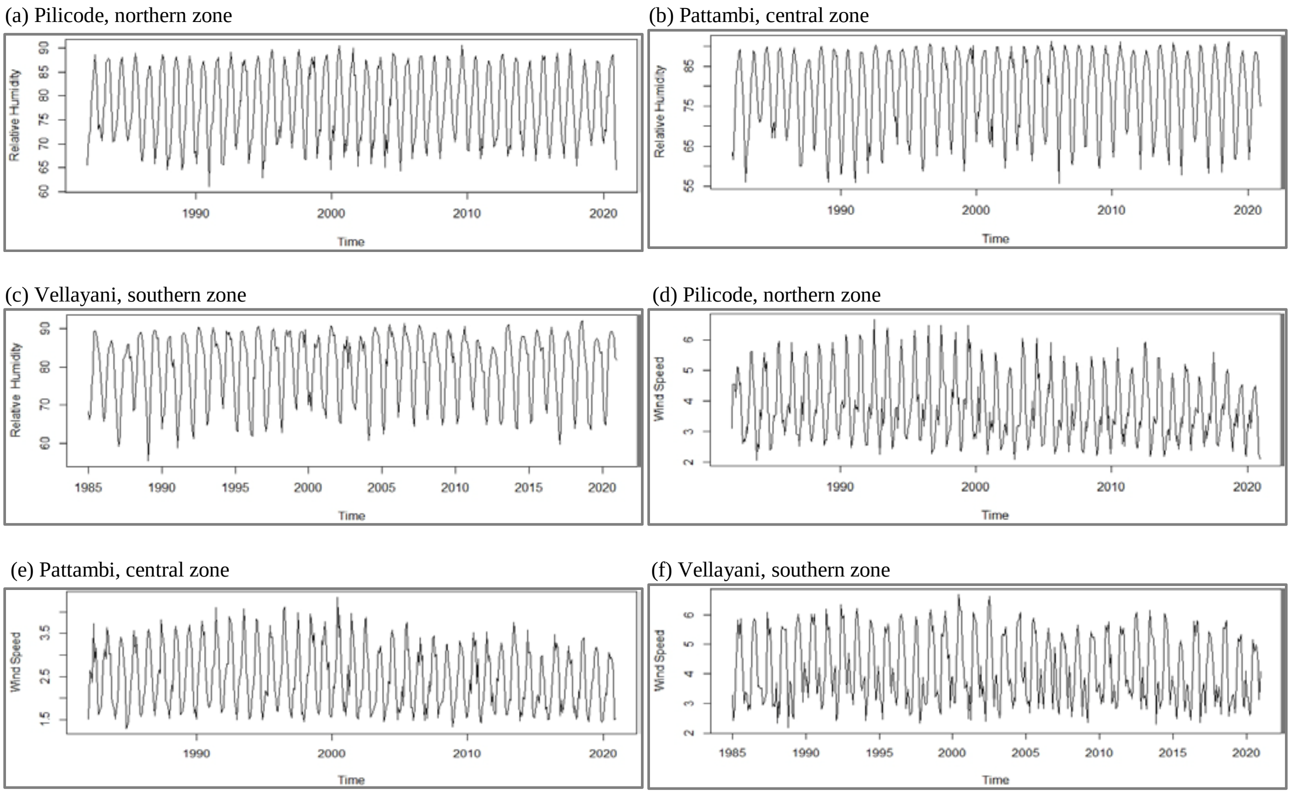
$$BIC = -2 \times ln(L) + 2 \times ln(N)k \qquad (3)$$

$$AICc = -2 \times ln(L) + 2 \times k + \frac{2k(k+1)}{N-k-1} \qquad (4)$$

Where *L* is the value of the likelihood, *N* is the number of recorded measurements and *k* is the number of estimated parameters (Krishnan *et al*., 2022). Now a day, software directly fits the best model and identified the parameters.

2.2.3. *Diagnostic Checking of Model*

The diagnostic checking of the fitted model was done with the help of the Ljung-Box test (Ljung and Box, 1978). If the residuals of the fitted model have autocorrelation (Wang *et al*., 2006), then the fitted model cannot be used for forecasting. The residuals obtained from the SARIMA model fitted for the data should not be auto-correlated with each other. The standardised



Figs. 2(a-f). Time series plot for relative humidity (a-c) and wind speed (d-f) for each zones of Kerala

residuals should be independently distributed, identical and have a constant variance and zero mean for the model to be considered as best fit (Cryer and Chan, 2008).

Test statistics for the Ljung-Box test

$$Q = n(n+2)\sum_{k=1}^{m} \frac{T_k^2}{n-k} \tag{5}$$

where n is the number of measurements, T_k is the autocorrelation between the residuals at lag k and m is the number of lags being tested.

2.2.4. *Evaluation of the predicted model*

The performance of the model is verified by using different methods like MSE, RMSE, MAE and RMAPE.

$$MSE = \frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2 \tag{6}$$

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n} (y_i - \hat{y}_i)^2} \tag{7}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n} |y_i - \hat{y}_i| \tag{8}$$

$$RMAPE = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{y_i - \hat{y}_i}{y_i}\right| \times 100 \tag{9}$$

where y_i is the observed value and $\hat{y}_i$ is the anticipated value using the model. The performance of the best selected models is indicated with least value for MSE, RMSE, MAE and RMAPE.

3. Result and discussion

In this study, SARIMA model was used for attaining future values of relative humidity and wind speed for different zones of Kerala. The analysis of monthly weather data was carried out using R software. Prior to undergoing the modelling using SARIMA, the stationary of weather parameters must be checked using an ADF test. The time series plot of weather parameters of different zones of Kerala are given in Fig. 2.

The time series plots for monthly relative humidity and wind speed for three different zones suggest that over

TABLE 1

ADF test for different zone of Kerala

Weather Parameter	Zone	Test Statistic	P value
Relative Humidity	Northern	-15.09	0.01
	Central	-13.92	0.01
	Southern	-11.96	0.01
Wind Speed	Northern	-17.39	0.01
	Central	-12.91	0.01
	Southern	-16.60	0.01

TABLE 2

Model selection criteria for different zones of Kerala

Weather Parameter	Zone	AIC	BIC	AICc
Relative Humidity	Northern	1840.55	1856.48	1840.66
	Central	2096.82	2112.75	2096.92
	Southern	1758.51	1774.05	1758.62
Wind Speed	Northern	535.31	551.24	535.41
	Central	64.98	92.85	65.27
	Southern	587.33	602.87	587.44

TABLE 3

Parameter estimated for SARIMA model for each zone of Kerala

Weather Parameter	Zone	Model	Parameters
Relative Humidity	Northern	SARIMA (1,0,0) $(1,1,0)_{12}$	ar1 0.2573 sar1 -0.4656
	Central	SARIMA (1,0,0) $(1,1,0)_{12}$	ar1 0.4258 sar1 -0.5370
	Southern	SARIMA (1,0,0) $(0,1,2)_{12}$	ar1 0.5589 sma1 -0.9084 sma2 0.0190
Wind Speed	Northern	SARIMA (1,0,0) $(1,1,0)_{12}$	ar1 0.0951 sar1 -0.5072
	Central	SARIMA (1,0,1) $(2,1,1)_{12}$	ar1 0.7848 ma1 -0.6083 sar1 -0.0240 sar2 -0.0888 sma1 -0.8623
	Southern	SARIMA (1,0,1) $(1,1,0)_{12}$	ar1 0.8551 sar1 -0.7767 sar2 -0.4356

TABLE 4

Results of Ljung-Box test statistics for each zone of Kerala

Weather Parameter	Zone	Q Statistic	P value
Relative Humidity	Northern	37.96	0.156
	Central	27.12	0.912
	Southern	34.12	0.162
Wind Speed	Northern	26.25	0.098
	Central	21.33	0.263
	Southern	33.69	0.068

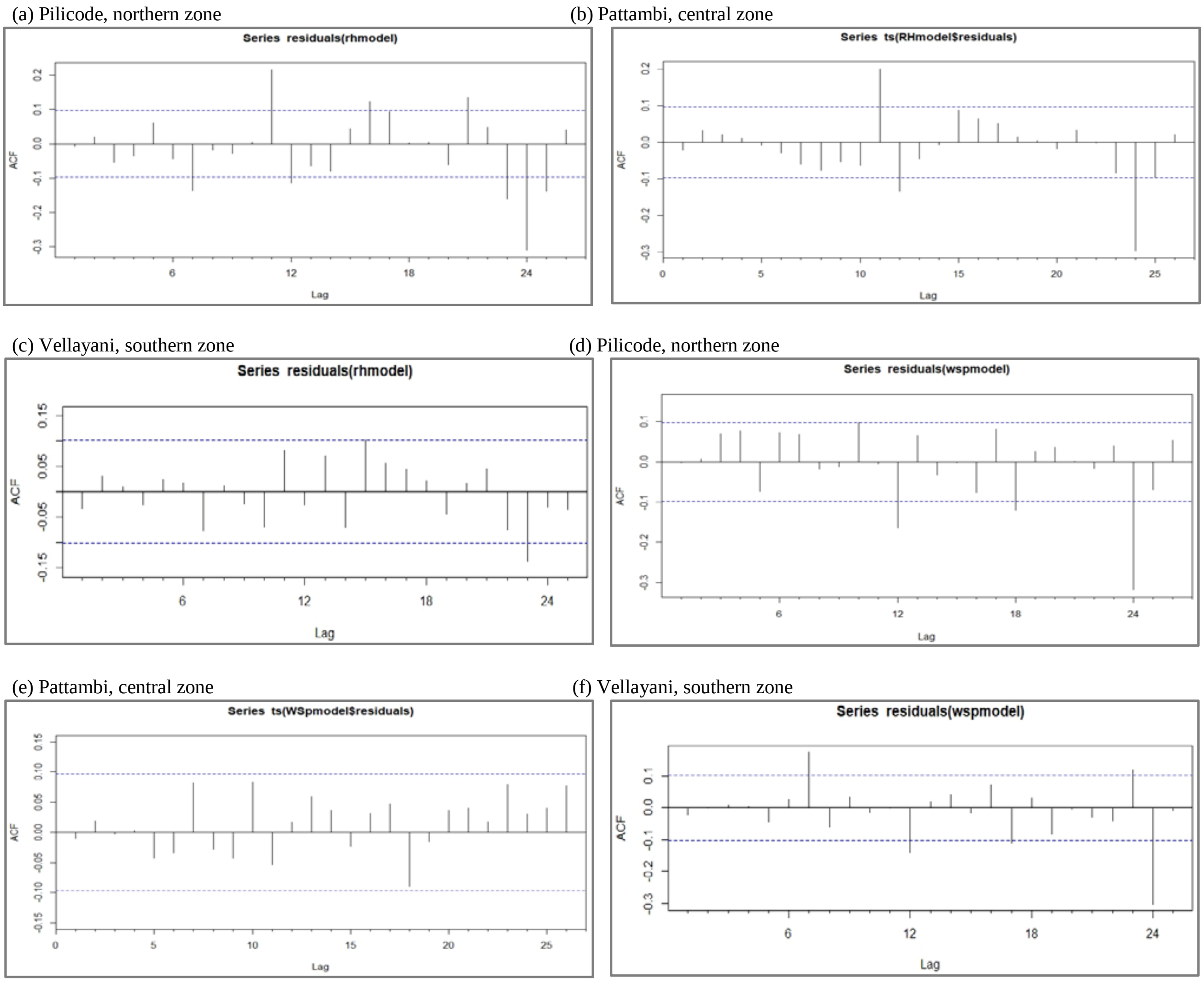
the years there are some variations. The values are increasing and decreasing without showing a specific trend. The stationary of weather parameters was checked using an ADF test and outcomes are presented in Table 1.

The ADF test results declared that both the relative humidity and wind speed are stationary for northern, central and southern zones of Kerala. In order to undergo the SARIMA analysis using the R software, weather data for each parameter are divided into a training set and a testing set. The training set is utilized for suitable model selection whereas validation of the fitted model is done using the testing set of data. The training set of northern and central zones consists of data from 1982-2015, whereas testing set included data from 2016-2020. However, the training set of the southern zone consists of data from 1985-2015 and a testing set from 2016-2020. The R software fitted the SARIMA model for both relative humidity and wind speed using a training set for different zones of Kerala. The best measure for selection of a SARIMA model suitable for relative humidity and wind speed for each zone is based on AIC, BIC and AICc values. The value of SARIMA model selection criteria is described in Table 2.

The best models suitable for the relative humidity and wind speed for each zone are depicted in Table 3. The values of parameters estimated for the SARIMA model selected for relative humidity and wind speed of each zone are also shown in Table 3.

The next step is diagnostic checking of the fitted model using Ljung-Box test. Outcomes of the Ljung-Box test statistics are presented in Table 4.

The results presented on Table 4 clearly indicated that residuals in each SARIMA model fitted for relative humidity and wind speed for northern, central and southern Kerala have no autocorrelation. Thus, diagnostic checking of the SARIMA model indicated that fitted models are the best suited model for each parameter. ACF plots for the error terms obtained from the SARIMA model fitted for weather parameters in different zones of Kerala are given in Fig. 3.



Figs. 3(a-f). ACF residual plots for relative humidity (a-c) and wind speed (d-f) in each zone of Kerala

The ACF plot depicted in Fig. 3 suggested that the residuals do not show any specific pattern for both relative humidity and wind speed in each zone of Kerala. The lines are lying with the 95% confidence limit at different lags of up to 12 with some deviations which may not affect forecasting of weather parameters.

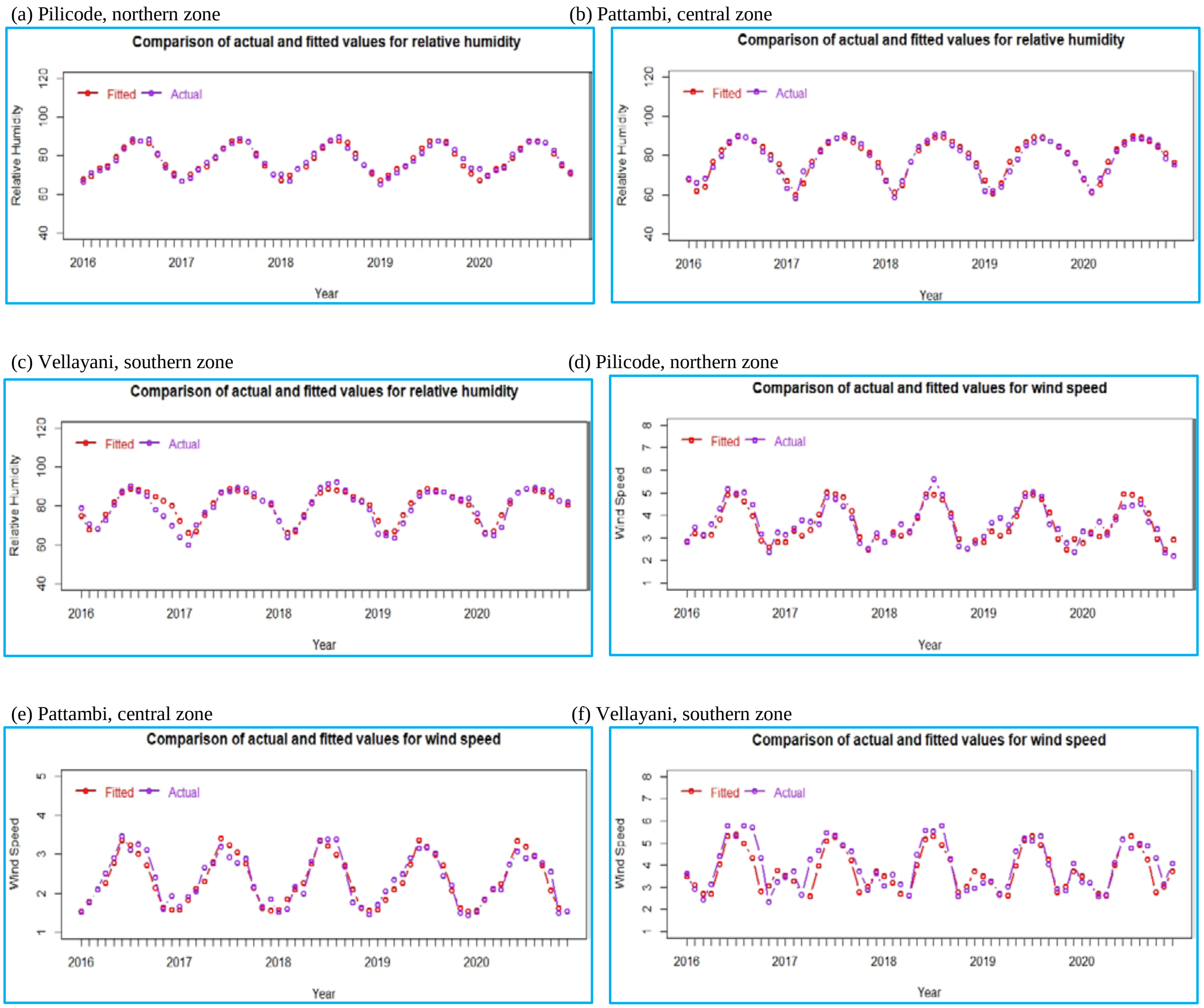
The next step was validation of the model by forecasting for the last 5 years and comparing it with the testing data. In order to undergo validation of the model MSE, RMSE, MAE and RMAPE were calculated using observed and predicted values and results are depicted in Table 5.

TABLE 5

Validation of SARIMA model fitted for each zone of Kerala

Weather Parameter	Zone	MSE	RMSE	MAE	RMAPE
Relative Humidity	Northern	2.85	1.69	1.31	1.71
	Central	5.26	2.29	1.78	2.42
	Southern	10.21	3.19	2.26	3.04
Wind Speed	Northern	0.12	0.35	0.29	8.30
	Central	0.04	0.2	0.15	6.46
	Southern	0.30	0.54	0.38	9.62

It is clearly understandable from Table 5 that error values calculated for each weather parameter from different zones are very low such that the model can be used for forecasting weather parameters with higher precision. However, MSE value for relative humidity in southern zone is indicating higher error values compared



Figs. 4(a-f). Actual v/s Fitted values of relative humidity (a-c) and wind speed (d-f) in each zone of Kerala

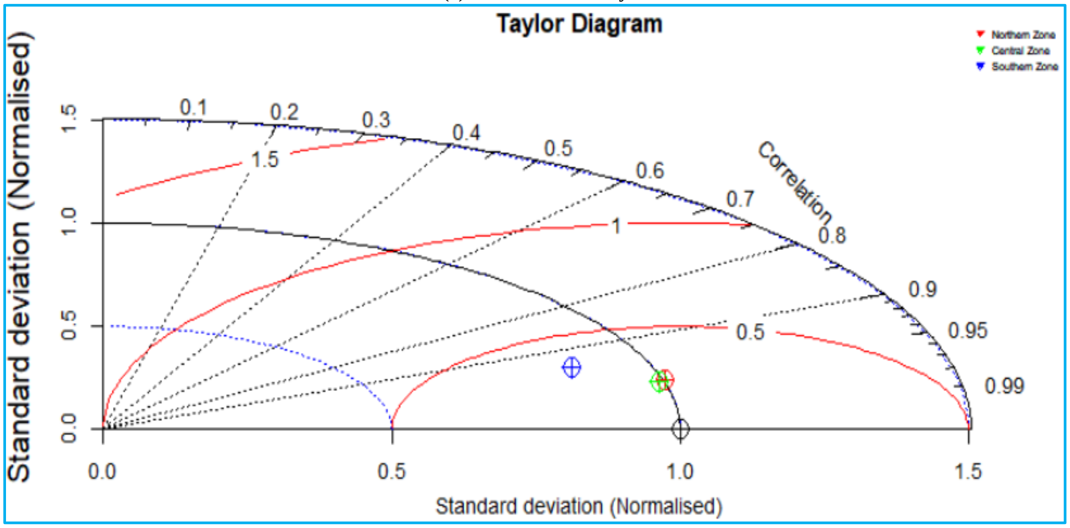
to other zones may be due to random fluctuations. The RMAPE values for relative humidity and wind speed in northern, central and southern zones of Kerala is less than 10 per cent which concluded that fitted SARIMA model is showing accurate prediction. The illustrations in Fig. 4 showed the real and fitted values of relative humidity and wind speed by employing the SARIMA model which can explain the efficient performance of the model.

The comparison between the actual and fitted value for weather parameters in different zones of Kerala shown in Fig. 4 indicated that the model fitted is sufficient and in order to confirm the accuracy, Taylor diagram was plotted for relative humidity and wind speed in different zones of Kerala and it is displayed in Fig. 5.

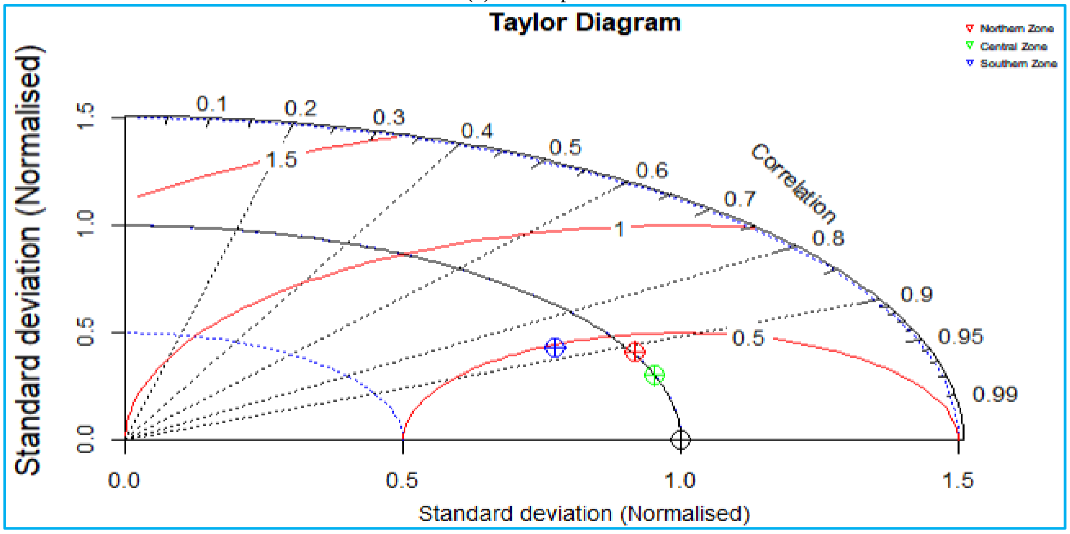
The Taylor diagram showed in Fig. 5 indicated that observed and predicted values are highly correlated with optimum standard deviation and thus the SARIMA model fitted should be applied for forecasting future values. Using the best selected model, weather parameters are forecasted for the next 5 years (2021-2025) and it is displayed in Fig. 6 and Fig. 7.

The plot of forecasted values of relative humidity in different zones of Kerala showed in Fig. 6 suggested that almost the values are lying closely with each other. It is noted that during initial starting of each year, northern zone is having maximum relative humidity whereas central zone have the least. In the middle part of each year, the relative humidity of each zone coincides with

(a) Relative Humidity



(b) Wind Speed



Figs. 5(a&b). Taylor Diagram plot for Actual v/s Fitted values of relative humidity (a) and wind speed (b) in different zones of Kerala

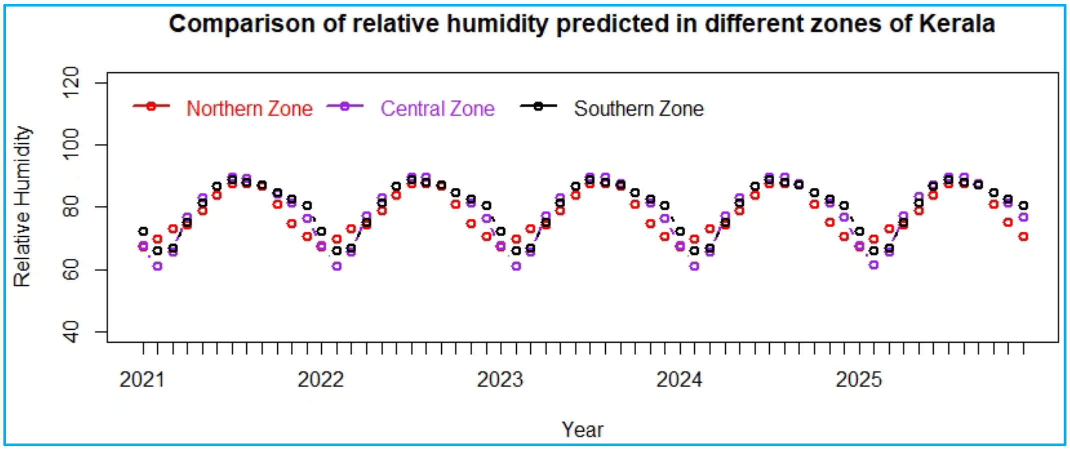
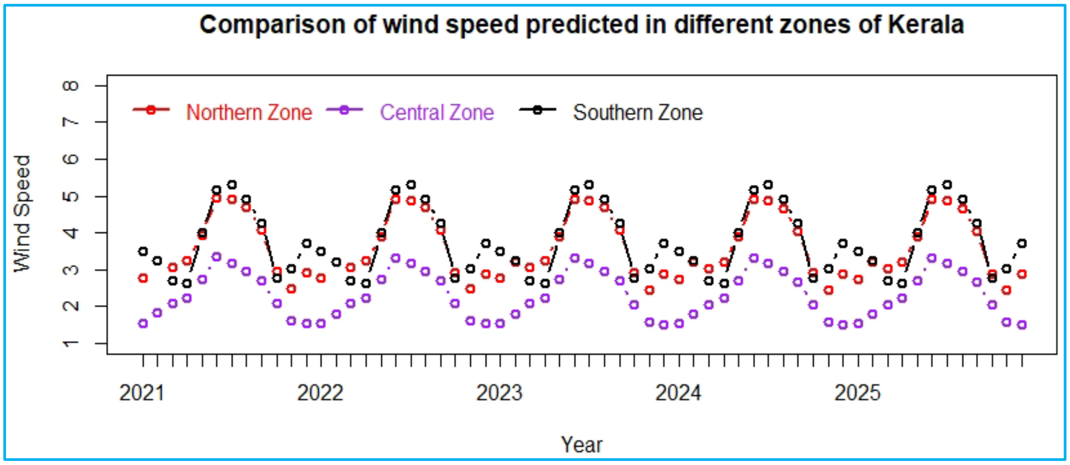


Fig. 6. Predicted values of relative humidity in each zone of Kerala



Figs. 7. Predicted values of wind speed in each zone of Kerala

each other. The predicted values of relative humidity in the final stage of each year suggested that northern zone is showing the least value whereas central and southern zones are indicating comparatively higher values. It is also indicated that the forecasted values of relative humidity is showing slight increase in each year.

The plot of predicted values in each zones of Kerala presented in Fig. 7 concluded that southern zone have the highest, northern zone have moderate and central zone have the smallest values of wind speed throughout the year. The wind speed predicted in different zones also indicated a slight decrease over the next 5 years.

4. Conclusion

In this study, the main aim was to undergo modelling and forecasting of relative humidity and wind speed for the northern, central and southern zone of Kerala. The data was collected through data access viewer for a period of 39 years (1982-2020) for the northern and central zone from RARS, Pilicode and RARS Pattambi respectively, whereas for the southern zone of Kerala, data was collected from RARS, Vellayani over a period of 36 years (1985-2020). R software was employed for the fitting of the SARIMA model for weather parameters. The results concluded that for relative humidity the best performed model was SARIMA (1,0,0) $(1,1,0)_{12}$, SARIMA (1,0,0) $(1,1,0)_{12}$ and SARIMA (1,0,0) $(1,1,0)_{12}$ for northern, central and southern zones of Kerala respectively, whereas for wind speed, SARIMA (1,0,0) $(1,1,0)_{12}$, SARIMA (1,0,1) $(2,1,1)_{12}$ and SARIMA (1,0,1) $(1,1,0)_{12}$ for northern, central and southern zones of Kerala respectively. The evaluation of the SARIMA model selected for both relative humidity and wind speed was done with the help of MSE, RMSE, MAE and RMAPE values. The calculated error values for both the weather parameters in three different zones of Kerala are showing relatively smaller values. Even though, the MSE value of relative humidity in southern zone is comparatively higher, the RMAPE is almost similar for all the three zones such that it may not affect the performance of the fitted SARIMA model. The RMAPE value is less than 10 per cent in all cases which suggested that each fitted SARIMA model is showing good performance with maximum accuracy in forecasting of weather parameters. The fitted model was also used for forecasting weather parameters for the next 5 (2021-2025) years.

The results suggested that there was a slight increase in relative humidity whereas a considerable decline in wind speeds for northern, central and southern zones of Kerala. The slight increase in relative humidity can cause rise in cases of diseases for crops since relative humidity favours growth and development of both fungus and bacteria. It can also increase attack of pests, can reduce evapotranspiration, led to closure of stomata, decline in absorption of carbon dioxide etc. The decline in wind speed can led to decrease in photosynthesis due to decrease in uptake of carbon dioxide and also decrease the rate of cuticular transpiration. The scientific research community must take precautionary measures to overcome the problems caused due to change in climatic conditions. The scientific research and forecasts community should also guide the farmers to take necessary steps to avoid loss of yield due to increase in relative humidity or decrease in wind speed,

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