A Comprehensive Study of Rice Production and Price in Bangladesh: Geospatial Visualization and Predictive Modeling Techniques

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***Abstract*—This study presents a detailed spatiotemporal analysis of rice production and price in Bangladesh using datasets from 1971- 72 to 2020 for production and 2010- 2022 for price. The analysis comprises three main areas. Initially, through geospatial visualization methods like heat charts and chloropleth charts, we examine the growth and trends in the area, cost, and production of rice across different regions of the country. Secondly, a comparative analysis of production and price trends is done by visualizing and supporting the understanding of their dynamics over time. Our findings reveal significant indigenous variations in rice production and emphasize the significance of considering spatial factors in policy decisions aimed at enhancing the effectiveness and sustainability of this important sector. Finally, we employ predictive modeling techniques such as GridSearchCV, Ridge regression, Decision Tree, and LightGBM to predict rice prices for 2021 and 2022. Our analysis shows that the GridSearchCV and Ridge regression models were particularly accurate in their predictions. Overall, this study provides precious insights into the dynamics of rice production in Bangladesh and can inform unborn exploration and policy-making.**

***Index Terms*—component, formatting, style, styling, insert**

I. Introduction

Bangladesh's food security and socioeconomic growth depend on rice. As an agrarian country with a high population density, policymakers, academics, and agricultural stakeholders must understand rice production and price patterns. This is also crucial for achieving sustainable development goals (SDGs) in Bangladesh. The study of rice production and pricing gives useful insights into performance, difficulties, and viable measures to ensure food security, promote economic growth, and foster sustainable agricultural practices.

Rice production and price trends in Bangladesh are examined in this research. These major characteristics will help us comprehend the rice sector's dynamics and drivers. Rice Production and Rice Price datasets are used for the study. From 1971-72 to 2019-20, the Bangladesh Rice Research Institute gathered statistics on rice production. It provides a detailed summary of Bangladesh's rice output across multiple decades, including Aus, Aman, Boro, and Total Rice production. Rice prices from 2010 to 2022 are from Bangladesh's Department of Agriculture Marketing, Ministry of Agriculture. This dataset provides rice prices in marketplaces, districts, and divisions throughout the nation. Rice price patterns and geographical dispersion might help explain regional rice price variances.

Two goals drive this investigation. We first want to visualize rice production and pricing patterns throughout Bangladesh using geospatial analysis. Policymakers and agricultural stakeholders will benefit from this research on rice production and price changes. Second, we seek to explore the relationship between rice production and price, investigating whether there are any interdependencies or correlations between these two key variables. This comprehensive study aligns with and supports the achievement of key SDGs including SDG 2 (Zero Hunger), SDG 8 (Decent Work and Economic Growth), and SDG 12 (Responsible Consumption and Production).

Geospatial analysis reveals geographical patterns and variations that other approaches may miss. We can comprehend Bangladesh's rice sector's spatial dynamics and drivers by combining rice production and price analysis with geospatial methods. This insight may guide targeted policies and actions to improve rice sector productivity, market efficiency, and price stability. This research adds to Bangladesh's rice production and price dynamics knowledge base. We want to help policymakers, scholars, and stakeholders develop sustainable and resilient rice sector policies by evaluating historical trends, regional patterns, and possible linkages.

II. Related Works

Mamun et al. identified distinct cluster regions in various seasons, revealing significant differences among rice production regions in Bangladesh and also provided a great insight on region specific rice cultivation scenario in Bangladesh [1]. Moreover, Kabir et al. presented a three-winged framework for increasing rice productivity in Bangladesh through yield enhancement, increased adoption of technology, and production accumulation in unexplored spaces [2].

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III. Methodology

A. Data Collection and Preprocessing

In this study, we used two datasets to analyze rice production and pricing in Bangladesh. The first dataset, obtained from the Bangladesh Rice Research Institute [3], contains information on Aus, Aman, Boro, and total rice production in Bangladesh from 1971-72 to 2019-20. The dataset contains yearly production statistics for every rice variety, enabling a thorough examination of the evolution of the rice-producing sector over many decades. The second dataset, obtained from the Department of Agriculture Marketing, Ministry of Agriculture, Bangladesh [4], contains information on the price of Aus, Aman, and Boro rice in different markets of different districts in different divisions of Bangladesh from 2010 to 2022.

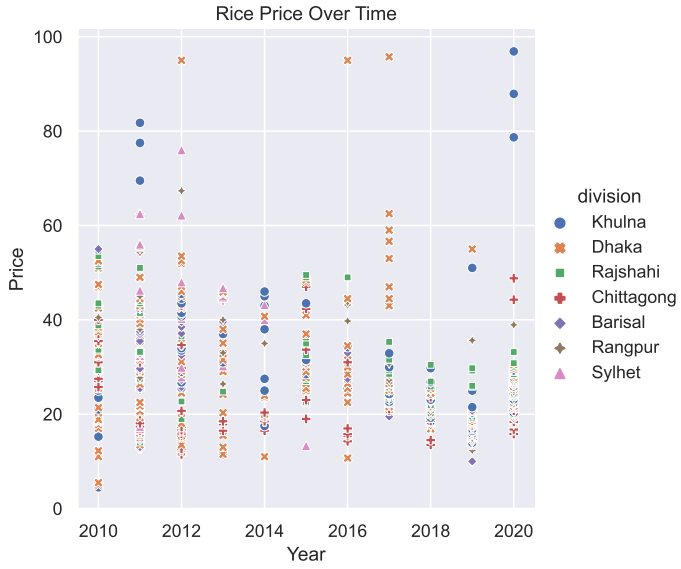

Fig. 1: Average Price of Rice by Divisions

Both datasets underwent data preprocessing procedures to guarantee the accuracy and consistency of the data before the study. This included fixing any missing values, standardizing the layout of variables and values, and cleaning the datasets to get rid of any duplicate or incorrect entries. To find and fix any abnormalities or inconsistencies in the datasets, data validation processes were also created. In order to guarantee the dependability and correctness of the data utilized for geospatial analysis and exploratory data analysis, these preprocessing processes were essential.

B. Geospatial Analysis of Rice Price Over the Map

We performed geospatial analysis using these datasets to visualize and analyze trends in rice production and pricing. We used heat maps to show rice prices over time district-wise and division-wise. We also created a chloropleth map of Bangladesh showing the average rice price for each district. These visualizations show the density and intensity of average rice prices in years from 2010 to 2020 for each district of Bangladesh.

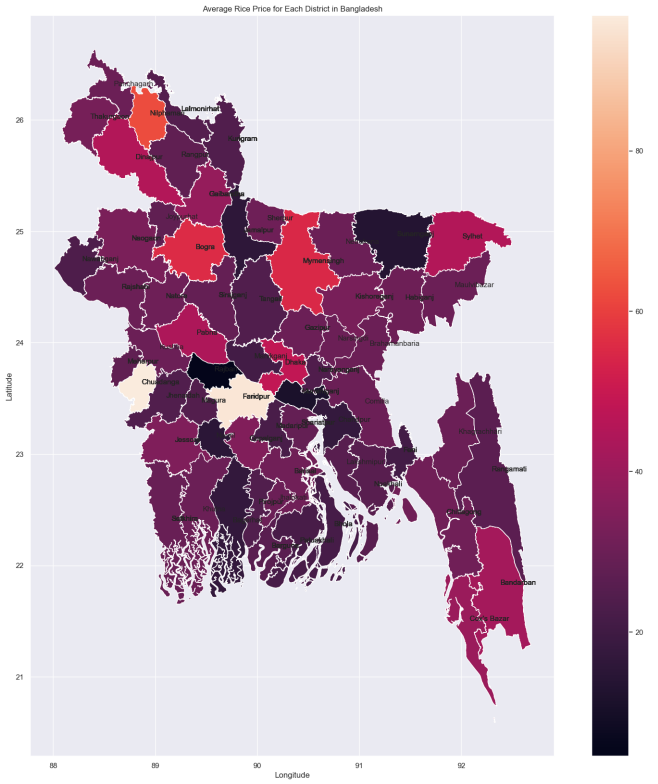

Fig. 2: Chloropleth map of Bangladesh visualizing geospatial distribution of rice price over time

C. Analysis of Rice Production Vs Rice Price

To analyze trends in rice production, we plotted line graphs showing Aus, Aman, Boro, and total rice production year-wise from 1971-72 to 2019-20. We also plotted line graphs showing Aus, Aman, Boro, and average rice prices year-wise from 2010 to 2022. Then, we plotted Rice Production and Rice Prices of Aus, Aman, and Boro separately in 3 line graphs years from 2010 to 2022. This allowed us to compare and analyze trends in production versus prices of Aus, Aman, and Boro rice.

D. Price Distribution and Prediction of Rice Price

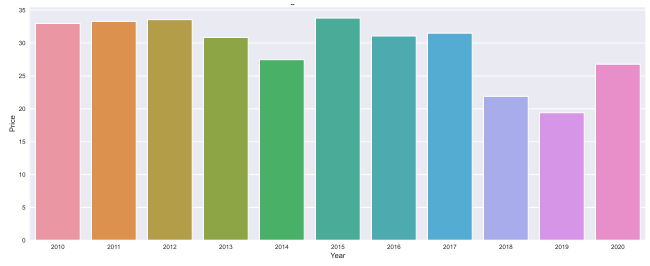

Fig. 3: Average Price of Rice from 2010 to 2020

We also performed a statistical analysis of the data. We plotted a bar chart of the average price of rice each year to show the most costly year. We then created a correlation heatmap to see the correlation between features such as division, district, upazila, bazar, and merchandise.

Finally, we trained four models (GridSearchCV, Ridge regression, Decision Tree and LightGBM) on 80% of the Rice Price dataset (from 2010 to 2020) to predict the Rice Price of year 2021 and 2022. We then compared the predicted price with the actual rice price of these two years. We plotted bar plots of actual price and predicted price and scatter diagrams to analyze our results.

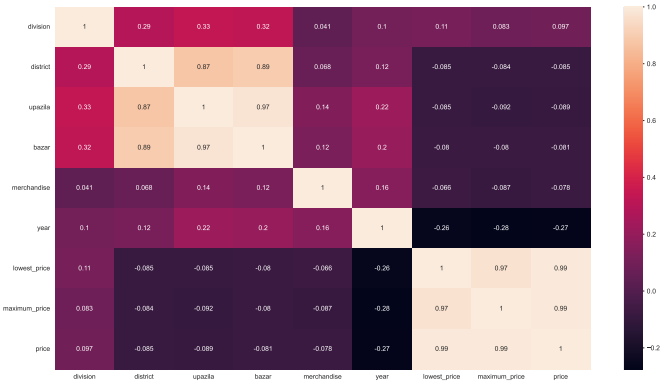

Fig. 4: Correlation Matrix of Rice Price Dataset

IV. Results & Analysis

In this study, we conducted a spatiotemporal analysis of rice production and price in Bangladesh using two datasets: Rice Production in Bangladesh from 1971-72 to 2019-20 and Price of Rice in Bangladesh from 2010 to 2022. Our analysis revealed significant regional variations in rice production and price, highlighting the importance of considering spatial factors in policy decisions aimed at improving the efficiency and sustainability of this important sector.

Our implementation, findings, and analysis can be divided into 3 parts. Firstly, We visualized the geospatial distribution of rice prices over time using heat maps and a chloropleth map of Bangladesh as shown in figure 2. From the Chloropleth map of Bangladesh, we can visualize the geospatial distribution of rice prices over time. These maps showed the density and intensity of average rice prices across different regions and years. From these visualizations, we can see that increment in rice prices in different districts of Bangladesh is not linear. Also, some districts' prices are much higher than the other districts.

Secondly, We plotted a line graph depicting Aus, Aman, Boro, and total rice production year-wise from 1971-72 to 2019-20. From This, we can see that Rice production has increased throughout the years though it was non-linear. One thing to notice that rice production has decreased in the years from 2012 to 2015 significantly and in these years, the average price of rice was much higher than any other. Later, it increased gradually again. We also plotted line graphs separately showing Aus, Aman, Boro, and average rice production and prices year-wise from 2010 to 2022. These graphs allowed us to compare and analyze trends in production vs prices for these rice varieties. Our analysis shows that though rice production increased throughout the years, the price of rice also increased sometimes due to Transportation costs, Land decrease, population increase, etc.

Next, we examined the distribution of rice prices using a bar chart that illustrated the average price of rice each year. We also explored relationships between features such as division, district, upazila, bazar, and merchandise using a correlation heatmap. We found that the average price has strong relationship with the districts and years. This is because of the transportation of rice throughout Bangladesh as specific regions produce almost the whole production of rice. We then trained four predictive models (GridSearchCV, Ridge regression, Decision Tree, LightGBM) on 80% of the Rice Price dataset (2010-2020) to predict the Rice Price for 2021 and 2022. We then matched the Prediction price with the Actual rice price for the 2 years 2021 and 2022. Our evaluation showed that the predictions from GridSearchCV and Ridge regression models were close and accurate.

A. Predictive Modeling Techniques

We selected four predictive models (GridSearchCV, Ridge regression, Decision Tree, LightGBM) to predict rice price in Bangladesh for 2021 and 2022. These models were chosen for their effectiveness in making accurate predictions.

1) GridSearchCV: GirdSearchCV is a model selection technique that performs an exhaustive search over a specified parameter grid to find the best model. In this study, we used GridSearchCV to find the best hyperparameters for our predictive models. This allowed us to fine-tune our models and improve their performance.

2) Ridge Regression: Ridge Regression is a linear regression technique that adds a regularization term to the loss function to prevent overfitting. The regularization term is controlled by a hyperparameter, which determines the strength of the regularization. In this study, we used Ridge Regression to predict rice price. This model was chosen for its ability to handle multicollinearity and its effectiveness in making accurate predictions.

3) Decision Tree: Decision Tree is a non-parametric supervised learning method used for classification and regression. It works by recursively partitioning the data into subsets based on the values of the input features and making predictions based on the majority class or average value in each subset. In this study, we used Decision Trees to predict rice price. This model was chosen for its interpretability and its ability to handle non-linear relationships.

4) LightGBM: LightGBM is a gradient boosting framework that uses tree-based learning algorithms. It is designed to be faster and more efficient than traditional gradient boosting methods by using histogram-based algorithms and other optimizations. In this study, we used LightGBM to predict rice price. This model was chosen for its efficiency and effectiveness in making accurate predictions.

V. Conclusion

This research sheds light on Bangladesh's rice market dynamics. Geospatial rice price data helps policymakers stabilize

prices and intervene in markets. Rice production patterns show the significance of analyzing types separately and addressing land shortages and changing climates.

Market dynamics and price changes are shown via distribution analysis and correlation investigation. The predictive modelling shows machine learning's promise in price forecasting, enabling decision-making and risk management. Rice production and price dynamics are better understood because of this study. It promotes rice sector sustainability by aligning with SDGs like Zero Hunger, Decent Work, and Economic Growth.

Data availability and quality restrict this study's value. More studies should investigate rice production and pricing. Rice production and price analysis are crucial to sustainable development and human well-being, according to the research. This research improves our knowledge of Bangladesh's rice production and price, influencing policy, fostering market stability, and supporting sustainable development.

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