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ANALYSIS OF STABILITY, GROWTH AND FUTURE PROJECTIONS OF JUTE IN BANGLADESH

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ABSTRACT

Jute is the principal cash crop of Bangladesh and it plays a very significant role in the socioeconomic position of jute farmers. This study presents an overall overview of past trends of jute production in Bangladesh from 1969-70 to 2023-24 and future predictions of jute production from 2024 to 2032. Based on extensive time-series data, we examined regional trends in jute production, farm practice stability, and the role of economic and environmental factors in jute production. Descriptive statistics indicated large fluctuations in jute area and production with significant regional variations. Some regions, such as Rajshahi, Bogura, Jashore, and Faridpur, demonstrated an increase in 'area' and 'production' contributions in a cyclic manner. However, regions like Dhaka, Mymensingh, Cumilla and Rangpur recorded a periodic decline in growth. The hilly areas of Chottogram, Rangamati, and Sylhet had relatively low percentages of cultivated land because their soil type does not favor jute growing. The study highlighted the constancy in geographical coverage of jute while documenting a substantial rise in production efficiency, achieving an annual growth rate of 0.83%. Predictive SARIMA (Seasonal Autoregressive Integrated Moving Average) model suggested continued growth of jute production through 2032, driven by agricultural technology development, improved jute varieties, favorable policies, and increasing market demand. Our findings are informative for policymakers and agricultural industry stakeholders and bring the demand for region-specific planning and continued agricultural innovation to the forefront.

***Keywords*:** Jute production, Regional trend, Predictive analysis, SARIMA model

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1. INTRODUCTION

Jute is one of the most versatile natural fibers that comes from *Corchorus capsularis* (White Jute) and *Corchorus olitorius* (Tossa Jute), both of which are part of the family *Tiliaceae* (Rahman et al. 2017). Jute is often referred to as the golden fiber of Bangladesh not only because of its golden color but also because of its economic importance. Bangladesh is the second largest producer of jute in the world after India, which has an average production of jute 1.68 million metric tons per year (Gupta et al. 2009; Akter et al. 2020). In fact, until the mid-20th century, around 80 percent of the world's jute was produced in East Pakistan (present-day Bangladesh), making it the most sought-after commodity until the early 1980s. As per recent estimates, jute comes second only to cotton as the most used and commercialized natural fibers in the world (Guo et al. 2023). India, Bangladesh, China, Myanmar, Nepal and Thailand are the major jute producers. India and Bangladesh are the leading countries in jute production. The average area of jute production is shared as follows: India (57.78%), Bangladesh (30.81%), China (5.96%), Thailand (2.37%), Myanmar (2.35%) and Nepal (0.74%) (Islam and Alauddin 2012).

In Bangladesh, around three million farming households are involved in jute production. The jute harvest comes at a crisis period for marginal farmers and agricultural laborers who have otherwise run out of food. Food security for these most vulnerable groups is also guaranteed from the incomes generated from the sales of jute fiber and the wages queuing for disbursals to the workers (Hossain and Abdulla 2015). Contextual determinants show that the provision of social safety nets alone would hardly create any meaningful economic activity in Bangladesh in employment generation. Those primarily operational and capital indifferent sectors have greater scope for job creation, resulting in social advancement. The high degree of labor intensity in jute cultivation has been of utmost importance and, therefore, an asset to the sector, considering the level of rural unemployment in the country (Hossain and Abdulla 2015).

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Jute is an eco-friendly natural fiber and has many environmental advantages. It lasts for one growing season in the field, but biomass production at a given land area is much enhanced, while its by-products are biodegradable, meaning the system free of them will decompose in the soil after using up all their purpose (Islam and Alauddin 2012). As for the extrusion of jute textiles, other essential advantages are high viscoelasticity, low extension, elongation and tempering ability with superior length of fibers. Ecologically speaking, the jute fabric is comparatively better than synthetic fibers due to its biodegradability (Islam and Ahmed 2012; Islam and Alauddin 2012).

Jute is one of the most cultivated cash crops in Bangladesh, which occupies nearly 10% of the cropped area and helps earn about 16% of the foreign exchange from raw jute and jute products (BBS 2010). In the year 2006-07, jute contributed 1.3% to Bangladesh's GDP (Sheheli and Roy 2014). Growing and marketing jute and jute products manufacturing employs a good section of the population. Nevertheless, jute farmers in Bangladesh cannot fully enjoy the jute's benefits due to limited market access and traditional farming practices, which lower productivity than those practiced with modern technologies (Rahman et al. 2017). Given these challenges and in a bid to restore the lost stature of the Jute industry in the global market, the Jute industry in Bangladesh is being promoted through policy measures aimed at investment and jute products export promotion, which is undertaken by the Government of Bangladesh (Islam and Alauddin 2012).

Jute cultivation in Bangladesh holds historical and geographic importance, as it generates a good amount of revenue for the global jute market. Nowadays, consumers have shown a growing acceptance of jute and its products as an alternative source to synthetic ones. About 30% of the total world production of jute comes from Bangladesh (Sheheli and Roy 2014). This means jute cultivation trends and future jute production estimates are required in such regions or countries.

2. MATERIALS AND METHODS

2.1. Research Location

The People's Republic of Bangladesh is located on the northeastern side of South Asia. In the northern direction are the beautiful but far-off mountains of the Himalayas, while in the southern direction is the Bay of Bengal. These awe-inspiring physical features consist of a basin with an area of about 148,460 square kilometers that is crisscrossed by several rivers and streams. The geographical extent of Bangladesh lies between latitudes 20°34' and 26°38' and longitudes 88°01' and 92°41'. Bangladesh has international boundaries with India to the west (West Bengal), east (Tripura and Assam) and north (West Bengal and Meghalaya) and Myanmar is located in the southeast. Fig. 1 presents the layout of the study.

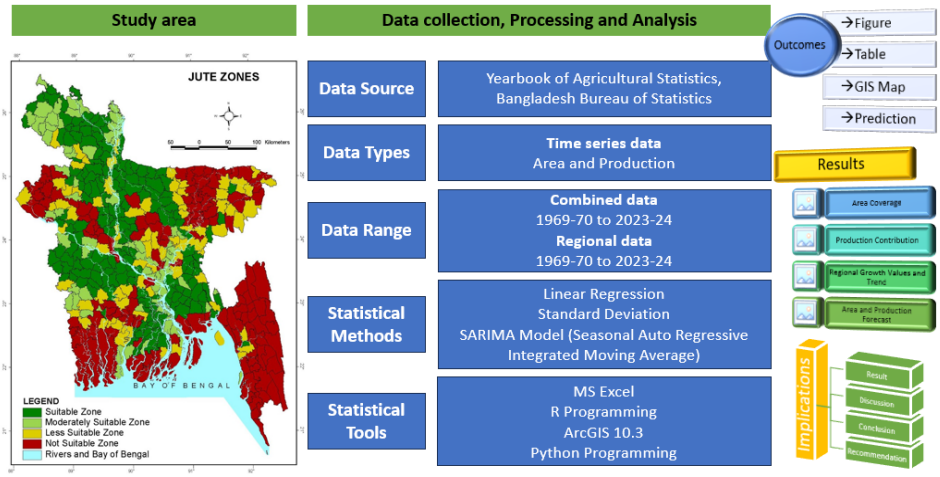

Fig. 1: A conceptual framework of the study.

2.2. Planned Work

Jute area coverage and production information were obtained from the Bangladesh Bureau of Statistics (BBS). The dataset contains information regarding annual areas under cultivation of jute in lakh acres and production in lakh bales for the years 1969-70 to 2023-24.

This research is designed using data available in the various editions of the Bangladesh Bureau of Statistics. For the analytical procedure, secondary information consisting of time series data was divided into two sections, Part I being region wise 1969-70 to 2023-24 and Part II aggregated 1969 to 2023. The regional variations were analyzed by considering an unchanging regional base of homogeneous environments. Region-wise scenarios would provide a base to explain the effects of specific conditions as well as agricultural development. All data in this study

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has been rolled into 14 agricultural regions, which are based on the working areas of the Department of Agricultural Extension, which covers over 64 districts across Bangladesh. The illustration of the regions studied is shown in Fig. 1.

A geographic information system (GIS) based map was incorporated to illustrate variations in area and jute production in Bangladesh spatially. However, administrative shape file of Bangladesh was downloaded and used from the Bangladesh Agricultural Research Council website. The specific link of the shape file ("Administrative map") is http://maps.barcapps.gov.bd/index.php.

2.3. Descriptive Statistics

Descriptive statistical analysis was performed in order to present the features of the data set. The following statistics were assessed for every year jute cultivation area and production: maximum, minimum, first quartile (25th percentile), third quartile (75th percentile), mean, median, standard error of mean (SE Mean), standard deviation, skewness and kurtosis. These calculations were performed with the help of pandas and scipy.stats libraries and results were presented in a transposed data frame for better understanding.

2.4. Time Series Visualization

Time series plots were prepared in order to explore the trends in jute cultivation and jute production over the years. The libraries matplotlib and seaborn were used to create the plots. Two basic time series plots were made, one with reference to jute area and the other regarding jute production. These plots presented the yearly change of each variable in the form of line graphs, whereby on the x-axis were plotted the years, and on the y-axis were either jute area (in lakh acres) or production (in lakh bales). Furthermore, an additional graph in the form of a line graph was provided to give trends between jute area and jute production within the same time frame.

2.5. Predictive Modeling

In light of the trends in jute cultivation area and production over the years, and in trying to extend these trends into the future, especially into the future jute cultivation areas and jute production, the SARIMA model (Seasonal auto regressive integrated moving average model) was applied. The sklearn.model_selection was used to divide the data into training and testing sets with a test set at 20%, while a random_state of 42 was employed for consistency. The linear regression models for the areas under cultivation of jute and production of jute were incorporated independently into the training dataset.

2.6. Future Predictions

For the projecting periods (2024 to 2032) of the jute cropping area and production, values were extrapolated from the SARIMA model trained using linear regression. Such predictions were also presented in the form of scatter plots, which contained historical data as well. The plots presented using the matplotlib showed the year's actual measured values and the estimated values using different colors and markers. The plots were also well labelled with appropriate axis labels, titles, and legends for better clarification.

2.7. Statistical Evaluation

The test data values and predictions for the regression models based on linear results were compared to quantify the predictive power of the models. In addition, the following performance metrics were calculated: coefficient of determination – R^2, mean squared error, and root mean square error.

3. RESULTS

Analysis of past time series data from 1969–70 to 2023–24 exhibits the patterns of jute cultivation area and its output for different years. The range of jute cultivation and its statistics are illustrated in Fig. 2. It has been noted that the geographical coverage of jute has remained fixed over the years and increased by an annual rate of 0.6788% after 2009-10. Nonetheless, the contribution of jute towards production has dramatically increased by an annual rate of 0.83%.

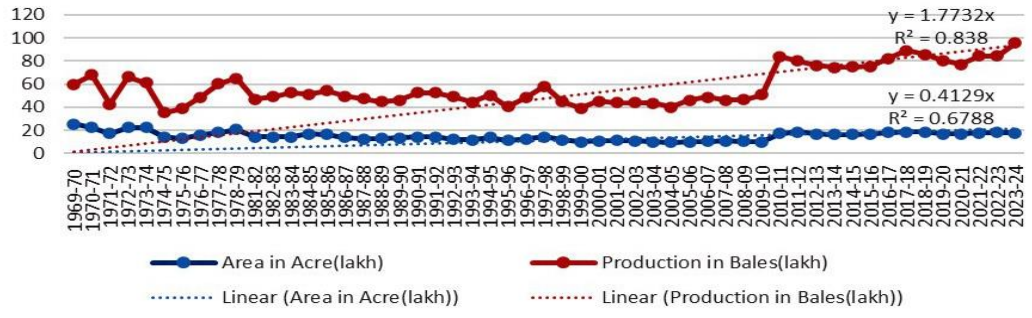

Fig. 2: National area coverage and production of Jute during 1969-70 to 2023-2024.

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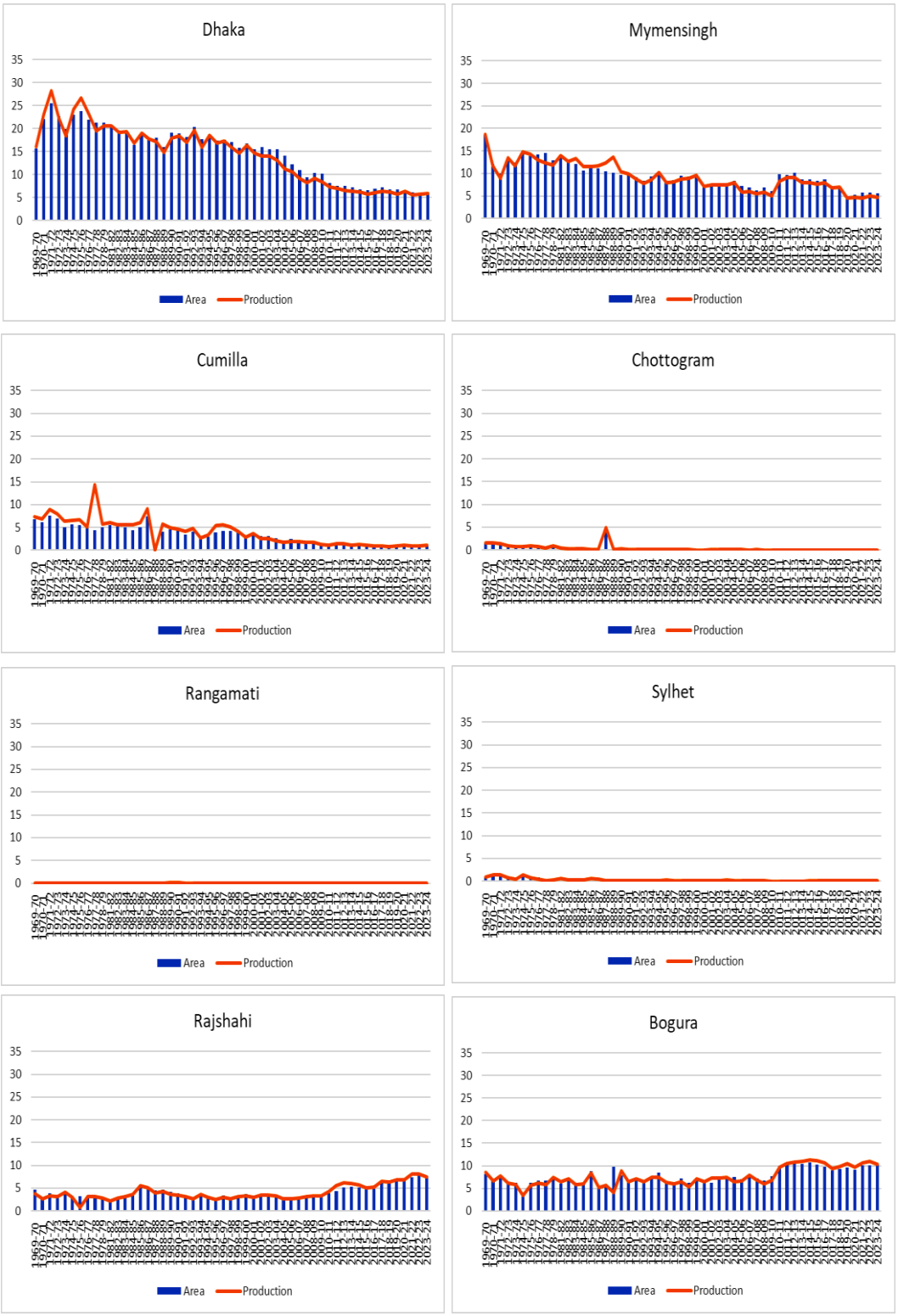
3.1. Regional Trend and Growth Analysis of Jute in Bangladesh

It has been noted that the geographical coverage of jute has remained fixed over the years and increased by an annual rate of 0.6788% after 2009-10. Nonetheless, the contribution of jute towards production has dramatically increased by an annual rate of 0.83%. Fig. 3 illustrates the total area under jute cultivation and the jute production in Bangladesh for a period of fifty-three years region-wise. Some regions, such as Rajshahi, Bogura, Jashore and Faridpur, demonstrate an increase in 'area' and 'production' contributions in a cyclic manner. However, regions like Dhaka, Mymensingh, Cumilla, and Rangpur recorded a periodic growth decline (Fig. 3).



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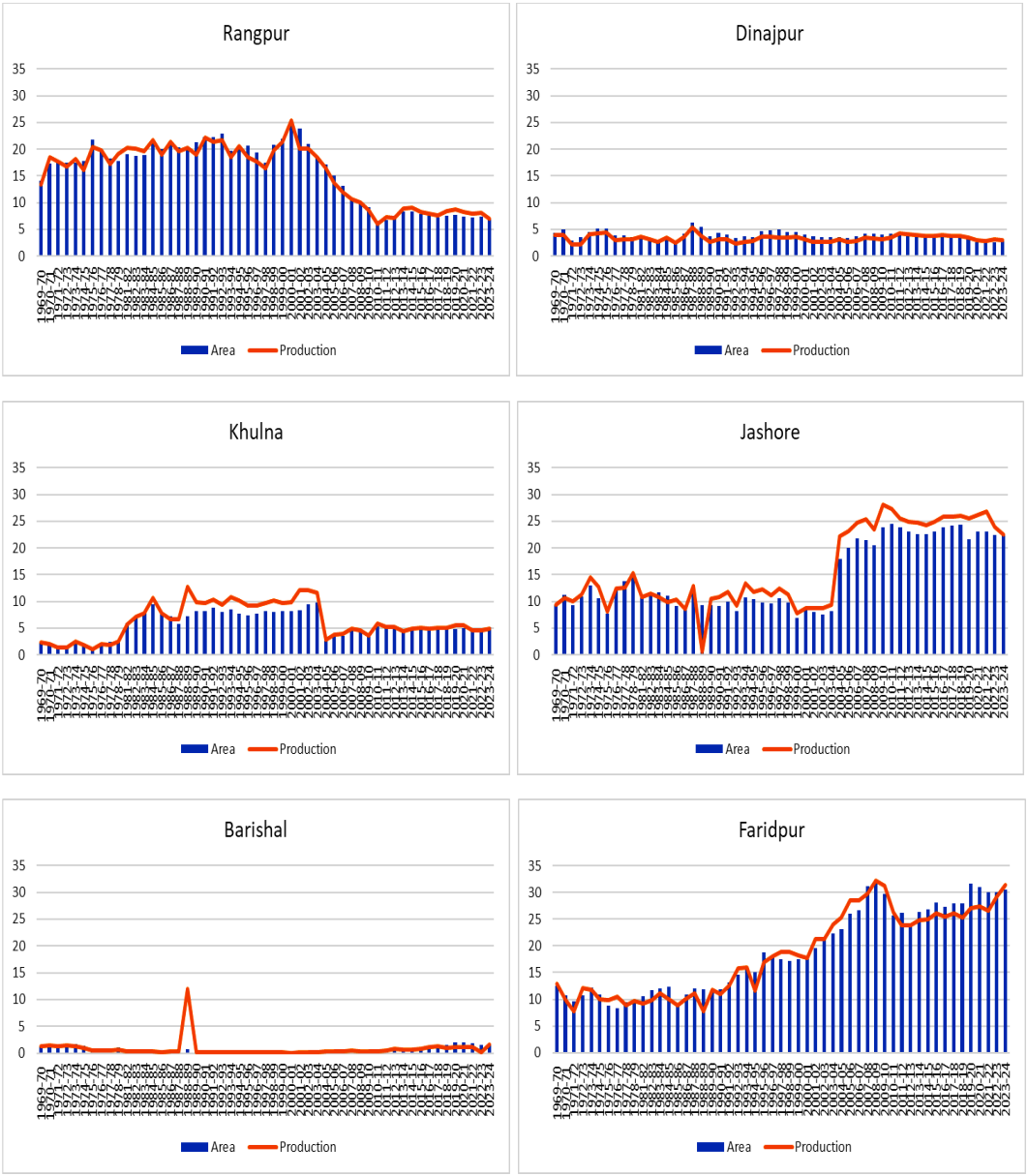

Fig. 3: Regional jute production and area coverage during 1969-70 to 2023-24.

Over the last few years, there has been a slow depletion in the area and output in the Dhaka region. Jute farming in Cumilla has come to a standstill as a result of, among other factors, the expansion of economically viable plants and the growth of industries. The hilly areas of Chottogram, Rangamati, and Sylhet have relatively low percentages of cultivated land because their soil type does not favor jute growing (Fig. 4-6). Coverage and Rangpur's productivity gradually declined in the last ten years concerning the 2000-2010 decade. On the other hand, coverage of jute area and production in Jashore substantially increased in 2003 and 2005, averaging growth between ten percent to twenty-three percent. In contrast to other regions, Faridpur recorded an increase in the area and production of jute, making it a national boost (Fig. 4-6).

3.2. Descriptive Statistics

Descriptive statistics are used to summarize the basic characteristics of the data under study. Table 1 presents basic descriptive statistics for the area and production of jute for the time series covering the last 53 years (1969-70 to 2023-24) in Bangladesh. This includes maximum and minimum values, 1st quartile, 3rd quartile, mean and median values, standard error of the mean, standard deviation, coefficient of skewness, and coefficient of kurtosis for each variable.

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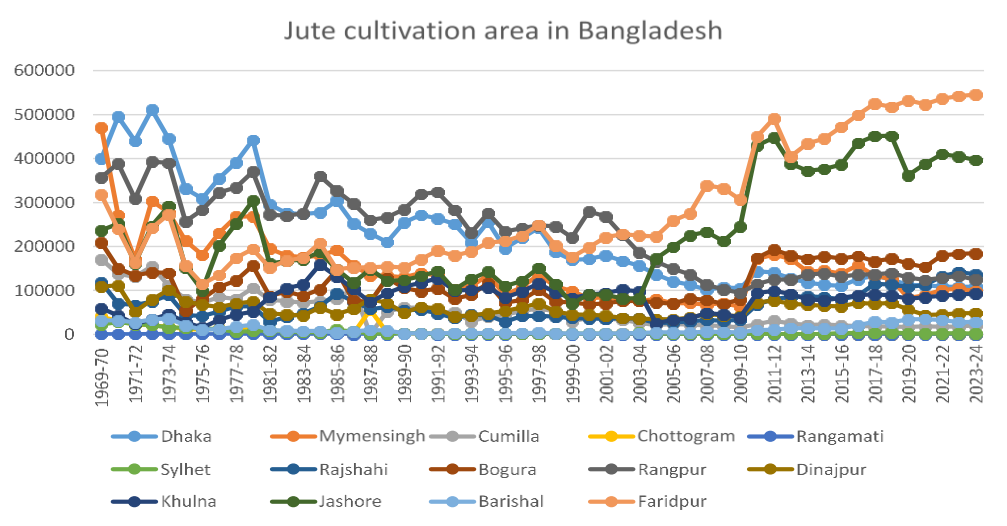

Fig. 4: Trend of regional jute cultivation area (acres) in Bangladesh.

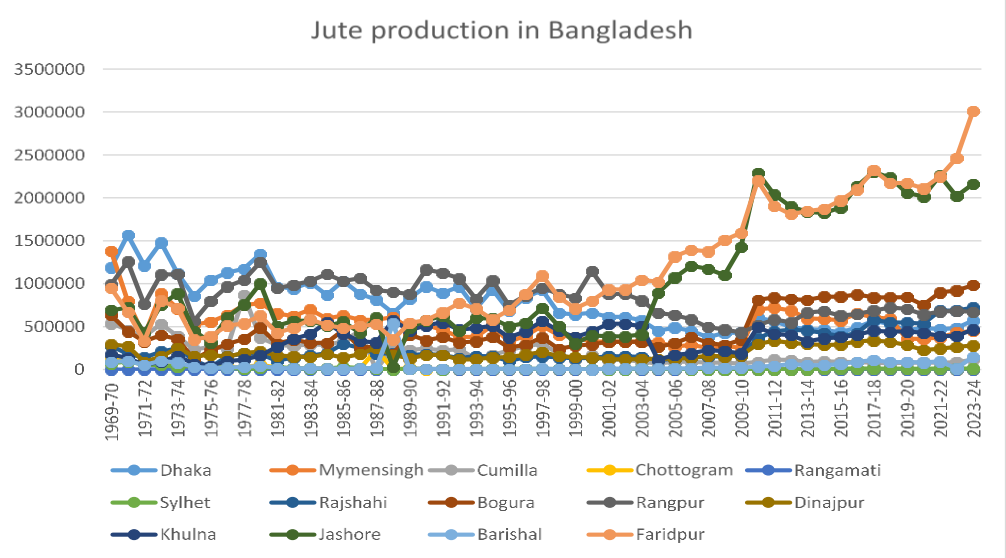

Fig. 5: Trend of regional jute production (bales) in Bangladesh.

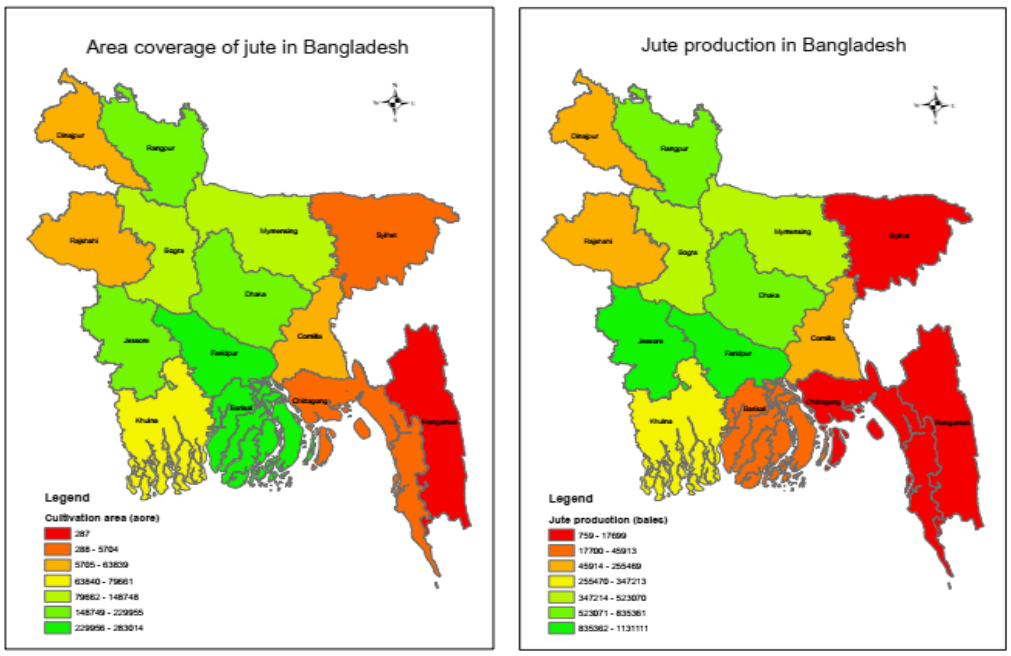

Fig. 6: Spatial (regional) distribution of jute cultivation (acres) and production (bales) in Bangladesh.

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Bangladesh's highest jute cultivated area is 25.43 lakh acres, alongside the highest production of 95.82 lakh bales. Conversely, the lowest areas cultivated and produced jute are 9.65 lakh acres and 35.30 lakh acres and bales, respectively (Table 1). These data showed a wide range of changes in the highest and lowest areas of jute cultivation and its production in Bangladesh. The averages are nearly identical to the middle values, meaning all the measures are symmetrically dispersed except production with slight positive skew. The median figures assist in understanding the distribution of data around a figure. From the findings, the average jute area holds 14.42 lakh acres, and the average jute production is 50.90 lakh bales (Table 1). Jute yield shows extreme fluctuation because its standard deviation is remarkably high when the jute area shows a dull out pattern. In addition, skewness and kurtosis provide insights about the shape of the distribution. From the findings, the values for skewness and kurtosis show that the distributions are almost normal but not entirely. The right-hand side of the distribution is positively skewed (0.53 and 0.73), meaning there are a few large areas under cultivation and a few instances of very high production.

3.3. Historical Trends and Forecast Analysis in Jute Area Coverage and Production

The records from 1970 showed remarkable changes in jute area coverage in Bangladesh. Fig. 7 indicates that a maximum coverage area had been achieved only to slump sharply decades ago, with the lowest recorded around the beginning of the 2000s. After the year 2000, however, a gradual increase in the area under jute cultivation has been observed, although this has been punctuated by considerable oscillations (Fig. 7).

Table 1: Descriptive statistics of area and production of jute in Bangladesh

Measures	Area (in lakh Acres)	Production (in lakh Bales)
Maximum	25.4297	95.81581
Minimum	9.64967	35.29745
1st Quartile	11.8164	46.18553
3rd Quartile	17.51325	74.36226
Mean	15.09945	57.95724
Median	14.4228	50.89728
SE Mean	0.515488	2.211979
Standard Deviation	3.752811	16.10345
Skewness	0.539609	0.72619
Kurtosis	-0.18282	-0.8079

Table 2: Forecasting of area and production of jute along with a 95 % confidence interval from 2024 to 2032

Year	Area (in lakh Acres)	Production (in lakh Bales)
2024	13.19257	71.57592
2025	13.13116	72.10170
2026	13.06976	72.62747
2027	13.00835	73.15325
2028	12.94694	73.67903
2029	12.88553	74.20481
2030	12.82413	74.73058
2031	12.76272	75.25636
2032	12.70131	75.78214

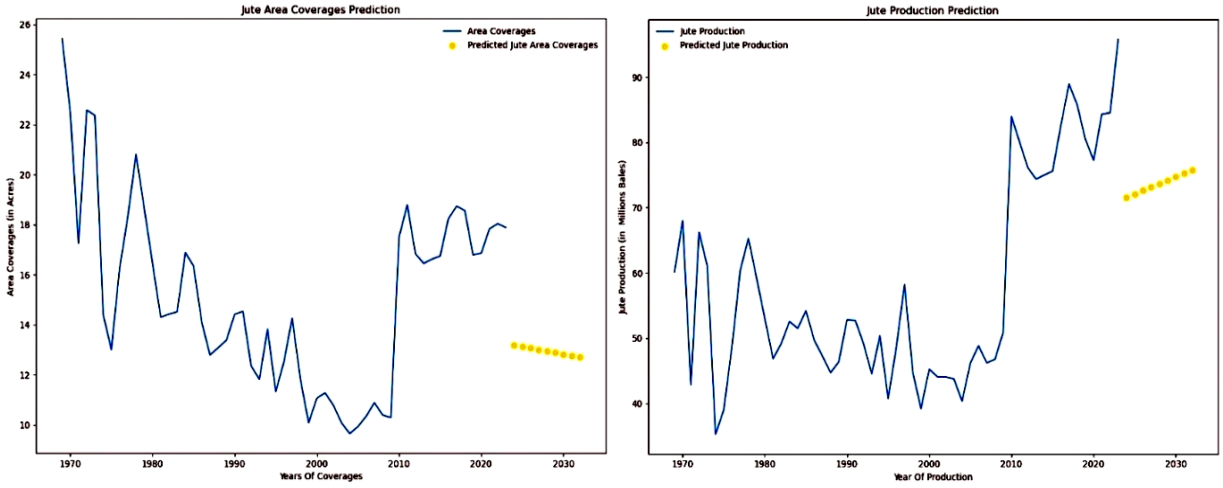

Fig. 7: Forecasting of jute area coverage (lakh acres) and production (lakh bales) in Bangladesh.

3.4. Jute Production Variations and Trends

Future Outlook jute production analysis for the same periods shows high deviation. The volumes of production were also marked by high peaks and low valleys. Around 2010, there was a marked upturn in production suggesting that either the yield per hectare or the farming methods have been improved. The predictions using the SARIMA model for the future are as positive as the current trends, which indicate that jute production is projected to continue upward from 2024 through 2032 (Fig. 7; Table 2). This is attributable to

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several factors including better farming practices, a favorable or increasing external and local market demand, and adequate government assistance.

The relationship between area and production also points to growth trends that are not only linear, but there are a few instances when production has grown faster than its respective area coverage. This deviation points out enhancements in cultivation parameters or yield per unit area. The projections of both elements up to 2032 are very positive concerning the Bangladeshi jute industry (Fig. 7; Table 2). The forecasts, in tandem with the historical data, indeed share invaluable perspectives on the cycling trends of jute farming and production. In optimistic predictions of the future, the forecasts reiterate that the jute sector, which is highly imperative to Bangladeshi agriculture, is bound for expansion if not in the present time for the near future.

4. DISCUSSION

Jute is the primary cash crop of Bangladesh, which has a significant impact on the socioeconomic conditions of jute farmers. Approximately 30% of jute and related products sold worldwide come from Bangladesh (Ahad et al. 2018). About 10% of the nation's agricultural land area and 6% of its total land area are used for jute production. Approximately 39% of agricultural exports are made up of jute. Bangladesh is the world's biggest exporter of raw jute, accounting for about 29% of total jute production, and produces about 33% of the world's jute (Islam et al. 2015). Bangladesh's economy has always been significantly reliant on jute. Bangladesh made large sums of foreign exchange in the 1970s from the export of raw jute, jute products, and jute-based arts and crafts. It was given the nickname "Golden Fiber of Bangladesh" for this reason. The Bangladeshi government has been working to boost the jute industry and regain its lost market share in recent years. The government is attempting to start a revolution in the jute industry, and its current policy is to encourage investment and facilitate the export of jute products (Islam and Ali 2017).

Through long-term data from 1969-70 to 2023-24 on jute cultivation in Bangladesh, this analysis illustrates the region's agricultural stability, and productivity trends (Bezabih et al. 2023). Even though the area covered geographically remains the same, jute production has grown by 0.83% annually (Fig. 2), largely due to yield improvements, possibly linked to enhanced farming techniques or the use of high-yielding jute varieties (Ahmed et al. 2024; Hossain et al. 2024; Chourasia et al. 2025). This efficiency improvement is with empirical studies on sustainable agriculture that trace yield increases to advances in agricultural management and adaptation-tolerant varieties of crops that can weather environmental instability (Rahman 1999).

4.1. Inter-Crop Differences in Jute Cultivation

The analysis by region shows jute cultivation in Bangladesh is not straightforward. In particular, Rajshahi, Bogura, Jashore, and Faridpur, have shown upward trends over periods in the cultivated area and the volume produced (Fig. 3-5). They may be experiencing a better climate, richer soil, or more aggressive agricultural practices. On the contrary, Dhaka and Rangpur regions have declined and in fact, Cumilla has completely stopped growing jute, most likely because crops that are easy to manage, such as commercially driven vegetables, are replacing these areas alongside urbanization. This reveals that industrialization and urbanization have a primary influence on agricultural land, and high-value crops like vegetables are replacing jute, indicating a shift driven by market demands (Quddus 2007; Satterthwaite et al. 2010). However, the limited scope of area for jute cultivation in Chittagong, Rangamati, and Sylhet can be due to the poor quality of the soils sustained there, hence the need for region-based agricultural policies. The alarming decrease in jute area coverage and production experienced in Rangpur from 2000 to 2010 also draws attention to the region’s susceptibility to shifts in the economy as well as climate changes (Kumar et al. 2024; Malek et al. 2024).

4.2. Influences of Observational Statistics

The exhaustive records of the area and production of jute over five decades and a half show tremendous variations and it produced more inconsistent figures, as observed with the high chaos (Fig. 6). The deviation of jute standard production is said to be higher because the jute area has been constant over the years but the jute growth in that area has varied over the years. This may be because the agricultural input, diseases, or other life forms that affect the yields change from year to year (Hasan and Sano 2014; Hasan et al. 2015; Hasan 2020; Karki et al. 2022). There exist several outliers in the data observed, apparent cropping area and output figures, which will likely come from a few years of high and extended irrigation or intensive cropping techniques. Jute production remains sensitive to economic and environmental changes. Studies highlight that production varies with climatic conditions, leading to yield fluctuations due to inconsistent rainfall or temperature extremes and economic pressures such as shifts in labor availability or input costs (Islam et al. 2009; Islam et al. 2020; Mollah et al. 2021; Hasan et al. 2025; Hossain et al. 2025). This variance is supported by predictive modeling (Senthamarai and Karuppasamy 2020; Bhusanar and Meena 2023; Gautam and Adhikari 2024), which suggests the potential for yield stability with better management of resources and climate-resilient jute varieties.

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4.3. Future Outlook and Predictive Analysis

Predictive SARIMA model indicates potential growth in jute production, forecasts positive and hopeful turns (Fig. 7; Table 2). This positivity may probably come from the technical achievements which are being experienced by jute farmers, for instance the introduction of improved agronomic practices and government support for the jute sector, bolstered by local and international market opportunities (Sheheli and Roy 2014; Akter et al. 2020; Sharna and Kamruzzaman 2020). The other possible factors that may contribute to this predicted growth would include effective government promotions of the county's jute sector and opportunities for local and export market diversification (Sharna and Kamruzzaman, 2020; Niloy 2021). Encouraging prospects for the jute sector in Bangladesh are increased production capability by mechanized cultivation methods and expansion of climate resilient modern jute varieties, which align with economic goals and environmental sustainability. Research suggests that policy support, such as government subsidies for jute cultivation and market expansion, could further enhance jute's role in Bangladesh's economic growth and in achieving sustainable development goals (Quddus 2018; Datta et al. 2024). A stable jute acreage coupled with higher production highlights yield efficiency improvements, bringing economic equilibrium to jute-producing areas. Better yield from unchanged cultivable land implies a possibility of significant economic gain, rendering valuable information to inform agricultural policy in sustainable jute production. The evidence validates excellent growth prospects for Bangladesh's jute sector, cementing its place as a valuable economic resource. The industry's future and stability are policymaking, food security enhancement, and economic development strategic pillars of Bangladesh (Hossain and Abdulla 2015).

5. CONCLUSION

The detailed analysis of the 53-year trends in jute cultivation in Bangladesh highlights deep regional disparities and the dynamic trend of agricultural production under economic, environmental, and policy-related factors. Despite stable geographical coverage, the dramatic increase in production efficiency is evidence of the success of intensified agricultural practice and perhaps the utilization of high-yielding jute varieties. The long-term viability of the jute sector is evidenced in the promising growth forecasts, foretelling a bright future brought about by technological advancement and aggressive government support. Regions that have seen declines in jute cultivation identify issues caused by urbanization and industrialization and refer to the need for balanced regional development policies safeguarding agricultural interests. The future constant growth in jute production until 2032 illustrates a bright future for the sector, which is a lifeline to economic stability and the livelihood of tens of millions of rural Bangladeshis. This study traces the past trend of jute cultivation and foresees a bright future, demanding unrelenting support and innovation in Bangladesh's agricultural practice. By aligning future agricultural policies with the insights provided by this extensive data analysis, Bangladesh can ensure the sustained growth and global competitiveness of its jute industry.

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Data Availability: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author's Contribution: All the authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Md. Moniruzzaman Hasan and Md. Ariful Islam. The first draft of the manuscript was written by Md. Moniruzzaman Hasan and Md. Ariful Islam. All the authors commented on the draft version of the manuscript and read and approved the final manuscript.

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