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Dynamics of Betel Leaf Production in Bangladesh: Trends, Challenges, and Market Integration

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Abstract

Betel leaf (Piper betel) is an important commercial crop in Bangladesh for local consume as well as for the export market. This research examines the pattern, associations and profitability of betel leaf production on an updated basis with a quantitative research design and secondary data sourced from the Bangladesh Bureau of Statistics. To account for the cyclical variation of production and prices, the Cobweb Theory of economic sequence was used as a frame work. The data were analyzed using descriptive statistics, trend analysis, correlation, and regression. The findings indicate that the production and cultivation area of betel leaf are cyclical patterned, following the Cobweb theory, with an increase of production in a certain time, then decreased price and then the subsequent reduction of production. Relations between production and wholesale price presented a strong negative significant correlation, thus, as production increased, wholesale price decreased, though farmers profitability depended more on increased production. The regression analysis showed that there was no strong relation between profitability, production, and crop area. Regional analysis indicated differences in cultivation and production trends between divisions. The results indicate that betel leaf growers face challenges created by price increases, excessive supply, under-demand, and market and production uncertainties brought by natural disasters, pests and instability/carnage in market. The provision of access to market, stabilize price and regional support to farmers could reduce the uncertainties affecting the betel leaf industry in Bangladesh and provide pathways for growth.

Key Words: Betel Leaf Production, Cobweb Theory, Farmer Profitability, Market Dynamics, Regional Cultivation Trends

1. Introduction

Betel leaf (Piper betel) also known as paan occupies a significant position in the agriculture of South Asia as well as Bangladesh, where betel leaf serves as one of the vital cash crop and source of livelihood of a large number of farmers around Bangladesh. The socio-economic significance of betel leaf goes further by contributing to not only domestic consumption but also contribute to export market, making it rural and national agricultural contributor. But, in recent years there has notable changes in the production pattern, price dynamics and distribution across the nation which leads to depth examination to guide policy and support agricultural development.

Agronomic, economic and environmental factors influence the production and performance of the betel leaf cultivation. Previous study reveals upward trajectory of betel leaf cultivation over the years which happened by expanding areas for cultivation and improved agronomic practices(Haider et al., 2013). However, in recent times the uprising growth has not stayed the same or linear because of the fluctuating patterns in production and cultivated lands caused by climate variability, pest attacks and socio-economic disparities. Understanding these recent trends between betel leaf production and price is crucial to face the emerging challenges such as climate change and labor shortage that affect the sector's sustainability (Upoma et al., 2024). Price behavior in agro-market, notably betel leaf, is influenced by the relation of supply and demand factors that is affected by market inefficiencies, availability and the complex production system(Mahfuza et al., 2023). Bangladesh have experienced demand pressure in recent years influenced by the domestic demand and increased export opportunities despite the fluctuating production levels. Thus, Given the crop's intensive character for cultivation, enormous labor and time bring into question whether farmer's profitability is sustained or strengthened (Barrett et al., 2012).

A vital are and topic of research is the correlation between betel leaf's production and farmer profitability while higher production theoretically increase farmer's incomes but the real-world scenario is obscured due to price volatility, cost ineffective and uneven market condition. Previous studies indicate, profitability in cash crops with similar traits is frequently reduced whenever supply surges drop prices or market inefficiencies limits farmer's income. Investigating this complexity in betel leaf production is crucial for Bangladesh to identify the challenges and potentiality(Jahan & Islam, 2024; Mahfuza et al., 2023; Upoma et al., 2024).

This study is a comprehensive three-part examination of the betel leaf industry of Bangladesh. It starts with an analysis of production volumes and market prices during a recent 15-year period in order to highlight major trends and patterns. Secondly the study highlights whether increased farm production leads into improved farmer incomes, examining the correlation between productivity and profitability in the present market reality. Finally, it contrasts growth in practices and output by regions to show regional divergences, to address and give suggestions on regionally specific policies that address regional needs and opportunities in the sector.

The study employs descriptive statistics, correlation, and regression analysis to estimate land use, production, price, and profitability. The findings contribute to a better understanding of the relationship between production, pricing, and profitability in betel leaf agriculture, which has substantial socioeconomic implications and needs further research. Furthermore, the findings provide policy-relevant recommendations to improve the livelihoods of betel leaf farmers while promoting sustainable sector development in Bangladesh. The study connects empirical results to theoretical frameworks in economics by incorporating this analysis within the framework of agricultural market behavior theories, such as the Cobweb Theorem (which explains the cyclical adjustments of supply and price in agriculture). This theoretical foundation supports interpretations of observed fluctuations as it helps in developing methods to minimize fluctuations and improve stability. Due to the growing demand for betel leaf in Bangladesh and the crop's enormous export potential, it is critical to understand production trends, farmer profitability, and regional differences. Intervention on these dimensions will inform policymakers

while also fostering dialogue on the development of betel leaf value chains, enabling environmental and climate resilient agro-based practices, and protecting farmer incomes and long-term livelihoods(Barrett et al., 2012).

2. Literature review

2.1 Overview of the Betel Leaf Industry and Supply Chain in Bangladesh

Betel leaf (Piper betle L.) is acknowledged as a significant cash crop in Bangladesh, possessing both cultural and economic importance (Mahfuza, Sayem, & Hassan, 2020). In 2012–2013, the national betel leaf area was 22,413 hectares and produced 136,284 metric tons. This was a 3.06% increase from 1991 to 2013 (Islam & Matin, 2017). More recent estimates show that cultivation is steadily increasing. In 2016–17, almost 23,876 hectares were under cultivation, generating almost 214,000 metric tons (BBS, 2017). This growth is in line with an increase in production that meets both domestic and foreign demands, especially from countries like India, Saudi Arabia, and the United Arab Emirates (Banglapedia, 2015; Mahfuza et al., 2020). Bangladesh is one of the main producers of this crop in South Asia (BBS, 2017). It grows well in tropical conditions and is produced a lot in places like Bagerhat, Khulna, Jessore, Rajshahi, and Sylhet.

The structure of the supply chain and marketing is complicated and has a big effect on how much money farmers make. Intermediaries control the marketing chain, which means that manufacturers get substantially lower pricing than merchants do (Zabir et al., 2019). Farmers usually depend on middlemen to auction leaves, which means they can't sell them directly. This limits their market power and affects how profits are shared (Schütte & Kreutzmann, 2015). Studies show that market intermediaries are a big problem and that there aren't many organized markets. This means that more production may not mean more profit for farmers, since most of the profits go to the middlemen (Hasan Banu & Princy, 2019). Because betel leaves spoil quickly and there aren't any places to store them, they have to be sold right away at the current prices. This sometimes leads to distress selling and price fluctuations (Hasan Banu & Princy, 2019; Sahoo & Sahoo, 2018). Bangladesh mainly exports betel leaves to India, Saudi Arabia, the UAE, and a few European countries (Banglapedia, 2015). The demand for betel leaves has increased among diaspora communities all over the world and the growing recognition of its medicinal values and acceptance as a cultural element have opened up new markets for exports (Mahfuza et al., 2020). But there are certain problems that make it hard to produce and export. For example, poor quality control, perishability after harvest, and not enough transportation options (Mahfuza et al., 2020). Despite of these problems, the growth of local markets and the possibility of adding value to various items like pan masala and medicinal products could increase both domestic profits and exports (Mahfuza et al., 2020).

2.2 Production Trends and Determinants of Betel Leaf Cultivation

Production trends over the last three decades indicate robust growth. Analyses using 29 years of time-series data forecast production growth up to 296,217 metric tons by 2023 (Mahfuza et al., 2020). This rise occurred due to some factors such as increased farmer interest, favorable climatic conditions in districts like Rajshahi, and higher demand in domestic and international markets (Mahfuza et al., 2020). The Sylhet region is known for its fertile soil and good weather for growing crops. The region is a major producer of betel leaves, which make up a large part of the country's total output (BBS, 2023; Upoma, Mazumder, Monshi, Mouri, & Alam, 2024). In several study sites, the amount of yield was noticed to be higher than the national average. The highest yield was 9.44 t/ha from four-year-old boroj (Islam & Matin, 2017).

But some factors such as agronomy, socio-economic condition and infrastructure have a big impact on production level. Research involving ANCOVA and stepwise regression analysis highlights critical factors that influence betel leaf yield. These factors are access to irrigation, farmer training, marketing agreements, the amount of organic fertilizer (cow dung) that is used and farm size (Upoma et al., 2024). Access to irrigation and training significantly improves production (Upoma et al., 2024). The crop requires a large amount of investment at first, mainly due to the high cost of building baroj (Dey, Sharma,

Gautam, Swain, & Singh, 2022). Input cost sensitivity tests show that labor, fertilizer, pesticide, and selling-distribution costs greatly affect output, but irrigation had minimal impact (Sabur et al., 2022). The results showed that returns to scale were getting bigger, which means that better cost management might make the business more profitable (Sabur et al., 2022).

There are a number of factors that are responsible for limiting the crop's output. Too much rain during the busiest times of the year can cause diseases like leaf and root rot, which have a direct effect on output (Upoma et al., 2024). Also, post-harvest losses are caused by a lack of good planting materials, restricted extension services, lack of loans and workers as well as bad storage and transportation facilities (Upoma et al., 2024). Farmers encounter significant production difficulties in various forms, such as the scarcity of skilled labor, degradation of soil, natural disasters, and pest infestations (Sahoo & Sahoo, 2018). These issues make it harder for the farmers to gain the most output and export potential (Islam & Matin, 2017). So, even if betel leaf production output in Bangladesh has been going up and is likely to keep going up, it is important to deal with these structural problems in order to keep production growth going (Mahfuza et al., 2020). That greater cost management could make profits increase significantly (Sabur et al., 2022).

2.3 Price Dynamics, Market Integration, and Farmer Profitability

The relation between production and farmers' profits is a complicated one. It is affected by big changes in prices and various problems in the market. There is a strong positive link between production and pricing, which means that more production usually means higher price hence higher farmer income (Mahfuza et al., 2020). But, big changes in price in different seasons the year can have a big effect on how profitable a business is. From December to March the market price of betel leaves are at their highest. On the other hand, the prices drop significantly during the monsoon season when there is more supply than demand (Mahfuza et al., 2020; Islam & Matin, 2017). Because there is too much of the product available and not enough storage space to store them without perishability. This causes the prices to fall a lot from winter to summer (Chandra & Sagar, 2004). This unpredictability, along with a lack of regulated markets as well as bad infrastructure, makes it hard for the farmers to market their produce, Resulting in poorer levels of profit (Chandra & Sagar, 2004; Sahoo & Sahoo, 2018).

Betel leaf farming was proven to be profitable in the long run, although it demands high costs at the start. It can be seen that in the first and second years of setting up a boroj, the benefit-cost ratios (BCR) were usually less than one, mostly because of the increased cost of setting up the business. However, from the third year onwards, the business is known to become much more profitable (Islam & Matin, 2017). The fourth year had the best returns, with a BCR of 1.50, a net present value of Tk. 1,168,864/ha, and an internal rate of return of 59%, which is much higher than the cost of capital (Islam & Matin, 2017). Some other works regarding this topic showed that BCRs were between 1.24 and 1.62. In this scenario the best returns were gained in the second to fourth years of starting the business (Zabir et al., 2019). Sensitivity study verified that cultivation continued to be profitable despite lower profits or increased costs, indicating the enterprise's relative resilience (Islam & Matin, 2017).

Despite the farmers having higher gross margins, the amount of money they receive is still much lower compared to the retail price that the consumers pay. The reason behind this disparity is mostly the grasp of the middlemen over the supply chain (Zabir et al., 2019). It is usually the retailers who frequently obtain the greatest profit margin, decreasing the net profit for producers (Zabir et al., 2019). The effectiveness of the market differs from channel to channel. For example, a channel with fewer middlemen provides the producers with a greater percentage of the consumer's money (Duduskar, 2022; Dey et al., 2022). Furthermore, the farmers have to deal with various kinds of challenges, such as changing prices, high transportation costs, a shortage of storage facilities, and the fact that middlemen take a lot of their profits (Duduskar, 2022; Sahoo & Sahoo, 2018). This indicates that while production might have increased but farmers' actual economic benefits are constrained by inefficient markets and inequality profit distributions (Hasan Banu & Princy, 2019). Therefore, profitability is heavily

influenced by the ability to reduce losses, enhance quality, and improve market access for both domestic and export markets (Mazumder, Roychowdhury, & Banerjee, 2016).

2.4 Regional Distribution and Comparative Analysis of Betel Leaf Cultivation

Betel leaf cultivation scenario varies vastly across different regions of Bangladesh. It is mostly done in areas with favorable climatic and logistic conditions and there are big differences between regions. The production is the highest in regions like Rajshahi, Khulna, Jhenaidah, Kushtia, Sylhet, and Chittagong (Guha, 2006; BBS, 2017). Regionally, production differs across divisions due to various land types, cultivation methods (such as bareja and open system) and market accessibility (Zabir et al., 2019). For example, farmers in Bagerhat district depend a lot on betel leaf for their livelihoods, yet their yields per hectare are still lower than the national average (Zabir et al., 2019). Farmers in Rajshahi had to use more water for irrigation because of its hotter climatic conditions compared to other regions of Bangladesh, while farmers in other districts had different amounts of inputs and returns (Islam et al., 2015).

A study in the Sylhet region highlighted its prominence due to fertile soils and suitable agro-climatic conditions (Upoma et al., 2024). Research in areas like Noakhali, Rajbari, and Khulna showed that yield levels were higher than national averages in these study sites (Islam & Matin, 2017). In the Kushtia-Jhenaidah region, input cost sensitivity was a key focus, revealing regional-specific factors affecting productivity (Sabur et al., 2022). The literature shows that regional disparities highlight the need for comparative analysis to understand profitability across divisions (Zabir et al., 2019). Variations in land quality, cultivation systems and access to markets and infrastructure are some of the reasons that are primarily responsible for the different conditions in different regions. (Zabir et al., 2019).

The challenges also come up differently by region. While disease and price volatility are universal constraints, some areas may face more severe issues with irrigation (e.g., Rajshahi), while others might be more vulnerable to waterlogging or have less access to major marketing channels (Islam et al., 2015). Analyzing production trends, profitability, and regional variations offers insights for policy aimed at ensuring fair pricing and sustainable market development (Zabir et al., 2019). The sector's future depends on addressing regional production limitations, improving storage and market access, and stabilizing prices to enhance farmer returns and export potential across all major cultivating regions (Chandra & Sagar, 2004).

3. Development of Hypothesis

Economist have long history to use the Cobweb Theory to examine the dynamic connection between production, pricing and and profitability in agricultural market. The Cobweb theory based on the initial work of Ezekiel(Ezekiel, 1938) and later developed by Kaldor and others (Kaldor, 1934). The theory gives us the notion where production decision lag behind price observation, this theory describes how producer set her decision based on previous year prices(Ezekiel, 1938; Kaldor, 1934). Several previous studies showed that the Cobweb theory described price and output changes for various crops(Allen, 1959; Gori et al., 2015; Gouel, 2012). Through understudied, betel leaf has similar motion that making the Cobweb theory important.

H1: The production of betel leaves and market prices demonstrate cyclical patterns that correspond with Cobweb theory marked by several stages of rising productions followed by price decline and production reduction followed by price inflation.

H2: Rising betel leaves production do not directly enhance farmer profitability due to price reductions caused by supply-demand disparities. Domestic price volatility caused by the cobweb effect.

4. Methodology

4.1 Research Design

The present study is based on a quantitative research design with an emphasis on statistical analysis of secondary data from "Yearbooks of Agricultural Statistics" published by the Bangladesh Bureau of Statistics (BBS). Since the purpose is to understand recent trends, relationships, and profitability in betel leaf production, a time-series and correlational approach was adopted. The Cobweb Theory of agricultural markets was selected as the guiding theoretical framework because it explains how cyclical fluctuations in agricultural production and prices occur due to the delayed response of farmers to previous price signals.

4.2 Data Sources and Collection

This study is based on fully secondary data from BBS data official source including Yearbooks of Agricultural Statistics. The datasets cover 15 yearn agricultural data of production, price and total cultivation area from 2009-10 to 2023-24. We input the data into dataset using SPSS 26 and Microsoft Excel to look at trends.

4.3 Variables of the Study

The research considered multiple variables categorized as follows by Production-related variables (National and Domestic) such as Production (Metric Ton), Area of production (Acres) and Yield per acre (kg). Price and Profitability variables such as Average wholesale price (Large, Medium, Small categories), Average retail price (Large, Medium, Small categories), Harvest time market price and Profitability index. External factors such as Production losses due to natural calamities (Metric Ton)

4.4 Statistical analysis

In this study, used SPSS 26 and Microsoft Excel for data analyze and visualization. The three objectives of the study were followed by the organizing of the analysis. This study used descriptive statistic to analyze trends, correlations and profitability in betel leaves cultivation in Bangladesh. Descriptive analysis, including mean, standard deviation, minimum and maximum, used to compute statistical summary of production, price and yield area. To analyze the recent trends which were represented in the line graph against year (X-axis) to visualize the fluctuations and growth trends. Similerly followed price and domestic trends of betel leaves production. Correlations were analyzed among production, wholesale price, and profitability to assess the relationship between increased production and farmer income. Significance levels (p-values) were employed to assess the statistical significance of relationships. A regression model was created using profitability as the dependent variable and production and crop area as independent factors, including R, R^2 and Adjusted R^2 along with ANOVA test and coefficients.

5. Result and Discussion

The descriptive statistics give an overview of betel leaf production and productivity over last 15 years (2009-10 to 2023-24). The average cultivation area was 54,380.50 acres where the minimum cultivate area was 44,141.00 acres and maximum area was 59,415.00 acres. The standard deviation range of 4328.05 acres, which indicated that the land use changes slightly from year to year. The average production of betel leaf was 190,617.14 metric tons with significant range SD= 51,452.73matric tons. The per acre production was 3,273.92 kg, where the minimum range was 2,030.00 kg and maximus was 3,907.00 kg.

Statistic	Area of Crop Production (acres)	Production (Metric Ton)	Per Acre Yield (kg)
Mean	54,380.50	190,617.14	3,273.92
Std. Deviation	4,328.05	51,452.73	683.46
Minimum	44,141.00	91,681.00	2,030.00
Maximum	59,415.00	296,993.00	3,907.00

Table 1: Descriptive Statistics of Betel Leaf Production

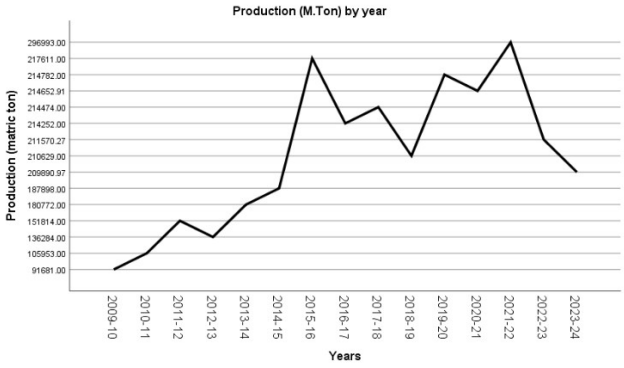

Figure 1. Production flow of betel Leaf.

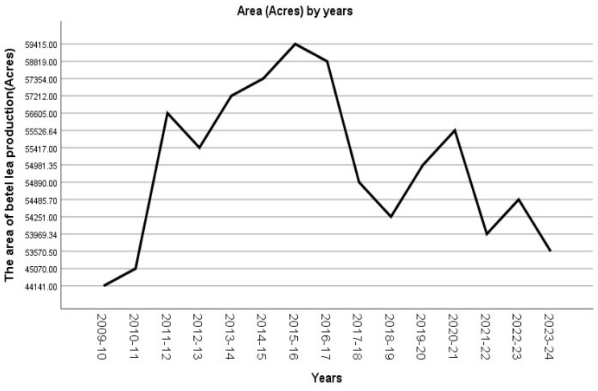

Figure 2. Cultivation flow of betel leaf.

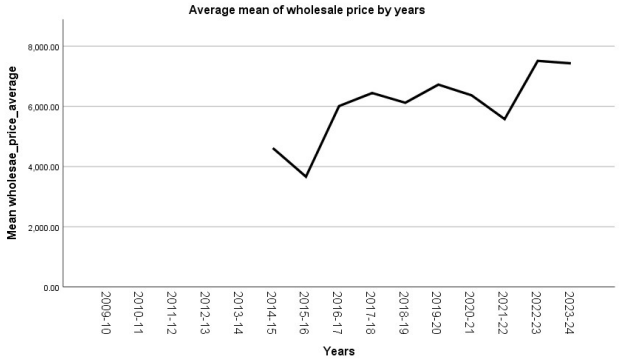

Figure 3. Price flow of betel leaf

In 2009-10 to 2015-16, the trend of betel leaf production reflects a consistent rise where the trend was dramatic peak in 2015-16, the output reached its highest growth level. Following that, the trend showed unstable nature which characterized by fluctuations. Significant decline was observed in 2018-19 and 2023-24. However, the apex of production was reached in 2021-22, signifying a substantial production rise. Despite this, following the 2021-22 period and the downward trend remains into 2023-24, indicating current difficulties in betel leaf cultivation. (Figure 1.)

Following that, the trend flow of betel leaf cultivates area shows unstable behavior with fluctuation. Significant decreases were observed in 2018-19 and 2023-24. However, the highest trend was reached in 2021-22. The decline trend from 2021-22 to 2023-24 was evaluated that's indicate continued production challenges. (Figure 2.)

In contrast to production and area of cultivation, the wholesale price demonstrates a consistently increasing pattern over the years. Following early volatility, prices increased gradually before reaching their highest point in 2022–2023. From 2013-14 and 2014-15 showed a decline pattern. The increase in pricing indicates that market demand has remained and surprising supply in recent years. (Figure 3.)

Both production and Area of cultivation follow a similar pattern which indicates rapid growth up to 2015–16, peak in mid-decade, followed by fluctuations and a recent decline. Nevertheless, wholesale Price opposite to production and cultivation area, where average wholesale prices have been steadily going up trend. This pattern indicates that strong demand and possibly lower supply. The contrast between price and production as well as area of betel leaf cultivation indicates supply constraints and profitability difficulties that may affect farmer decision and sustainability.

Variables	**Production**	**Wholesale Price**	**Profitability**
Production (Metric Ton)	1	-0.829 (p = 0.083)	-0.264 (p = 0.668)
Wholesale Price (Average)	-0.829 (p = 0.083)	1	0.096 (p = 0.878)
Profitability	-0.264 (p = 0.668)	0.096 (p = 0.878)	1

Table 2. Correlation Matrix between Production, Price, and Profitability

The correlation analysis reveals that the rising production trends that push down wholesale price which did not significantly increased farmer profitability. This statement suggested that betel leaf farmers were at risk to price fluctuations and imbalance in the market. (Table 2.)

Model Summary	**R**	**R^2**	**Adjusted R^2**	**Std. Error of Estimate**
Model 1	0.618	0.382	-0.236	751.45477

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Regression	698125.224	2	349062.612	0.618	0.618
Residual	1129368.553	2	564684.277		
Total	1827493.778	4			
Coefficients	**B (Unstandardized)**	**Std. Error**	**Beta (Standardized)**	**t**	**Sig.**
Constant	-27705.275	28811.202	–	-0.962	0.438
Production (Metric Ton)	-0.001	0.011	-0.064	-0.108	0.924
Crop Area (000 Acres)	0.515	0.512	0.594	1.006	0.420

Table 3. Regression Analysis of Profit on Production and Crop Area

The multiple regression analysis evaluated that the correlation between betel leaf cultivation area and production. The analysis showed that R value of 0.618 that demonstrated a moderate level of relationship between the predictors and dependent variable. The R^2 value was 0.382 and adjusted R^2 was -0.236. The standard error of the estimate was 751.45, indicating the mean departure of the observed value from the expected value.

The ANOVA test was employed to evaluate the overall significance of the regression model. The regression of the sum of square was 698125.224 with 2 degrees of freedom. The residual sum of square was 1129368.553, with again 2 degrees of freedom. The mean square for regression was 349062.612. The results suggesting that the regression model lacks statistical significance at standard thresholds($p<0.05$). On the other hand, the coefficients table showed that how each predictor affects dependent variables. The coefficient result was 0.515, indicating that positive relationship with dependent variable. However, it was not statistically significant ($t=1.006$, $p=0.420$). (Table 3.)

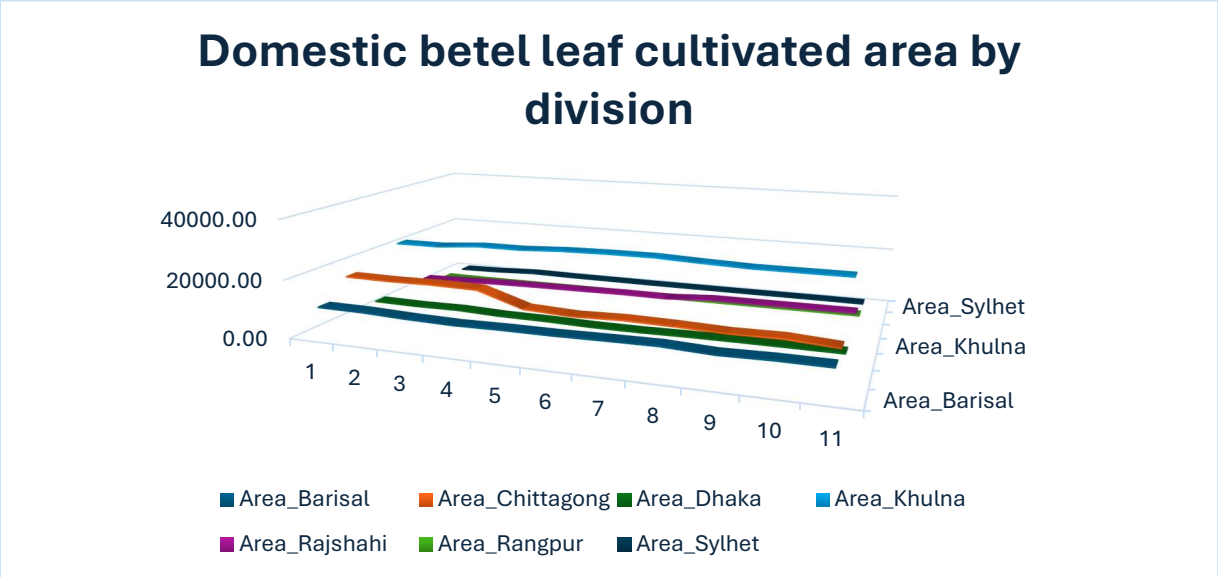

Figure 4. Domestic betel leaf cultivated area by division

The line chart showed that the cultivated area across different division in Bangladesh from 2013-14(labeled as 1) to 2023-24(labeled as 11). In the line chart, Barisal started with a high cultivated area around 25000 acres and gradually declined over the time, ending near 20000 acres. Following, Chittagong started around 15000 acres and then drop to approximately 5000 acres by 2023-24. Dhaka begins near 10000 and steadily declines to around 5000.Khulna was relatively consistent, begging and finishing at 20000 with slight. Others were following, begins with large area yet finishing at decline. (Figure 4.)

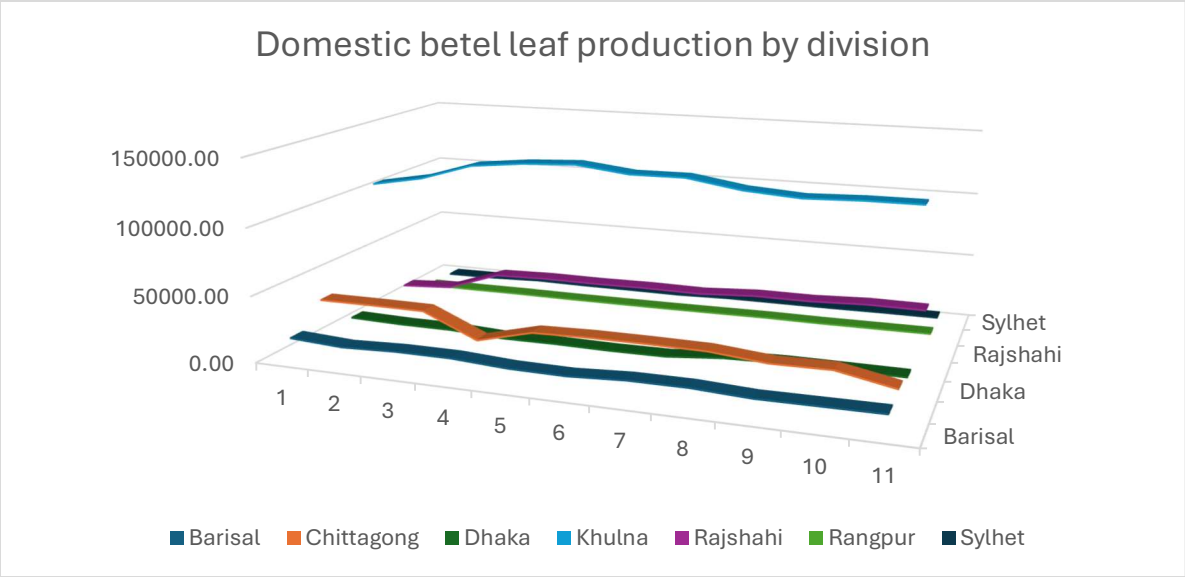

Figure 5. Domestic betel leaf production by division

The second chart line presented that betel leaf production trends in seven division. Production was measured in units metric tons. The graphic "Domestic Production of Betel Leaf by Division" presents betel leaf production trends in seven divisions—Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur, and Sylhet—over a 14-year period from 2013-14 (labeled as 1) to 2023-24 (labeled as 11).

Barisal had the highest beginning production outputs of nearly 12000 metric tons, somewhat mid period decline production growth. Demonstrating a very stable but decreasing tendency. Same flow followed by Chittagong, Dhaka, Rajshahi, Rangpur and Sylhet. On the other hand, Khulna remained stable with production throughout time with little changes observed. (Figure 5.)

The empirical results from Bangladesh's 15-year trend analysis of betel leaf cultivation yield an established yet complicated comprehension of the dynamics of agricultural markets. The descriptive statistics show that this sector is very unstable. The average yield is 3,273 kg/acre, with a range of 2,030 to 3,907 kg/acre, and the average production is 190,617 metric tons, with a standard deviation of 51,453 metric tons. This means that the industry changes a lot from year to year. So, this underlying instability makes it easier to use the Cobweb Theorem (Ezekiel, 1938; Kaldor, 1934), which says that cyclical delays in production decisions based on past prices cause cyclical changes in output and market price. The graphical patterns (Figures 1 and 2) and the correlation analysis (Table 2) give strong visual and statistical support for the first hypothesis (H1). The Cobweb Theorem says that the price and production of betel leaves follow a pattern that repeats itself. The predictions made by the theorem and the patterns that were seen are very similar. There is a "steady increase" in production from 2009–

10 to 2015–16, which leads to a "significant culmination." The cobweb model says that the rise in output was probably a response to higher prices in the past. This success set the stage for failure. By 2015–16, the market had grown so much that there was too much betel leaf. The next phase shows the cobweb effect, which is "unstable nature marked by fluctuations." The lower prices from the previous surplus (2016–17) discouraged farmers, which led to a decrease in both the area they farmed and the amount they produced. This "significant decline" in 2018–19 is the lowest point in the cycle. Prices went up because there wasn't enough of something, which led to more production, which led to the peak in 2021–2022. The overall declined trend from 2023-24 shows the pattern that occurred over and over throughout the years where excessive production of betel leaf in 2021-22 once again declined the market prices and discouraged farmers to cultivate betel leaf. The strong negative correlation ($r = -0.829$, $p = 0.083$) between output and wholesale pricing indicates the cobweb dynamics statistically. The p-value which is above 0.05 level indicates a significant trend that is essential for the economy and fits well with the theoretical expectation of a negative correlation in a cobweb cycle.

The descriptive statistical analysis shows crop production expanding in 2015-16 and 2021-22 and drops in 2018-19 and 2023-24. This demonstrates the betel leaf farming sector is having difficulties where the possible reasons can be natural calamities such as cyclone, excessive rainfall, drought as well as flood and climate change. Regardless of natural calamities changing crop pattern, pests and diseases and market uncertainty around prices can be the reasons creating difficulties in this farming sector. The standard deviation)51,452.73 metric tons) shows that production can change a lot from year to year, affecting farmer's livelihood and income stability. The land in the cultivated area is quite similar to the trend in production displaying big drops in some years, demonstrating to farmer's behavioral pattern regarding their land use where they cultivate based on projected returns and external shocks, Also, the geographical split shows that Barisal consists the most cultivated land for Betel leaf production but it has shrunk over time just as other regional areas such as Chittagong and Dhaka(Mahfuza et al., 2023; Sabur et al., 2022). On the other hand, cultivated area of Khulna stayed same over the period that create the idea that regional agro-climatic conditions, farmer preferences or market situations are different.

Even the amount of betel leaf cultivation and production has changed over the years, the average wholesale price keeps rising up such as prices went up from 2013-14 to 2022-23 with highest possibility of wholesale prices in latter year. The growing wholesale prices are different from the unstable production and declined area, suggesting a probable supply shortage or higher demand pressure in the national market. It can be predicted that even the price surge despite the unstable production, the supply side is facing difficulties to keep up with the demand growth. Also, betel leaf cultivation is expensive and time consuming which takes a lot of work and effort to grow, makes it hard to quickly keep up with the overwhelming demand that can lead to price fall. Overall, the continuous price surge indicates the market is constrained, leading to the idea that farmers may get better prices but they additionally manage the risk of not being able to meet the demand, leading to lower output in production.

Thus, the overall analysis suggests that betel leaf production faces tremendous and varieties of challenges, specifically, Fluctuating production levels and shrinking cultivated area indicate that farmer adapt to changing returns, fragile nature of betel leaves restricts storage and limiting bargaining strengths, Labor shortage or increased labor prices are significantly short due to the intensive nature for cultivating betel leaf and lastly, environmental factors such as rainfall patterns and betel leaf being the pest infestation prone variety can cause production uncertainty.

6.Limitation of study

The study used secondary data from the Bangladesh Bureau of Statistics' (BBS) "Yearbooks of Agricultural Statistics" from 2009–10 to 2023–24. The accuracy of the data may be impacted by reporting errors, inconsistent measurements, or missing information because it was derived from secondary official documents. The study primarily evaluate production, cultivated

area, wholesale price and profitability, yet other significant variable such as costs, climate events, technological adaptation, labor availability were not considered in our study.

7. Conclusion

Betel leaf farming in Bangladesh is significant for the country's culture, economy and agriculture, but it also has many problems. The time series data reveal that production has fluctuated rapidly and show the unpredictability of this crop. Large production in 2015–16 and 2021–22 but large declines in 2018–19 and 2023–24 indicate the sector's susceptibility to external shocks and issues with the domestic market. These cyclical patterns support the Cobweb Theory, the idea that farmers frequently decide what to grow based on what prices already were, making output (as well as farmer income) erratic. When prices are falling, producing more stuff doesn't necessarily mean farmers make more money. The negative correlation between production and pricing illustrates how more supply leads to less market price, and less net revenue returns to farmers. Though wholesale prices generally rise over time, it is retailers who are the biggest earners, so the gains of the supply chain are not distributed equally. Farmers are not able to negotiate as well or make as much money because of this inherent imbalance, high input costs. Khulna is producing well regarding betel leaf cultivation, but other divisions are struggling and that creates problems for production. Local initiatives as much as national ones can change the outcome of the agriculture of betel leaf such as water availability, climate adaptation, interconnection to markets. This crop is susceptible to environmental and socio-economic related stresses, including labor deficit, pest attacks, natural calamities, and postharvest losses. Finally, the demand for betel leaf in Bangladesh is increasing with a less profitable and volatile supply. For growth to be sustainable, the problems with the marketing system need fixing; it must be made more resilient to dramatic environmental shocks, and a regional market for crops must connect the villages to the cities. With the right policies and institutional support in place, the sector has the potential to develop rural livelihoods and could form part of national and export-oriented agriculture.

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