Forecasting and Visualization of Total Rice Production in Sumatera for Optimizing Rice Productions

Bintang Muhammad Ramdhan[1], Christopher Kenneth David[2] and Valen Claudia Chuardi[3]

[1,2,3] Information System, Faculty of Engineering and Informatics, Multimedia Nusantara University, Tangerang Indonesia

bintang.muhammad@student.umn.ac.id[1], christopher.kenneth1@student.umn.ac.id[2], valen.claudia@student.umn.ac.id[3],

Abstract. Rice is a staple food and a crucial agricultural product in Indonesia, especially in Sumatera, where rice fields are integral to its agricultural history. This research aims to analyze and visualize the factors influencing total rice production in Sumatera, including humidity, temperature, rainfall, and the total area of rice fields. By employing descriptive analysis and data visualization techniques using Tableau Desktop 2023.3, the study provides insights into the relationships between climatic factors and rice production. The research also includes forecasts to aid in optimizing rice production. This study is essential for improving rice yields, ensuring food security, and promoting sustainable farming practices in Sumatera and Indonesia.

Keywords: Rice production, Sumatera, climate factors, data visualization, Tableau, forecasting, agricultural optimization, food security

Chapter 1: Introduction

In Indonesia, rice is a vital part of people's diets and a significant agricultural product, especially on the large island of Sumatera. Sumatera's rice fields are a symbol of its long history in agriculture. Understanding how to improve rice production here is essential for food security, a strong economy, and sustainable farming practices.

Several factors affect rice production in Sumatera, including humidity, temperature, rainfall, and the total area planted with rice. Each of these elements plays a critical role in the amount and quality of rice grown. For example, humidity levels that are too high or too low can harm the rice plants. Temperature is also important, as rice needs warmth to grow well, with different temperature ranges being ideal for various stages of growth. Rainfall needs to be sufficient and well-timed throughout the growing season. The total area of rice fields determines how much rice can potentially be produced, with larger areas giving higher yields but also requiring more resources and management.

Given Sumatera's importance to Indonesia's rice supply, it's crucial to be able to predict and improve rice production here. Precise forecasts allow farmers to make informed decisions about planting and harvesting, maximizing yields and using resources efficiently. Optimizing rice production goes beyond just improving farming practices. It also involves managing environmental and climatic factors that affect crop performance. Stakeholders can use advanced technologies and data analysis to predict weather patterns, assess soil health, and implement precision farming techniques. This will not only increase rice production but also make it more sustainable.

This report focuses on analyzing the factors contributing to total rice production in Sumatera, Indonesia and to find the most optimized way to increase total rice production by considering what factors that impacts rice production positively. The study will cover commonly known factors attributed to rice or crop production such as humidity, average temperature, rainfall and total area of land used for crop purposes. The geographical scope will include a comparative analysis of average temperature between provinces in Sumatera. The report will also determine which province is the top rice producer and how that combination of factors contributed to a province being a top rice producer.

This research holds significant value for optimizing rice production in Sumatera and ensuring Indonesia's food security. By analyzing and forecasting the interrelationships between humidity, temperature, rainfall patterns, and the total area of rice fields, the research can provide crucial insights for the local agricultural department. This information can be used to strategically select optimal locations for new rice fields and guide resource allocation for existing ones. Ultimately, the research empowers stakeholders to make data-driven decisions that enhance overall rice production in Sumatera, contributing to a more stable and sustainable agricultural future for the region.

Chapter 2: Literature Review

According to Sondakh et al. (2023), the study investigates rice production forecasting using statistical models. The authors examine various factors influencing rice production and apply time series models to predict future production. The research findings indicate that the use of statistical models can provide accurate and beneficial predictions for rice production planning in Sumatra (Sondakh et al., 2023). This literature is relevant as it discusses forecasting techniques similar to those used in the research on rice production in Sumatra.

According to Siswanto and Dewi (2021), the article focuses on the use of information technology in agricultural management, including rice. The authors discuss the implementation of Geographic Information Systems (GIS) and data mining to monitor and predict agricultural production. The data visualization methods applied help farmers and decision-makers optimize production outcomes (Siswanto & Dewi, 2021). The relevance of this article lies in the use of technology for visualization and prediction of rice production, which is a crucial part of the research under review.

According to Prambudi et al. (2023), the article examines the impact of climate change on rice production in rainfed areas. The authors use climate and production models to analyze historical data and predict future impacts of climate change. The findings of the study indicate that climate change significantly affects rice production (Prambudi et al., 2023). This literature is important as it highlights external factors influencing rice production, which should be included in the predictive models.

According to Hadi et al. (2014), the article discusses the use of regression models and time series analysis in predicting rice crop yields. The authors emphasize the importance of selecting appropriate variables to improve prediction accuracy. The research results show that the models used can help in planning rice production and distribution more effectively (Hadi et al., 2014). The relevance of this article lies in the use of statistical methods supporting rice production prediction.

According to Suharto et al. (2021), the article highlights the application of statistical and machine learning methods for predicting agricultural production. The authors explore various algorithms such as linear regression, ARIMA, and random forest to improve prediction accuracy. The study findings indicate that combining multiple methods can yield better predictions (Suharto et al., 2021). This article is relevant as it examines various forecasting techniques that can be applied in rice production research in Sumatra.

According to Yuwono et al. (2023), the article reviews the use of information and communication technology (ICT) in agriculture, focusing on decision support systems for rice production. The authors describe how ICT can aid in data collection, analysis, and visualization of production results. The findings show that integrating ICT can enhance agricultural efficiency and productivity (Yuwono et al., 2023). The relevance of this article lies in the use of technology to support the prediction and optimization of rice production.

According to Rahman et al. (2023), the article discusses the application of climate prediction models for agriculture. The authors investigate how climate predictions can be used to plan rice production and reduce crop failure risks. The research findings show that accurate climate prediction models can help farmers make better decisions (Rahman et al., 2023). This article is relevant as it integrates climate factors into rice production prediction models.

According to Fadli et al. (2022), the article discusses the use of forecasting methods in various sectors, including agriculture. The authors emphasize the importance of prediction accuracy for planning and decision-making. Various methods such as ARIMA and neural networks are discussed in the context of agricultural yield prediction

(Fadli et al., 2022). The relevance of this article is in its review of various forecasting methods that can be applied in rice production research in Sumatra.

According to Indrawati et al. (2023), the article focuses on agricultural extension programs and their impact on rice productivity. The authors analyze the effectiveness of extension programs in increasing farmers' knowledge and agricultural practices. The research findings show that effective extension programs can enhance rice production outcomes (Indrawati et al., 2023). This article is relevant as it highlights the importance of non-technical interventions like extension services in improving rice production.

According to Anggraini et al. (2019), the thesis explores factors affecting rice production and methods to optimize it. The authors discuss the role of technological innovations, policy interventions, and environmental considerations in enhancing rice yields. The study provides a comprehensive analysis of strategies to improve rice production efficiency in various regions (Anggraini et al., 2019). The relevance of this thesis lies in its broad examination of factors and methods to optimize rice production, aligning with the objectives of forecasting and visualization research.

Chapter 3: Method

The research method employed in this study is descriptive analysis, aiming to systematically characterize the collected data. Data collection involved two primary methods: secondary data collection and literature review. Secondary data were sourced from an open data source, Kaggle (https://www.kaggle.com/datasets/ardikasatria/datasettanamanpadisumatera/data.

The literature review included collecting and analyzing scientific sources relevant to the research topic, such as scientific journals, official reports, and publications discussing the importance of rice or food production to a nation and what factors that contributed to the sum of rice produced in a country or specific region. This review helped understand the theoretical and empirical context of the relationship between rainfall, temperature, humidity and area used for rice farming, thus helping the analyzation process of rice production in Sumatera.

The research framework included several key steps: data collection from mentioned sources, data cleaning and processing to ensure quality and consistency, and data analysis using Tableau Desktop 2023.3 for creating interactive data visualizations. Tableau was used to develop a dashboard that maps and displays the relationship between total rice produced, rainfall, average temperature, and humidity across Sumatera's provinces, assisting the government and stakeholders in understanding how to optimize rice farming in Sumatera and across the country, based on the insights gained.

This research aims to provide a comprehensive understanding of climatic factors influencing rice production across Sumatera and offer effective visual aids for decision-making in optimizing and increasing rice production. The study's focus is on agriculture, particularly the total rice production in Sumatera. The research examines the relationship between climatic factors (rainfall, humidity, and temperature), area of land used for rice farming and total rice produced and develops a dashboard to visualize the data, aiding government decision-making.

The research began by identifying the main problem: the impact of rainfall, humidity, and temperature on rice production in Sumatera. Preliminary discussions and data reviews were conducted, and research hypotheses were formulated. An in-depth literature review followed, analyzing relevant literature to understand the theoretical and empirical relationship between rainfall, humidity, and temperature, and rice production.

Secondary data collection involved reliable sources like Kaggle, providing detailed information on total rice produced in Sumatera, rainfall, humidity, and temperature in all of Sumatera provinces. Data cleaning and processing ensured good quality and consistency for analysis. Statistical analysis identified relationships between rainfall, humidity, temperature, and total rice production using descriptive and inferential methods. The results were

visualized using Tableau Desktop 2023.3, creating an interactive dashboard for easier interpretation and understanding.

The analysis results were interpreted to identify key findings and evaluate research hypotheses, followed by compiling a research report and refining the dashboard for presentation. The final stage involved presenting the research results and dashboard to the government and stakeholders, along with recommendations for optimizing rice production in Sumatera and also Indonesia.

Samples were drawn from dtotal rice produced, rainfall, humidity, and temperature data over a period of time (10 years, from 2010 to 2020). The sample size was based on available annual data for each province over the analysis period. Population data collection used secondary data from reliable sources like Kaggle, including detailed information on rice production, rainfall, humidity, and air temperature. The stratified sample selection ensured balanced representation of all of the provinces of Sumatera, facilitating comparative analysis and minimizing bias from data quantity differences.

Data analysis used descriptive and inferential statistical methods to understand the relationship between rainfall, humidity, temperature, and rice production in the provinces of Sumatera. The main variables analyzed were total rice produced, rainfall (mm), humidity, and air temperature (°C), collected yearly from secondary sources. Descriptive analysis provided an overview of data distribution and identified anomalies or outliers.

Tableau Desktop 2023.3 facilitated data visualization, creating interactive visualizations like thematic maps, trend graphs, and dashboards to explore data in-depth. These visualizations highlighted temporal and spatial patterns not easily visible through conventional analysis.

Using these analytical approaches, the research provides comprehensive insights into how climatic factors affect rice production in Sumatera, forming a basis for policy recommendations for more optimized rice production in Sumatera.

Chapter 4: Result and Discussion

The dataset used in this research was retrieved from Kaggle, an open-source data repository, and from it, the data for total rice produced, rainfall, humidity, and temperature were retrieved. The data is then prepared via Jupyter Notebook to check the cleanliness and usability for visualization in Tableau Dekstop. After being examined, the data is then transferred to Tableau Dekstop for further analysis via visualization. Attributes used to conduct the research are: provinsi, produksi, suhu rata-rata, kelembapan and curah hujan.

4.1 Dashboard Visualization

Dashboards visualizations are made using Tableau Dekstop 2023.3 for the purpose of easier understanding of the data from the visualization that focuses on the topics. The first dashboard shows the sum total of rice produced from provinces of Sumatera from the 2010-2020 period, the spread of land area used for rice production and also the rice produced-to-area used ratio. The second dashboard shows the comparison of average temperature from the top and bottom 3 producers and also forecast the average temperature for the next year. The third dashboard shows the average humidity between the top and bottom three producers and also the forecast for the average humidity for the next year. The fourth dashboard shows the average rainfall between the top and bottom three producers and also the forecast for the next year. Finally, the fifth dashboard shows the rice production forecast for the next 5 years and also the history of rice production to see the fluctuations.

Each dashboard is designed to be interactive in order to increase user understanding when they are interacting with the dashboards by interacting with the colours legends and the graphs itself to highlight certain data. With these visualizations, stakeholders could be further informed in their decision to optimize rice production.

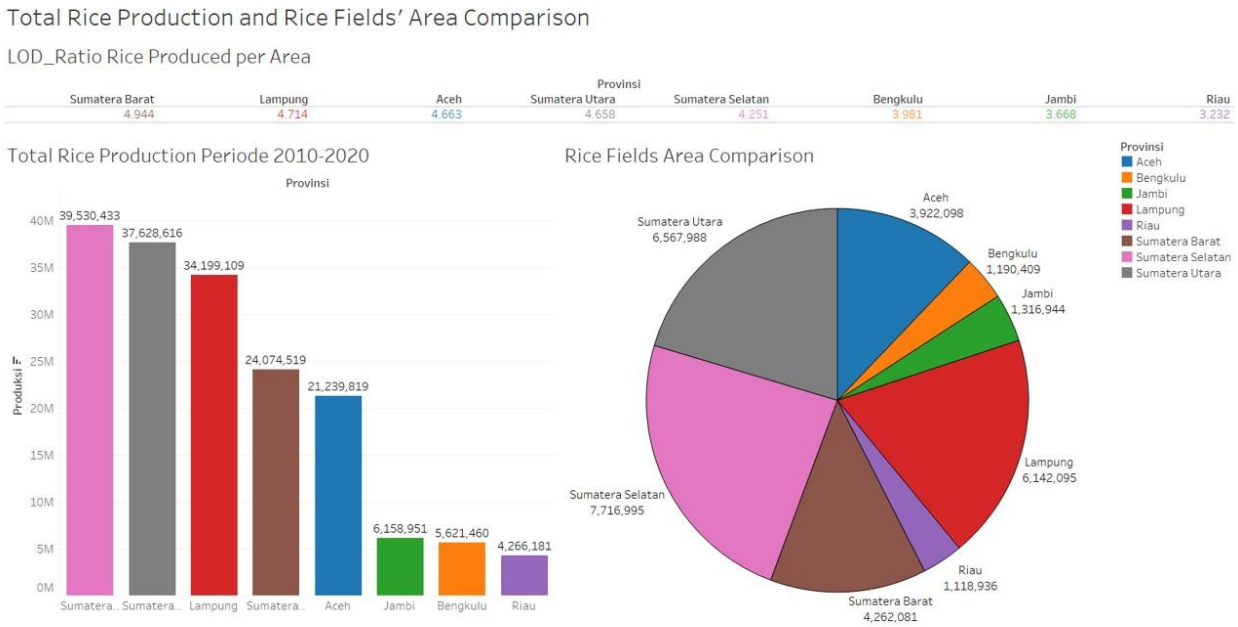

Fig. 1: Dashboard Visualization of Total Rice Production and Rice Fields' Area Comparison

This section presents the visualization results of the total rice produced in Sumatera, the land area used for rice farming in each province and also the rice produced to area used ratio for each province. This dashboard offers insight into:

- The total rice produced in each province for a 10-year period and from this visualization, the government or stakeholder could determine which province provides the most rice in this 10-year period.
- The area used for rice farming in each province so the government or stakeholder could determine whether to increase or decrease the area used, depending on their sustainability goals.
- The ratio of rice produced to area used for rice farming provides insight to what provinces should the government focuses on rice production. If the ratio is low, then the total rice produced is not equal to the area used. Based on that fact, the government or stakeholder could determine which provinces is the most ineffective or unoptimized rice producer.
- The top and bottom 3 rice producers are:
    - Top: Sumatera Selatan, Sumatera Utara, and Lampung
    - Bottom: Jambi, Bengkulu, and Riau

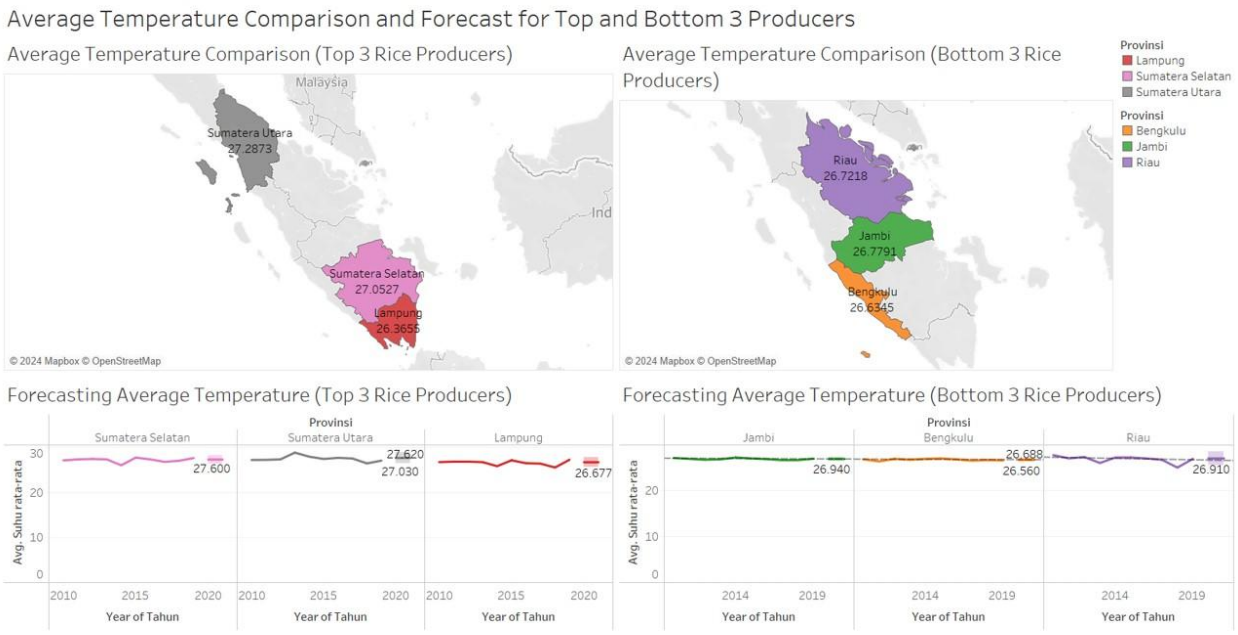

Fig. 2: Dashboard Visualization of Average Temperature Comparison and Forecast for Top and Bottom 3 Producers

This section presents the visualization comparison of average temperature between the top and bottom 3 producers and also the forecast for the next year for each section.

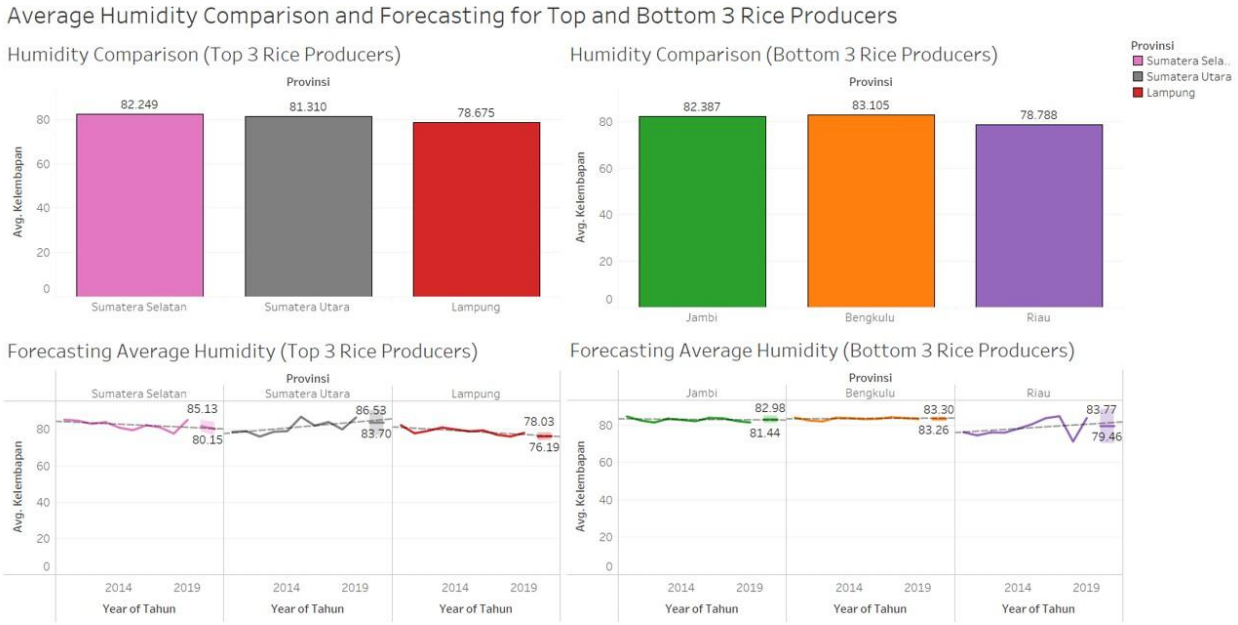

Fig. 3: Dashboard Visualization of Average Humidity Comparison and Forecasting for Top and Bottom 3 Producers

This section presents the visualization results of the total rice produced in Sumatera, the land area used for rice farming in each province and also the rice produced to area used ratio for each province. This dashboard offers insight into:

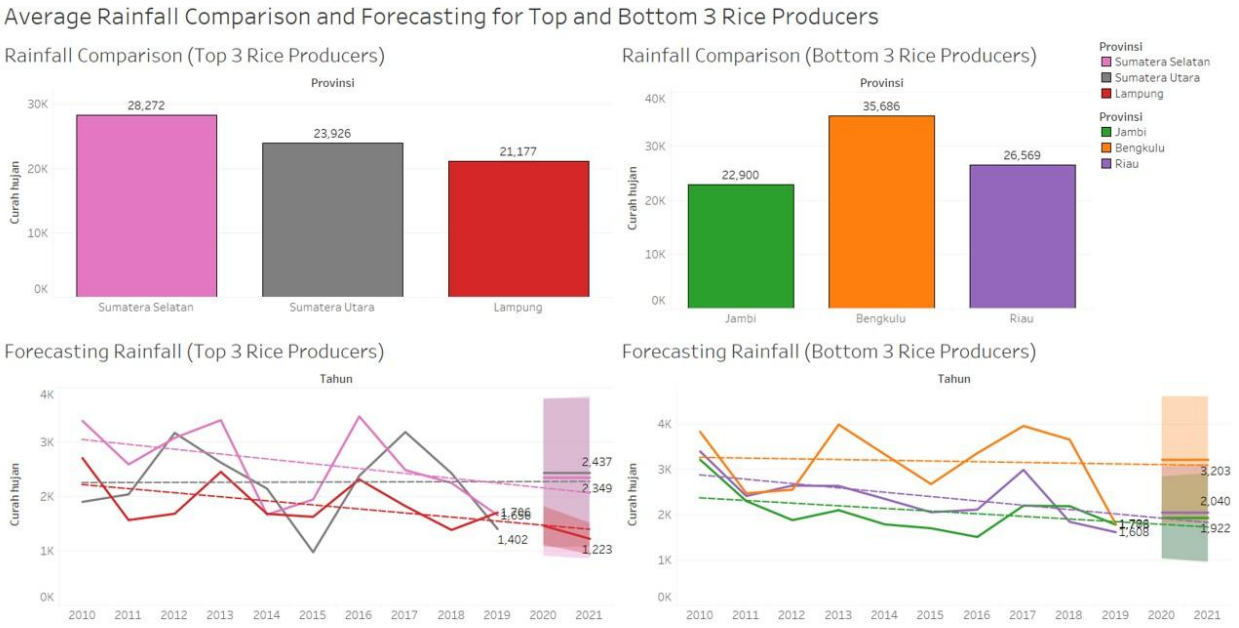

Fig. 4: Dashboard Visualization of Average Rainfall Comparison and Forecasting for Top and Bottom 3 Rice Producers

This section presents the visualization results of the total rice produced in Sumatera, the land area used for rice farming in each province and also the rice produced to area used ratio for each province. This dashboard offers insight into:

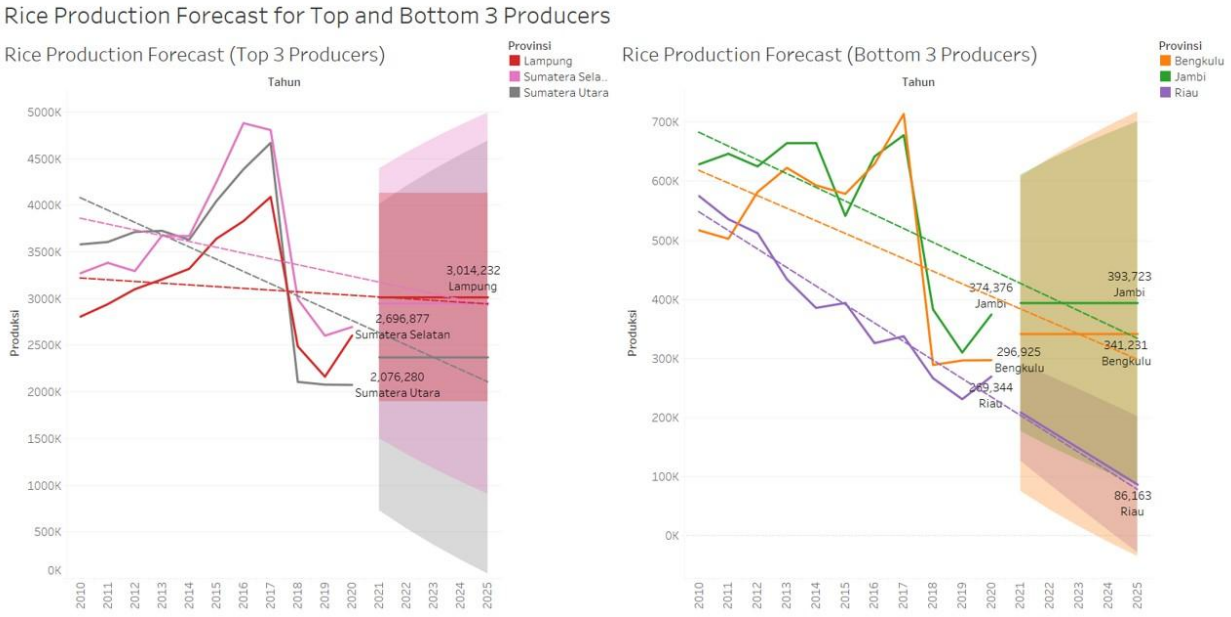

Fig. 5: Dashboard Visualization of Rice Production Forecast for Top and Bottom 3 Producers

This section presents the visualization results of the total rice produced in Sumatera, the land area used for rice farming in each province and also the rice produced to area used ratio for each province. This dashboard offers insight into:

Chapter 5: Conclusion

5.1 Summary of Findings

This research aimed to analyze and optimize rice production in Sumatera, Indonesia, through advanced data analysis and visualization techniques. Utilizing secondary data sourced from Kaggle and leveraging Tableau Desktop 2023.3 for visualization, the study examined key factors influencing rice yield, including humidity, temperature, rainfall, and the area of land dedicated to rice farming.

The study's findings indicate significant correlations between climatic factors and rice production. For instance, optimal temperature ranges and adequate rainfall were found to be crucial for maximizing rice yield. The interactive dashboards developed provide a comprehensive visual representation of these relationships, enabling stakeholders to identify trends and patterns more effectively.

5.2 Implications for Stakeholders

The insights derived from this research are valuable for various stakeholders, including farmers, policymakers, and agricultural planners:

1. **Farmers**: By understanding the climatic conditions that favor higher rice yields, farmers can better plan their planting and harvesting schedules, adopt suitable crop management practices, and mitigate risks associated with adverse weather conditions.

2. **Policymakers**: The study provides evidence-based data that can inform policy decisions related to agricultural subsidies, infrastructure development, and resource allocation. Policies aimed at improving irrigation systems and providing access to weather forecasting tools can significantly enhance rice production.
3. **Agricultural Planners**: The findings can guide strategic planning and resource distribution, ensuring that areas with optimal conditions receive the necessary support to maximize their production potential.

5.3 Recommendations

Based on the research findings, the following recommendations are proposed:

4. **Enhanced Climate Monitoring**: Implement advanced climate monitoring systems to provide real-time data to farmers, enabling them to make informed decisions regarding planting and harvesting times.
5. **Improved Irrigation Infrastructure**: Develop and maintain efficient irrigation systems to ensure consistent water supply, particularly in areas prone to variable rainfall.
6. **Capacity Building**: Conduct training programs for farmers on best practices in rice farming, focusing on climate adaptation strategies and sustainable agricultural techniques.
7. **Policy Support**: Formulate policies that support the adoption of innovative technologies and practices in rice farming, including subsidies for climate-resilient crop varieties and investment in agricultural research.

5.4 Future Research Directions

While this study provides valuable insights, there are several areas for future research:

8. **Longitudinal Studies**: Conduct long-term studies to monitor changes in climatic factors and their impact on rice production over time.
9. **Expanded Geographic Scope**: Extend the research to include other regions in Indonesia to compare and contrast findings, providing a more comprehensive understanding of the factors influencing rice production nationwide.
10. **Integration of Additional Variables**: Incorporate other relevant variables, such as soil quality, pest prevalence, and socio-economic factors, to develop a more holistic model of rice production optimization.

5.5 Conclusion

This research underscores the critical role of data-driven approaches in enhancing agricultural productivity. By harnessing the power of data analysis and visualization, stakeholders can make more informed decisions, ultimately contributing to the sustainability and resilience of rice production in Sumatera. The study's findings and recommendations pave the way for future innovations and improvements in agricultural practices, ensuring food security and economic stability for the region.

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