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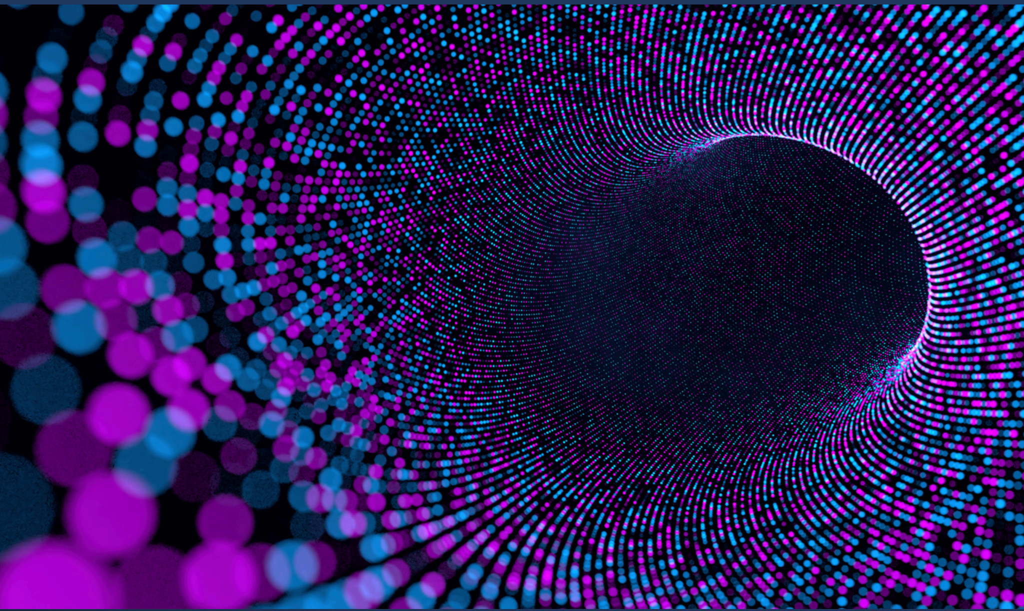

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Table of Contents

Research Article

SmartForecast: An Interactive Shiny R Dashboard for Rainfall Forecasting in Subang

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Abstract: *Forecasting plays a critical role in environmental planning, particularly in addressing rainfall variability that can impact urban development and flood preparedness. However, traditional forecasting tools often remain inaccessible to non-specialists due to their complexity. This innovation introduces SmartForecast, a user-friendly forecasting dashboard developed using the Shiny package in R, specifically designed to model and predict monthly rainfall in Subang, Malaysia, using historical data from 2014 to 2023. Modelled using the SARIMA $(4,1,0)(2,1,0)_{12}$ model chosen for its low RMSE and MAE, the dashboard transforms complex statistical forecasts into accessible visual and tabular outputs. Users can explore trends, forecast ranges, and descriptive statistics such as skewness, kurtosis, and the Jarque-Bera test. These features enhance interpretability, allowing policymakers, researchers, and the public to engage meaningfully with rainfall projections. The innovation supports transparent, evidence-based decision-making and promotes a culture of inclusive analytics in climate-sensitive sectors. By combining robust modelling with interactive design, SmartForecast serves as a practical tool for proactive environmental governance and sets the stage for scalable forecasting solutions in other contexts.*

Keywords: Rainfall forecasting, Shiny R, SARIMA, Climate Data

1. INTRODUCTION

Climate variability, particularly changes in rainfall patterns, poses significant challenges for communities, policymakers, and researchers alike. In Malaysia, heavy rainfall and unpredictable monsoon behaviour demand proactive planning to reduce the risk of flooding, infrastructure strain, and agricultural disruptions. Forecasting rainfall accurately is therefore crucial for supporting climate-resilient decision-making at both local and national levels. However, the technical complexity of many forecasting tools limits their accessibility to experts in data science or meteorology, leaving a gap in practical tools that can be used by non-specialists.

To address this challenge, *SmartForecast* was developed as an innovative, user-centred solution. It is an interactive forecasting dashboard built using the Shiny package in R, designed to provide accessible, accurate, and automated rainfall forecasts. This tool focuses specifically on Subang, Malaysia, and is powered by historical rainfall data recorded from 2014 to 2023, sourced from METMalaysia. Through the application of Seasonal ARIMA (SARIMA) modelling, SmartForecast generates forecasts that are both statistically sound and easy to interpret. By removing the need for programming skills and simplifying forecast interpretation, SmartForecast empowers a broader audience to engage with time series data. Its development aligns with the goals of Sustainable TVET Innovation by promoting digital inclusivity, enhancing data literacy, and encouraging evidence-based planning. The dashboard serves not only as a technical tool but also as a practical resource for decision-makers, educators, and the broader public in responding to local environmental challenges through informed forecasting.

2. METHOD & MATERIAL

This study used monthly rainfall data from Subang, Malaysia, obtained from METMalaysia for 10 years period from January 2014 to December 2023. The data was first cleaned by checking for missing values and outliers to ensure consistency and reliability before modelling. To perform the forecasting, the Seasonal Autoregressive Integrated Moving Average (SARIMA) model was applied based on the Box-Jenkins methodology. This approach involves four steps: model identification, parameter estimation, diagnostic checking, and forecasting. It is widely used for time series analysis with seasonal and trend components due to its systematic model-building process (Box & Jenkins, 1970). The best SARIMA model was selected by examining the autocorrelation function (ACF), partial autocorrelation function (PACF), and minimizing the Akaike Information Criterion (AIC). Forecast accuracy was assessed using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE) (Hyndman & Athanasopoulos, 2018). The forecasting dashboard was developed in R using the Shiny package. The application allows users to upload rainfall data, generate forecasts, and visualize results interactively through graphs and tables. Forecasts are accompanied by 95 percent confidence intervals to show the expected range of uncertainty. The dashboard was built using the Shiny package in R, which enables interactive web applications directly from R (Chang et al., 2023). The dashboard also presents summary statistics such as mean, median, skewness, kurtosis, and the Jarque-Bera test for normality. Figure 1 displays the user interface, descriptive statistics, and the boxplot of monthly rainfall in Subang. This integration supports user understanding of both the data and the model output without requiring programming skills, making *SmartForecast* practical for public, academic, and policy use. Figure 2 presents the histogram visualisation of monthly rainfall in Subang, allowing users to observe the distribution and frequency of rainfall values over the recorded period. By adjusting the number of bins, users can explore the underlying patterns such as skewness, data concentration, and outliers. This interactive feature enhances data interpretation, enabling informed decision-making based on the variability and spread of rainfall data. The histogram complements the descriptive statistics in Figure 1, offering a more intuitive grasp of the dataset's characteristics.

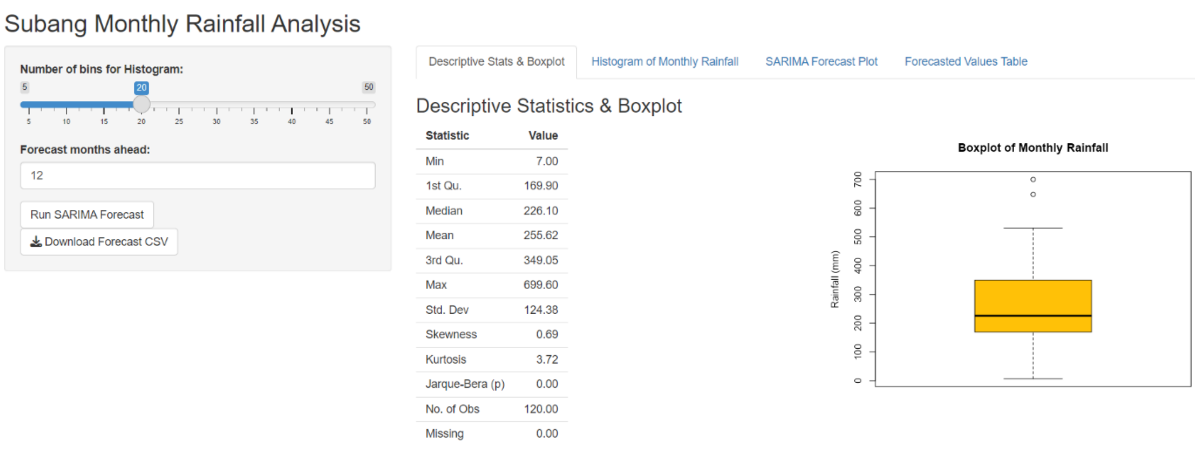


Figure 1. SmartForecast dashboard interface displaying descriptive statistics and a boxplot of monthly rainfall data in Subang.

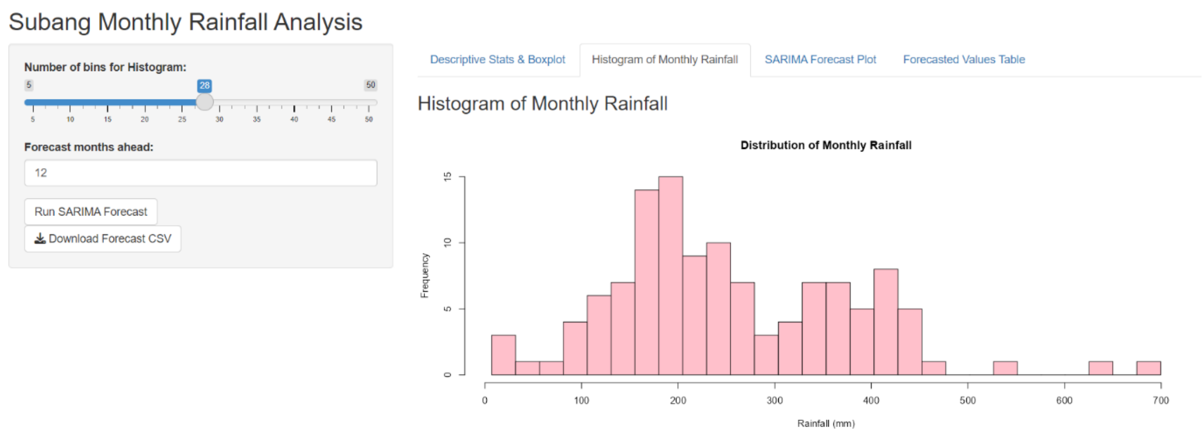


Figure 2. SmartForecast dashboard interface showing the histogram visualization of monthly rainfall distribution in Subang.

3. FINDINGS

The *SmartForecast* dashboard effectively forecasted monthly rainfall for Subang from January 2024 to December 2025. The model configuration selected, SARIMA (4,1,0)(2,1,0)$_{12}$, was based on its performance in achieving the lowest RMSE and MAE values, reflecting its strength in capturing both trend and seasonal structures in the historical data. Beyond its statistical robustness, the dashboard stood out for its innovation and accessibility. It allowed users to view historical and forecasted rainfall patterns through intuitive visuals, including shaded confidence intervals and year-labelled axes, which enhanced understanding of temporal dynamics. Figure 3 illustrates the outputs generated by the *SmartForecast* dashboard. The upper plot displays the historical rainfall series along with a dynamically generated SARIMA forecast, which can be adjusted based on user-specified durations. Forecasts are visualised with shaded regions indicating 95 percent confidence intervals, providing users with an understanding of potential variability in future rainfall patterns. Figure 4 shows the forecasted monthly rainfall values in table format. It includes the predicted amounts along with their 95% confidence intervals. This table allows users to view and compare exact forecast values easily, supporting clearer planning and reporting.

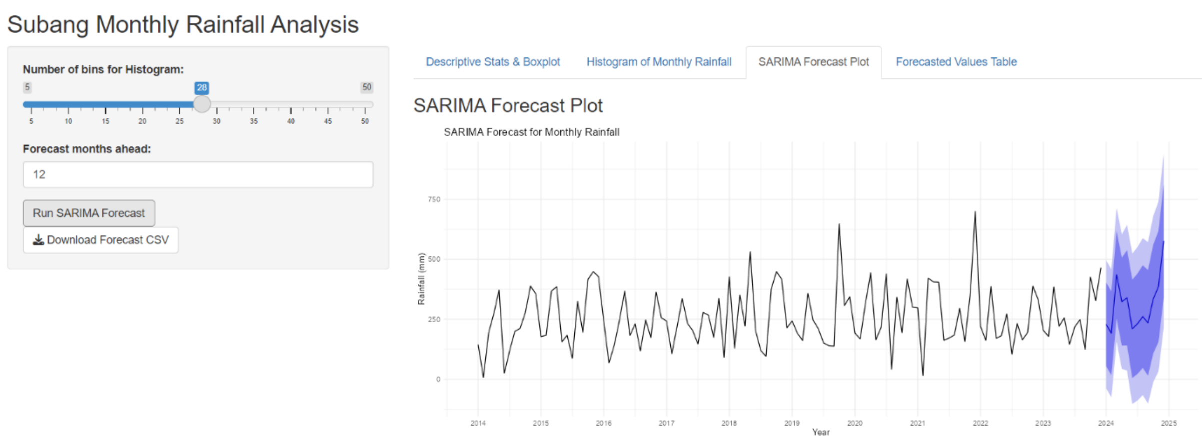
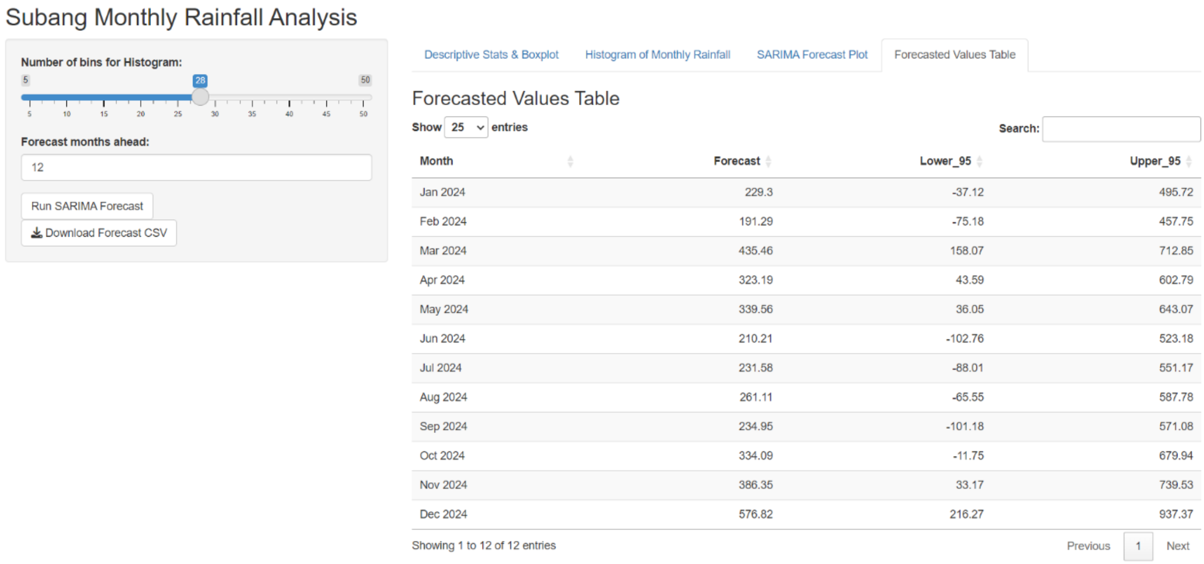


Figure 3. SmartForecast dashboard interface displaying the SARIMA forecast plot of monthly rainfall in Subang with confidence intervals



Month	Forecast	Lower_95	Upper_95
Jan 2024	229.3	-37.12	495.72
Feb 2024	191.29	-75.18	457.75
Mar 2024	435.46	158.07	712.85
Apr 2024	323.19	43.59	602.79
May 2024	339.56	36.05	643.07
Jun 2024	210.21	-102.76	523.18
Jul 2024	231.58	-88.01	551.17
Aug 2024	261.11	-65.55	587.78
Sep 2024	234.95	-101.18	571.08
Oct 2024	334.09	-11.75	679.94
Nov 2024	386.35	33.17	739.53
Dec 2024	576.82	216.27	937.37

Figure 4. SmartForecast dashboard interface displaying the forecasted monthly rainfall values in Subang, including corresponding 95% confidence intervals

The interactive nature of the dashboard empowered users from non-technical backgrounds, such as policymakers and community planners to explore forecast data meaningfully. Furthermore, the descriptive statistics module, integrated directly within the application, offered clear insights into rainfall distribution. This included key indicators like mean, skewness, kurtosis, and the Jarque-Bera test, which indicated that the rainfall data deviated from normality. These insights helped contextualize the forecasting results and provided a foundation for data-driven discussion and action. Overall, *SmartForecast* not only demonstrated predictive accuracy but also showcased how advanced statistical methods can be transformed into accessible tools. By merging SARIMA modelling with a user-friendly dashboard, the innovation promoted a more inclusive and proactive approach to environmental decision-making.

4. DISCUSSION

The development and implementation of the *SmartForecast* dashboard underscore the practical potential of merging time series modelling with interactive digital platforms. By adopting the SARIMA $(4,1,0)(2,1,0)_{12}$ model, which delivered optimal accuracy metrics, this innovation successfully bridged technical forecasting methods with a user-friendly interface that can be navigated by users with minimal statistical background. One of the most significant contributions of this work lies in its accessibility. Unlike traditional forecasting tools that often require specialist software or programming expertise, *SmartForecast* lowers the barrier to entry for data-driven decision-making. This is especially relevant in the context of climate resilience and urban planning, where timely and interpretable rainfall forecasts are essential for mitigating flood risks and managing water resources efficiently.

The dashboard not only visualises historical patterns and future projections, but also includes built-in descriptive analytics. These features enhance understanding and transparency for users, reinforcing confidence in the forecasts produced. Moreover, by incorporating visual indicators of uncertainty, the tool empowers users to plan around ranges rather than fixed outcomes, making it a valuable resource in real-world settings. This innovation supports the broader goals of sustainable development by encouraging inclusive access to predictive analytics. As the impacts of climate change become more unpredictable, tools like *SmartForecast* can play a crucial role in community-level preparedness and evidence-based governance.

5. CONCLUSION

In conclusion, the *SmartForecast* dashboard represents a meaningful step forward in making complex forecasting models accessible to a broader audience. By integrating the SARIMA $(4,1,0)(2,1,0)_{12}$ model within a dynamic R Shiny application, this innovation transforms raw rainfall data into actionable insights. Its user-friendly interface and built-in analytics tools help demystify time series forecasting for decision-makers, researchers, and the public. The successful application of this model to historical rainfall data from Subang highlights its potential for broader use across other regions and variables. With its ability to visualise trends, communicate forecast uncertainty, and provide statistical summaries, the dashboard encourages a data-informed culture in both environmental planning and policy development.

As climate variability becomes increasingly pressing, tools like *SmartForecast* offer scalable and adaptable solutions that can be tailored to various forecasting needs. The project has laid a strong foundation for future enhancements, including integration with real-time data and expanded functionality, positioning it as a valuable resource for inclusive and proactive environmental governance.

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"From Manuscript to Masterpiece"

Preface

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