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TREND OF BETEL LEAF PRODUCTION IN BANGLADESH: PROSPECTS AND CHALLENGES

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ABSTRACT

Betel leaf is one of the important cash crops that gaining popularity in recent time in Bangladesh. This study was conducted to identify the present and future production pattern of betel leaf in Bangladesh as well as its prospects and challenges. Secondary data of 29 years from 1991 to 2019 have been used to specify the production pattern and forecasting of betel leaf at national level by using deterministic, stochastic and dynamic time series model. While the primary data were collected from three sub-districts of the Rajshahi district namely Bagmara, Durgapur and Mohanpur to identify the prospects and challenges through SWOT analysis. This study found significant relationship among betel leaf production, price and annual average temperature of Bangladesh. A total of six growth models of different types were used for forecasting production, cultivation area, and price of betel leaf. Based on the model selection criteria cubic model, quadratic model, and growth model were chosen for initial forecasting of betel leaves production, cultivation area, and price respectively. Among the stochastic model auto regressive integrated moving average ARIMA (0, 1, 0) was fitted well to forecast the production. Finally, a dynamic regression model of ARIMA (1, 1, 0) with dynamic regressors has been used to forecast the production of betel leaf from 2020 to 2023. Forecast values range minimum 202770.41 tons to 296217.14 tons with 95% confidence interval. All the best-fitted models revealed that the production of betel leaf has an upward trend in the future. At the end SWOT analysis was implemented to identify the strengths, weakness, opportunities and threats involved in betel leaf farming which will be helpful for making future national level policy options. Diseases control at the betel leaf garden and access to credit for initial investments were identified as the major challenges for this enterprise.

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INTRODUCTION

A crop produced for its commercial value rather than for use by the grower is known as cash crop. The well-known cash crops of Bangladesh are tobacco, jute, tea, sugarcane, cotton, etc. But there are some other cash crops like betel leaf which are not in the spotlight like the traditionally known ones. Betel leaf is the leaf of a vine, scientifically named as *Piper betel* belonging to the *Piperaceae* family includes pepper and kava (Megagroup bd, 2018; Karim, 2015). This betel plant was originated in South and Southeast Asia. It is locally known as ‘Pan’ in Bangladesh and one of the vital cash crops of this country, where millions of people chew the item regularly. It is consumed mostly as betel quid which contains betel leaf, areca nut, and slaked lime (WHO, 1998). About 30% of adults chew betel quid in Bangladesh and the world context it is approximately 10-20% (Gupta and Warnakulasuriya 2002, Flora et al. 2012). In the daily life of people, betel leaf has possessed a special place in our literature, song, society, and culture. It is inconceivable to have any social function without serving betel leaf particularly in rural Bangladesh where 80% of the population lives. Apart from socio-cultural and ceremonial importance, it has the property of antacid, carminative, and tranquilizer which helps in digestion, removes the bad smell of the mouth, improves taste and appetite, and strengthens the teeth (Islam et al. 2015).

Betel leaf has been under cultivation in Bangladesh for centuries. It is produced almost in all parts of Bangladesh, but districts like, Cox’s Bazar, Chittagong, Greater Khulna, Greater Barisal, Greater Faridpur, Greater Rajshahi are remarkable for its production. Some parts of Rajshahi especially Bagmara, Durgapur, and Mohanpur Upazila are famous for its production. Now a days farmer are now showing more interest in betel leaf cultivation consequently betel leaf cultivation area also raised. Figure 1 illustrates the time series plot of production in metric ton (MT) and cultivation area in hectare (ha) of betel leaf in Bangladesh from the year 1991 to the year 2019. This figure indicates that the production of betel leaf showed a steady but significant rise until 2011. After that it dramatically increased and in 2016 it was highest for all twenty-seven years then experienced a little downward trend. Though an overall increase of production over the years there was a sudden increase and sudden decrease in actual production. Betel leaf cultivation area was also followed an increasing trend with some exceptions meantime.

Being a cash crop, betel leaf plays an important role in the economy and livelihood of many people in Bangladesh including the people of the selected research area. Lots of people are engaged in betel leaf production in the Northern part of Bangladesh. The production and price of betel leaf have a great impact on their livelihood as well. For high quality and flavor, betel leaf has a broad market demand and Bangladesh is exporting quality betel leaves in many countries of Asia and Europe. The leading exporting country of betel leaves is India, Saudia Arabia, Pakistan, United Arab Emirates, England, Germany, and Italy (Banglapedia, 2015). Despite being a commercially viable crop and substantial-high market potentialities in both domestic and foreign market, there are very few works so far have been done on betel leaf farming in Bangladesh. Among these (Islam and Matin, 2017) have studied on the benefit and cost of betel leaf and (Mridha et al. 2005) and tried to identify the influence of production inputs to the return of betel leaf. However, there is no such research has been conducted to investigate the present and future production of betel leaf in Bangladesh. To meet the increased demand for food over the years mostly research, technologies have focused mainly on annual crops rather than the perennial crops. But being the perennial crop, betel leaf has a high demand and market value, especially for Asian people. So forecasting betel leaf production and prices will be truly beneficial for farmers, governments, and agribusiness industries to understand its future potentialities and growth. Farmer’s decision and judgment about further investment in this farming can be influenced by the forecasts. Based on the forecasting result, the Government can execute its policies and programs to provide technical and market support, and incentives for this sector. On the other hand, not only the farmers and government, traders, and processors who deal with farm products give more attention to agricultural forecasting than do farmers. They take into account not only the available production but the probable future production of the betel leaf which may be forthcoming. So this study can extremely help them to understand the future production, and prospects and challenges for the betel leaf and improve their marketing strategies accordingly. Besides, no empirical research has been done to identify the prospects and challenges of betel leaf cultivation using SWOT analysis. Considering the above mentioned research gap this study has tried to identify the present and future production pattern of betel leaf in Bangladesh and investigate the prospects and challenges of betel leaf cultivation.

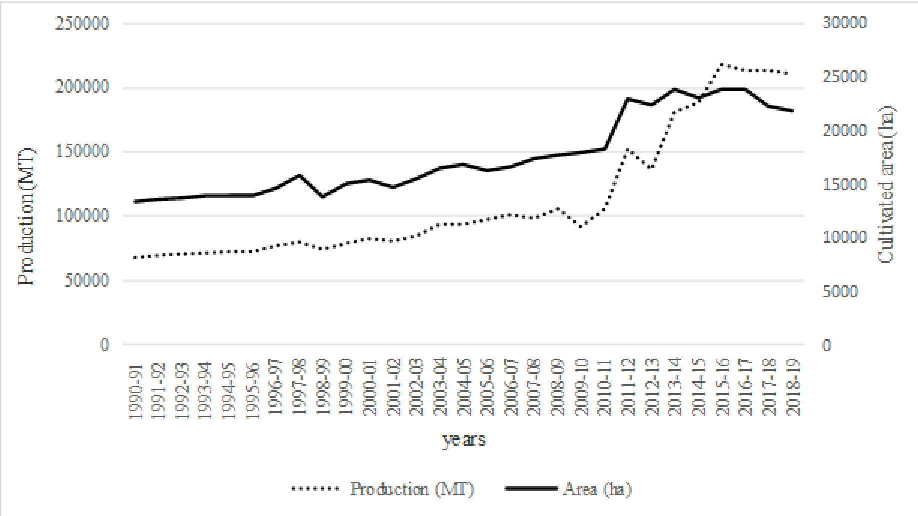


Figure 1. Betel leaf production and cultivation area in Bangladesh from 1991 to 2019

METHODOLOGY

Data collection

The study was conducted using both primary and secondary data. Secondary data on betel leaf production, cultivated area, and price in Bangladesh from 1991 to 2019 were collected from Bangladesh Bureau of Statistics (BBS) to measure the production trend. In addition, monthly temperature and rainfall data have been collected from Bangladesh Meteorological Department (BMD) to incorporate in the production models. Primary data were collected from the Rajshahi district as a large number of farmers are directly engaged in betel leaf production in this district. Betel leaf cultivation is increasing day by day in this district as it requires less cultivation and irrigation cost compared to many other crops (BSS, 2019). In the year 2017-18, the total betel leaf cultivation area in the Rajshahi district was 4780 acres and producing 28197 tons of betel leaf (BBS, 2018). In the study are, face to face surveys including three key informant interview (KII) and three focus group discussion (FGD) was carried out among agricultural extension officer (AEO), sub assistant agricultural officers (SAAO), and farmers to have a better understanding of the existing risk, and potentiality of betel leaf business.

Analytical technique

Time series data on betel leaf production was analyzed by deterministic, stochastic, and mixed-method model approach. The deterministic type model analyzes multiple time series data having trend patterns and provides an idea of what will happen in the future based on historical data. For forecasting purposes, different deterministic types of time series models presented in table 1 are being used. A stochastic approach of time series model is a function that relates the value of time series to previous value of that time series and its uncertain errors. The initial step in stochastic time series analysis is to check whether the series exhibits constant mean and variance over time. Most of the time series data tend to stationary after the first differences. Stationarity can also be checked by correlogram which is a graph of autocorrelation function (ACF) or partial autocorrelation function (PACF) at various lags. For a non-stationary series, the autocorrelation coefficient starts at a high value and declines slowly towards zero as the lag increases. The autoregressive integrated moving average (ARIMA) is one of the popular stochastic approaches of forecasting time series data. ARIMA (p, d, q) is the general model for forecasting purposes where p is the order of auto-regression, d is the order of integration, q is the order of moving average. The method of least squares or the method of maximum likelihood estimation can be used to estimate the parameters of the models. The Box-Jenkins methodology can be applied to fit the best autoregressive integrated moving average model for time series forecasting. ARIMA model is considered as better model for forecasting prices over the deterministic model; however, exceptions are also available (Hassan et al., 2013). In the recent days the dynamic regression model is getting popularity as the model performs better to detect short run forecast (Hassan and Kornher, 2019). Bangladesh Bureau of Statistics (BBS) is also started to forecast food grain and potato prices through this model (BBS, 2017). A dynamic regression is a mixed-model approach that allows lagged values of the explanatory variables to be included in the model space. This model is used to predict what will happen to the forecast variable if the explanatory variable changes, while the values of the explanatory variable are extrapolated for the forecast period. Besides the other comparative model, the dynamic regression model is considered in this study by assuming that the production of betel leaf may not only depend on its lag but also influenced by the price, cultivated area, rainfall, and temperature as in the following equation 1.

$$\Delta Production_t = \alpha + \sum \gamma_p Production_{t-p} + \sum \beta_a Area_{t-a} + \sum \beta_p Price_{t-p} + \sum \beta_j Temperature_{t-j} + \sum \beta_r Rainfall_{t-r} + Error_t \quad \text{.........} (1)$$

Where, α stands for constant, t indicates time, $\gamma_p, \beta_a, \beta_p, \beta_j$ and β_r are regression coefficients for production, area, price, temperature and rainfall, respectively.

Table 1. Different type deterministic models

Deterministic Models	Equation
Linear model	$Y_t = b_0 + b_1 t + e_t$
Logarithmic curve model	$Y_t = b_0 + b_1 \ln(t) + e_t$
Quadratic trend model	$Y_t = b_0 + (b_1 t) + (b_2 t^2) + e_t$
Cubic model	$Y_t = b_0 + (b_1 t) + (b_2 t^2) + (b_3 t^3) + e_t$
S-curve trend model	$\ln(Y) = b_0 + (\frac{b_1}{t}) + e_t$
Growth model	$\ln(Y) = b_0 + (b_1 t) + e_t$

Model selection criteria

In any statistical analysis, model selection is very important. In choosing between two competing econometric models take the following form: each econometric model is estimated by a method that solves some optimization problem; the models are then compared by defining an appropriate goodness-of-fit or selection criterion for each model, and the better-fitting model according to this criterion is selected (Hassan et al. 2011). Forecasting accuracy plays a vital role when deciding among several forecasting alternatives. Here, accuracy refers to forecasting error which is the deviation between the actual value and forecasted value of a given period. In this study, several forecasting error determinants are used: mean absolute deviation (MAD), the mean squared error (MSE), root mean squared error (RMSE), Bayesian information criterion (BIC) where Ljung-Box test reveals that the residuals follow white noise, and the mean absolute percentage error (MAPE). MAD is the average absolute difference between actual value and value that was predicted for a given period, MSE is the average of squared errors, RMSE is the square root of MSE, and MAPE is the average of absolute percent error. The formulas used to calculate the above-stated errors are

$$\text{MAD} = \frac{\sum |Y_t - f_t|}{n},$$

$$\text{MSE} = \frac{\sum (Y_t - f_t)2}{n-1},$$

$$MAPE = \frac{1}{n} \sum_{t-1}^{n} |\frac{e_t}{Y_t}| \times 100$$

Where Y_t the actual value for period t, f_t is fitted value for period t, n is the specified number of periods. Minimum the error the better the model fits. The best fitted stochastic model can be found out based on the maximum value of R^2 and minimum value of root mean squared error (RMSE), mean absolute percent error (MAPE), Bayesian information criterion (BIC) where Ljung-Box test will be insignificant. The Ljung-Box test is a test for autocorrelated errors. The functional form of the test statistic is as follows-,

$$Q = n(n+2) \sum_{k=1}^{h} (n-k)^{-1} \mathrm{p}_k^2$$

Which follows Chi-square (x^2) distribution with the degree of freedom h-m. Where n, k, h, m, and p_k refer to the number of observations, the number of lag, the maximum lag, the number of parameters, and the autocorrelation function respectively. Ljung-Box test can be used to test the hypothesis that all of the autocorrelations are zero, that is, the series is white noise.

SWOT analysis

A SWOT analysis was employed for evaluating the strengths, weaknesses, opportunities, and threats involved in betel leaf cultivation based on the primary survey, FGD, and KII. The acronym SWOT stands for ‘strengths’, ‘weakness’, ‘opportunities’ and ‘threats’. SWOT analysis is a simple but powerful tool for sorting up an enterprise or organization’s resource capabilities and deficiencies, its market opportunities, and the external threats to its future (Chermack and Kasshanna, 2007). It has four components: ‘strengths’, ‘weaknesses’, ‘opportunities’, ‘threats’. The SWOT analysis was chosen to identify both the internal and external factors that are favorable or unfavorable towards achieving the goals of the betel leaf enterprise. Strengths are categorized as internal helpful factors and weaknesses as internal hindering factors of betel leaf. While opportunities are external helpful factors and threats the external harmful factors.

RESULTS AND DISCUSSION

Characteristics of variables for modeling potential

In this study, the production of betel leaf was assumed to be related to its price, cultivated area, average rainfall, and temperature. Descriptive statistics of the variables are presented in table 2. The fluctuating nature of production, price, and cultivation area indicates the non-stationarity nature of time series. All the series except rainfall and temperature were observed to have a sudden upward drift from 2010. To understand potential variables to be included in the model a simple correlation measure is obtained by Pearson technique and presented in table 3. Area of crop cultivation is one of the prime explanatory variables of production forecasting. The relation between production and the cultivated area is significantly high (P-value<.001). Besides, the coefficient of variation of the cultivated area is also high (21.03%) which indicates its potentiality to include in the model. While with the farm-level price the production of betel leaf also has significant correlations (r=0.87, P<.001). For the weather variables production is significantly related to average temperature but not with the rainfall. Finally, the dynamic regression of production considers price, cultivation area, and temperature as explanatory variables besides the lag values of the production.

Table 2. Descriptive statistics of the variables

Variables	Mean	Standard Deviation	Minimum	Maximum
Production (MT)	113053.5	51468.6	67460	218000
Area (Ha)	17529.16	3718.044	13320	23876.45
Price (Tk/100kg)	2697.793	2145.855	780	8083
temperature	25.93	0.356	25.29	26.97
Rainfall	190.78	26.234	140.54	243.91

Table 3. Correlation matrix

	Production (MT)	Area (Ha)	Price	Temperature	Rainfall
Production (MT)	1				
Area (Ha)	0.938***	1			
Price	0.871***	0.901***	1		
Temperature	0.627***	0.616**	0.612**	1	
Rainfall	0.054	-0.049	-0.074	-0-085	1

*** p<0.01, ** p<0.05, * p<0.1

Trend of betel leaf production in overall Bangladesh

Identifying the actual pattern of betel leaf production is essential for forecasting future production. In this study, possible statistical models were applied for forecasting purposes. The sole purpose of comparing different models is to understand the future pattern of betel leaf production upward, downward, or stagnant. In this respect, deterministic, stochastic, and dynamic regression models are measured. Though it is assumed that the dynamic regression would perform better but the authors did not rule out the possibility of other models to be a best-fitted one. Firstly, six deterministic models for production were fitted. Table 4 shows the comparison of the model selection criteria. It is evident from table 4 that among the six models, the values of MAPE, MAD are smaller for the cubic model while the values of MSD are smaller in the growth curve model. The cubic trend model displays the minimum error values which indicate the greatest accuracy because for all three measures, smaller values usually indicate a better fitting model. Thus cubic model implies the suitability of this model among the deterministic models. Hereafter, Cubic trend of betel leaf production is displayed in figure 2.

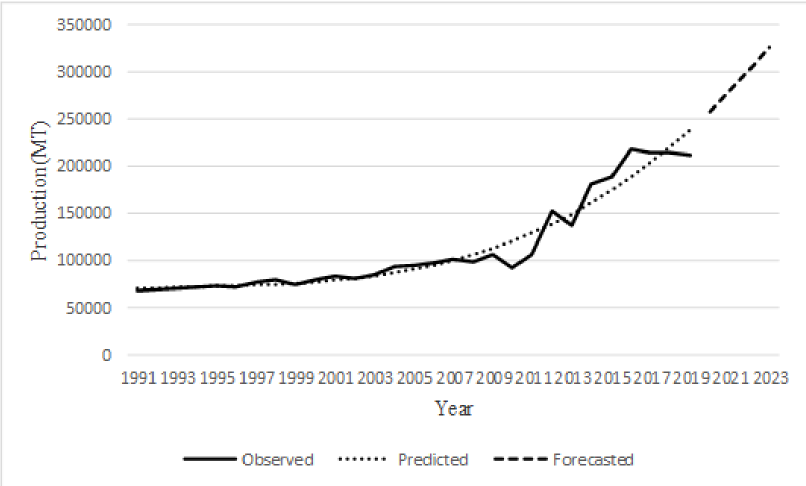


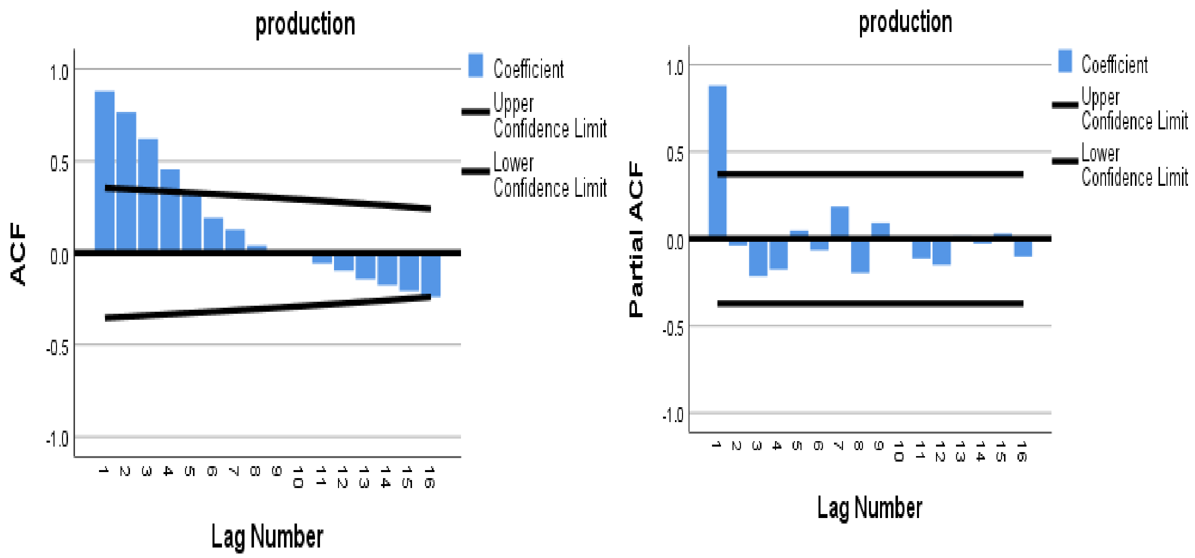
Figure 2. Cubic trend of betel leaf production

Table 4. Model selection criteria for betel leaf production forecasting

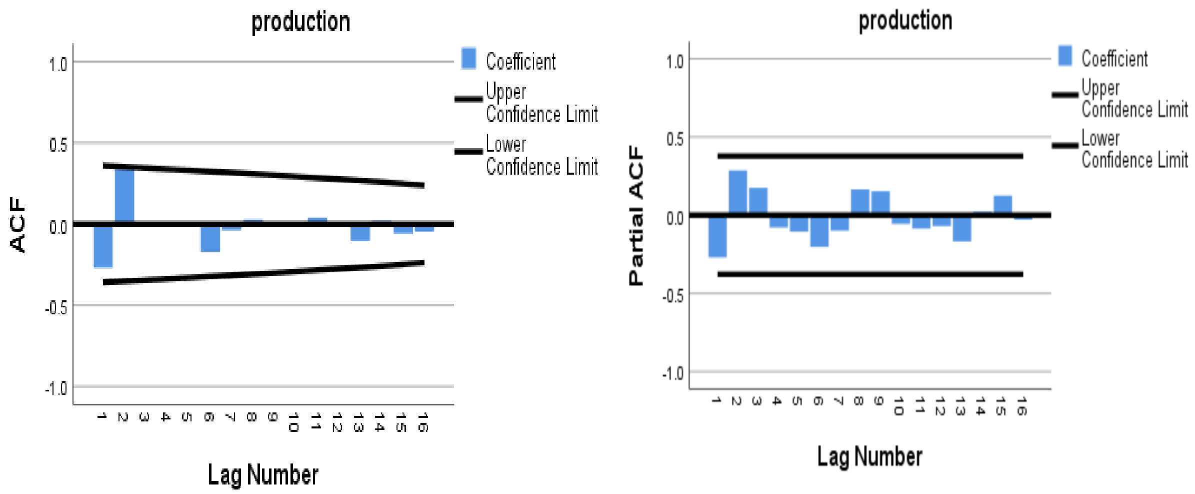
Growth model	**MAPE**	**MAD**	**MSD**
Linear model	19.589	20614.448	597223056.6
Logarithmic curve model	0.0085	29703.144	1281064487
Quadratic trend model	9.407	9757.8380	167428848.9
Cubic model	5.772	**7067.747**	**114434749.4**
S-curve trend model	26.551	32204.481	1988444878
Growth curve model	12.905	15410.9464	421230765.2

Table 5. Model selection criteria for the betel leaf cultivation area (ha) forecasting

Deterministic model	**MAPE**	**MAD**	**MSD**
Linear model	5.12	954	1365262
Logarithmic curve model	5	1005	1349345
Quadratic trend model	**4**	**768**	**1108919**
Cubic model	6	1067	1559399
S-curve trend model	4	830	2070917
Growth model	6	893	1946437



No difference



First difference

Figure 3. Auto correlation and partial autocorrelation of betel leaf production

Secondly, the stochastic model has been implemented for production. Time series models, especially ARIMA models are thought to be better than the deterministic growth models for short term forecasting purposes. As it is observed from the time plot that the production series fluctuated over time so the series in level would be non-stationary. Figure 3 shows the graph of the ACF and PACF for the production series in level and its first difference. The spikes of the non-differenced series are outside the boundary of 95% confidence interval. However, after the first difference (d=1) all the spikes are within the boundary. Such nature of the production data reflects that the series tends to stationary after the first difference. Also, the initial decay of the ACF and PACF from the lag one at the level series indicate that the number of orders of autocorrelation (p) and moving average (q) would range from 0 to 1 (Gujarati et al. 2011). Therefore, the ARIMA models of (0,1,0), (1,1,0), and (1,1,1) are estimated for the production of betel leaf and presented in figure 4, 5, and 6 respectively. ARIMA (0,1,0) seems to be a better fit than the other two ARIMA models based on the model selection criteria in table 7.

Table 6. Model selection criteria for the betel leaf price forecasting

Deterministic model	MAPE	MAD	MSD
Linear model	802.03	1140242.94	47.16
Logarithmic curve model	804.25	1145269.97	47.30
Quadratic trend model	799.82	1135236.70	47.03
Cubic model	797.59	1130251.41	46.90
S-curve trend model	517.99	770865.20	20.35
Growth model	**515.71**	**765160.52**	**20.21**

Table 7. Final model selection criteria for forecasting betel leaf production

Comparative models	R^2	MAPE	MAD	RMSE	BIC	Ljung-Q
Cubic model		6.21	8031	13413.679	-	-
ARIMA models						
ARIMA (0,1,0)	0.928	6.161	8308.620	13832.522	19.186	0.948
ARIMA (1,1,0)	0.932	7.331	8784.597	13718.245	19.291	0.960
ARIMA (1,1,1)	0.934	7.166	8588.009	13758.551	19.416	0.963
Dynamic or mixed model						
Model-1: $\Delta Production_t = f(price_t, temparature_t, area_t) + \varepsilon_t$	0.961	5.757	7392.285	10876.740	19.065	0.472
Model-2: $\Delta Production_t = f(production_{t-1}, price_t, temparature_t, area_t) + \varepsilon_t$	**0.970**	**4.925**	**6002.324**	**9628.033**	**18.940**	**0.794**

Table 8. Forecasted value of production (MT) by dynamic regression model-2

Year	Forecast	Lower limit	Upper limit
2020	222687.05	202770.41	242603.69
2021	239520.41	217505.64	261535.19
2022	252787.59	226174.03	279401.14
2023	267021.22	237825.31	296217.14

The dynamic regression model is a mixed model including ARIMA with the other explanatory variables (Pindyck and Rubinfeld, 2000). After identifying the proper dimension of the dynamic regression the predicted values of the cultivation area and prices are necessary for forecasting the production. In this study cultivation area and prices are fitted by the deterministic model and then the forecasted values of these two variables are included in the dynamic model. The time plot reveals that the price and area of betel leaf have an upward trend. Patterns of rainfall and temperature are well analyzed and forecasted by different institutions. Data transformations e.g. log, square root is not applicable for stationarity if the data series has a structural break. In such case use of a deterministic model is more useful to get a good forecast for individual series of explanatory variables. The deterministic model considers the various form of time as explanatory variables. There are several growth models, among them the linear, quadratic, cubic, S-curve, and growth models are more suitable for agricultural production analysis. The cultivation area per hectare is fitted by applying the different deterministic model and the estimated model selection criteria are presented in table 5. Based on the model selection criteria it is evident that the quadratic model fits the cultivation area well as the values of MAPE, MAD, and MSD are minimum. The cultivation area is then forecasted for the next four years (2020 to 2023) by the quadratic model. The fitted and forecasted graph of the cultivated area is given in figure 7. In the same way, by comparing MAPE, MAD, and MSD this study finds that the growth model is best fitted for the price compared to the other models (table 6). So, this model is further used for forecasting the price. In figure 8, the chart shows observed, fitted, and forecasted values of betel leaf price.

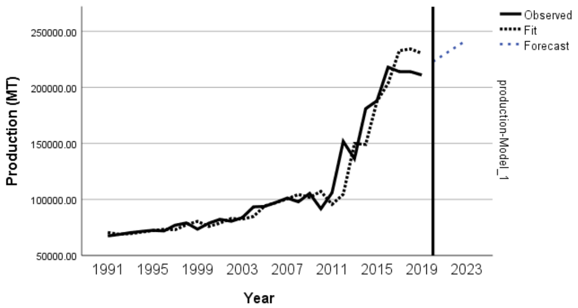


Figure 4. Modeling production by ARIMA (0,1,0)

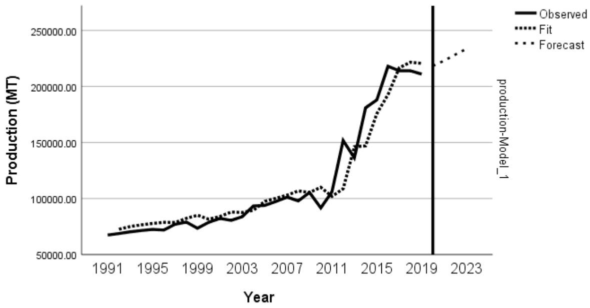


Figure 5. Modeling production by ARIMA (1,1,0)

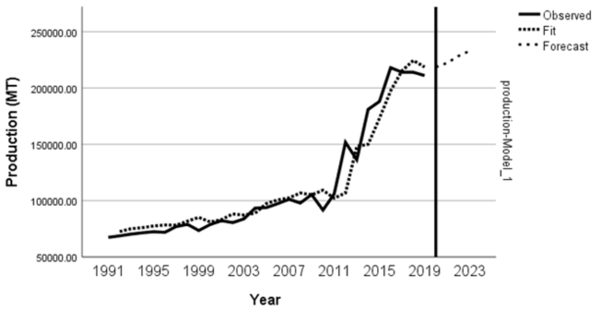


Figure 6. Modeling production by ARIMA (1,1,1)

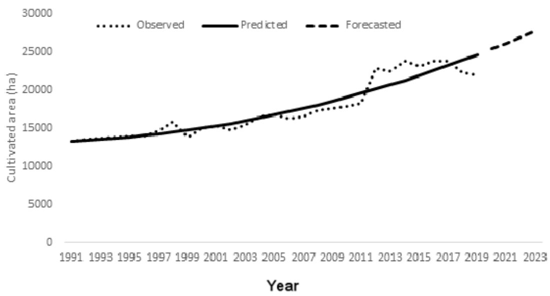


Figure 7. Plot of the quadratic model as a best fit for betel leaf cultivated area

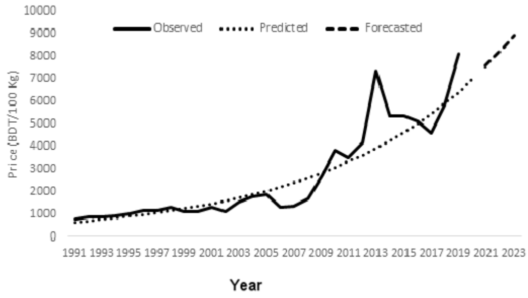


Figure 8. Plot of the growth model as a best fit for betel leaf price

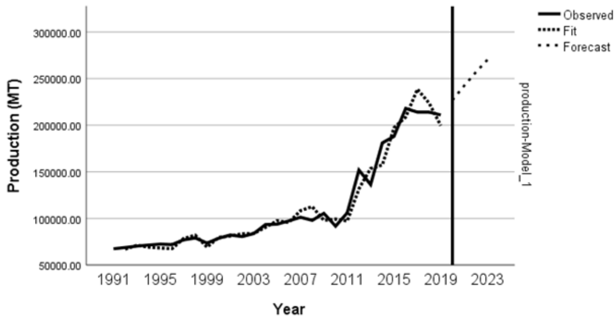


Figure 9. Dynamic regression model-1

In recent years' temperatures are frequently modeled for the precise estimation by various updated techniques. That's why in this study the individual model for temperature forecasting were not fitted. Rather, the forecasted rainfall by a non-linear support vector regressor (SVR) model was used (Shafin, 2019). Thus the authors anticipated the forecast values of all the explanatory variables through the best-fitted models. Finally, the dynamic regression models are estimated where two different models were found. The dynamic regression model-1 is a mixture model of ARIMA (0,1,0) and dynamic regressors especially, the price, area, and temperature. Figure 9 presents the fitted and predicted values by model-1. While model-2 includes ARIMA (1,1,0) with the same regressors. All the best-fitted models of betel leaf productions are compared and presented in table 7. In addition to the MAD, MSE, and MAPE this table 7 also includes BIC and the significance of Ljung-Q statistic. Dynamic regression model-2 has the highest value of R^2, lowest MSE, RMSE, MAPE, BIC, and, insignificant Q-statistic. Thus model-2: ARIMA (1,1,0) with dynamic regressors is considered as the best-fitted model. The ACF and PACF of model-2 residuals are presented in figure 10 and confirm the robustness of the estimated parameters as all the spikes are within the boundary. Figure 11 depicts the best-fitted model with a forecasting trend. Forecast values range minimum 202770.41 MT to 296217.14 MT from the year 2020 to 2023 with 95% confidence interval. Exact forecast values for the respective year's values are also given in table 8. Forecasting from all the best-fitted models revealed that the production of betel leaf will have an upward trend in the future. If the production increases the more people will be engaged in the value chain of betel leaf. So as an emerging business it is essential to find out and explore its prospects.

Betel leaf business in Rajshahi

In the study areas, betel leaf is one of the main cash crops for the farmers. So betel leaf has immense importance in their life and they treat their Pan Boroj as their child. According to the sources of the Department of Agriculture Extension (DAE), the topographic and climatic conditions of Mohanpur, Bagmara, and Durgapur are very suitable for the betel leaf farming. The acreage of betel leaf farming is around 2,000 hectares in this district producing around 35,000 metric tons of crops valued at around Taka 90 crore annually and over 25,000 farmers are involved in its farming (BSS, 2019). If any guests have arrived in their house and if the household head has no such money to treat their guests than they went to their Pan Boroj and harvest some betel leaves then sold these to the market (bazaar) to earn cash immediately. The farmers in these areas are now well encouraged and a good number are engaged in betel leaf farming due to its high profitability. In the survey area, the local units of betel leaf measurement or counting were bira, pon, kuri, gadi, etc. One Bira equivalent 64 pieces and thirty-two Bira equivalent one Poa. Ropes are measured in these areas by the length of an adult man's hand. The list of following strengths, weaknesses, opportunities, and threats of betel leaf enterprise in the Rajshahi district are generated on the basis of KII, FGD, and face to face survey.

Table 9. Initial Investment (Boroj preparing) cost per hectare in 2015

Item	Quantity/unit	Price (BDT)	Cost per hectare
Bambo matireial (Logor)	60 pan	2500	150000
Bamboo material (Pela)	30 pan	1866	56000
Roof making straw	70.50 pan	1700	119840
Rope	6241 hand	12	74900
Planting vine of Pan with washi	120000 piece vine		173768
Fertilizer and insecticide	-	-	20000
Irrigation charge	-	-	5000
Fence (hay, straw, dry leafs)	-	-	74900
The rental value of land	Yearly		80000
Labor			
Labor to set Logor and Washi	115 man-days	500	57500
Aile of the whole land and rows	104 man-days	300	31200
Labor (planting, soiling, watering, fencing)	150 man-days	500	75000
Total			**918108**

Table 10. FGD output about the seasonwise price range of betel leaf in different qualities

Months	Small-leaf	Medium-leaf	Large-leaf
	Price per Poa = 32 Bira in Taka		
December to March	800 to 1120	1600 to 1920	3200 to 3840
April-July	520 to 760	1000 to 1400	2200 to 2800
August-November	160 to 320	640 to 800	1600 to 1800

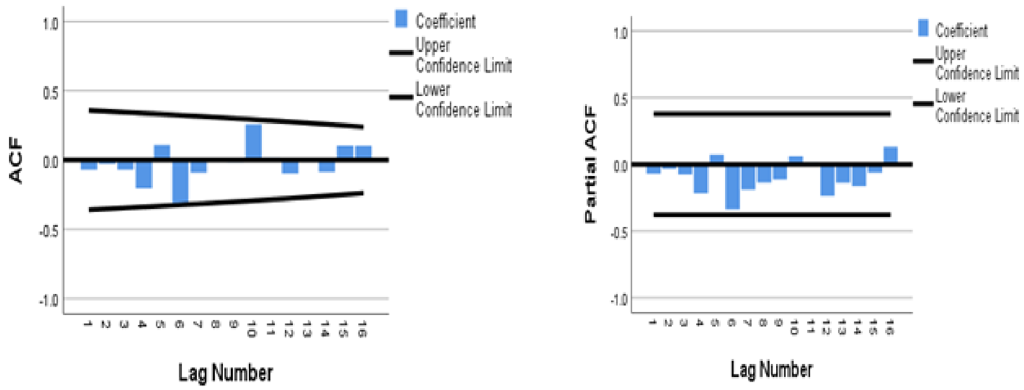


Figure 10. ACF and PACF of the residuals of the best fitted model

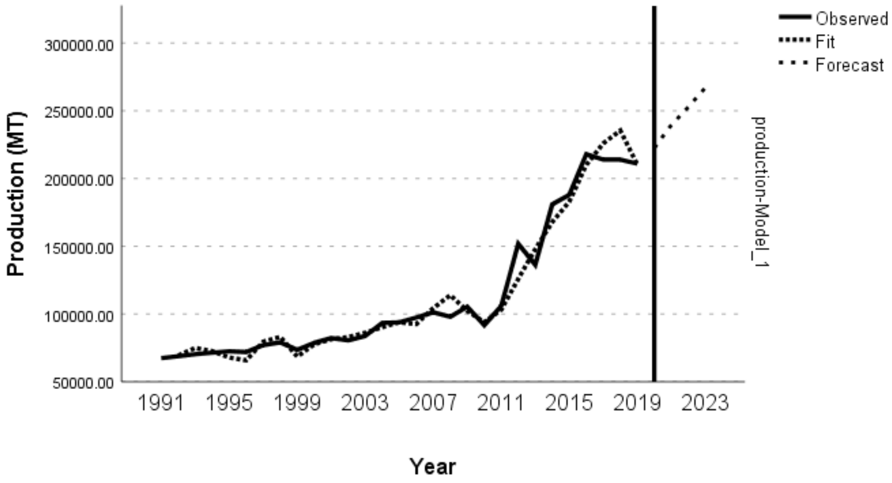


Figure 11. Dynamic regression model-2

Strengths

1. Being a perennial crop betel leaf does not need to be replanted each year. After harvest, they automatically grow back. Boroj setup is done only one time, not every year although some changes in set up are required each year of its lifespan. Therefore, the production cost is some extent lessens after a certain period.
2. As a cash crop betel leaf gives continuous production throughout the year that confirms a minimum level of return at any point in time of the year. Farmers have seasonal income from other crops, while betel leaf cultivation produces income throughout the year from a small piece of land. Table 10 represents the price of the betel leaves. Betel leaf price was varied following its size and month to month. Also, the sweetness of the leaf is considered as one of the important criteria for price variation. The price of the leaf was highest between December to March. The majority of the betel leaf growers mentioned that per hectare income from betel leaf was higher in comparison to the other crops in these regions.
3. Demand for betel leaf will always remain as it is an integral part of the culture and tradition of Bangladesh as well as the Bangladeshi people lives around the world. The consumers of betel leaf have fewer options to substitute their taste with other products.
4. The demand for sweet betel leaf produced in Bagmara and Mohonpur Upazilas has been increasing day by day. Because of the nature of the sweetness of its tests, these Upazaillas betel leaves always bear a unique demand. By covering most markets of different regions, it is being exported to various countries in the world.
5. Different bamboos made materials are essential inputs for preparing the new boroj and repairing the older one. Several types of bamboo materials (Logor, Washi, Pela) were essential for constructing the Boroj and these materials constituted 31% of the total cost. Because of the blessing of an abundance of natural agricultural resources like bamboo gardens in the study areas, the farmers have wider incentives to utilize such resources and invest in betel leaf enterprise.

Weaknesses

1. Betel leaf is sensitive to nursing and needs careful observation every day. If the boroj is not nursing in one-week results weed and leaf rotten.
2. Poor quality of vine can destroy the whole Boroj as the weak vine may rotten or dried within 30 days after planting. Farmers always faced difficulty in finding good quality vines.
3. It requires high initial investments. On average, for betel leaf cultivation total of 918108 BDT/hectare was required for the initial set up of the Boroj in 2015. All the inputs with the cost needed to construct a new Boroj per hectare are given in table 9.

4. Time lengthy to get the leaves from the new boroj as it takes a minimum of 9 months to produce marketable leaves.
5. It is a perishable crop and cannot be stored for a long time. The producer must speculate the quantity of harvest leaves for selling.
6. Diseases in the boroj may cause a serious issue. Diseases like leaf and stem rot are the prime constraint for the cultivation of betel leaf. Leaf rot can damage the total crop within a week when it attacks the vine. The pathogen mainly strikes during humid weather. Once infected, the symptoms progress quickly. Farmers growing betel leaf in three Upazilas of Rajshahi district incurred a huge loss as foot rot disease damaged about 60% of the cultivation in the year 2004 (Islam, 2005). Root rotten problem and fungus attacks cause the whole boroj to cut off. In fact, after the fungus attack, it is difficult to replant the boroj and its growth. Management of these diseases is difficult and still has no proper remedy or medicine to get off this problem fully. Though local extension officers and pathologist is trying the full remedy is not discovered yet.

Opportunities

1. It has a huge regional and global export market. Export is rising as the number of Bangladeshi migratory people across the world is increasing and among them, a well-known portion has a demand for it.
2. There are several spots of buying and selling betel leaves in the local areas. In Mohonpur Ekdiltala Paner Haat is the biggest betel leaf market not only in the Rajshahi district but also in the northern part of the country. After harvesting, the betel leaf growers carry most of their crops to the nearby betel leaf markets like Ekdiltala Paner Haat for wholesale marketing. Betel leaf sold in this market has tremendous demand at home and abroad for its quality and flavour that attracts many commission agent, wholesalers and retailers come to this market. Thus the cost of seller to find out the potential customer will be reduced.
3. A lot of products are now being manufacture to a small extent from betel leaf. These products are toothpaste, tooth powders, pan masala, mouth fresheners, facial cream, digestive agent, tonics and medicine, betel leaf essential oil, beauty and cosmetics products, appetizers, anti-septic lotions, skin emollients, etc.
4. Betel leaves are a powerhouse of antioxidants and anti-inflammatory. It has anti-microbial, anti-cancer, anti-diabetic, antiseptic, and anti-fungal properties. It can ease the constipation problem, improves digestion, and reduces respiratory issues. So being a medicinal crop it has a great prospect in the future.
5. A large number of the super shop is increasing across the country where betel leaf product is available. Hence the market for betel leaf is expanding gradually.
6. Different value added betel leaf-like ‘Agun pan’, ‘Masala pan’, ‘Tamakh pan’, ‘Zarda pan’ is being marketed day by day. These add value to the betel leaf. Thus it has a huge scope for considerable expansions across all formats and all regions of the country.
7. Potential for expansion in small towns since interest in betel leaf business is growing due to consistent crop yield.
8. Labor is required for pit preparation, fertilizer application, transplanting, intercultural operation, harvesting, and marketing. Bing labor-intensive crop betel leaf cultivation creates employment opportunities to a large extent.
9. The government is actively seeking investment in the food and agribusiness sector which might be helpful for the betel leaf farmers.

Threats

1. Betel leaf is much labor-oriented. During the peak time (monsoon) production exceeds demand. When there is good production in the boroj, the leaf must be plucked from the plant continuously otherwise there is a chance to lean off the whole plant. Non-availability of skilled labor at a reasonable wage rate is a big threat in this aspect. At present rural laborers are interested in engaging in non-farm activities rather than farming.

2. Lack of capital as one of the important constraints during setting the new Boroj. It is not easy to be eligible to get the loan or credit from banks or NGOs.
3. Underdeveloped transportation and communication in farming regions hinder the delivery of betel leaf to its potential wholesalers. Betel leaf cannot be stored for a long time after harvesting. If the harvested leaves are delayed to reach on time, then the color of the leaves becomes changing that lowers its market value. Therefore, the supply system must be well arranged otherwise without timely supply it will be a great loss for the producer. Overall poor road conditions, congestion, and tools can threaten the profit of betel leaf farmers.
4. In the monsoon waterlogging can cause the root perished, a good drainage system is required.
5. Betel leaf price has a fluctuating trend while farm labor wage rate is increasing over time. Causal labor is one of the important inputs to betel leaf cultivation consequently the rise in the wage rate of laborer lowers the total revenue as well as the profit.
6. It is vulnerable to climatic change. Environmental factors like temperature, humidity, and rainfall play a vital role in growth and infection on betel leaves. Excessive heat or cold may damage the production to a great extent resulting in a heavy loss in leaf yield every year.
7. Lack of technology and management is another problem in betel leaf cultivation. Since it is not a major crop in Bangladesh, there is a lack of suitable technology for betel leaf cultivation. Again due to poor education level and access to the information, most of the farmers are not able to use modern technologies. High tech mechanization like plucking the leaves quickly is strongly needed but it is difficult to improve high tech mechanization in developing countries like Bangladesh.
8. Changing the taste and preferences of the consumer of betel leaf might negatively influence its future demand.

CONCLUSION AND RECOMMENDATIONS

Betel leaf production has an upward trend. The entire best-fitted model predicts that the quantity demand for betel leaf will increase from 2020 to 2023. The area of cultivation and production of betel leaf is also rising. Methodologically, the dynamic regression model gives a better result for prediction than the deterministic and ARIMA models. This study also revealed the opportunities of betel leaf cultivation in the selected study area as a large group of people directly earned their livelihood through it. Factors like hired labor, crop insurance, and access to credit were the most important factors that may significantly influence the betel leaf business. This enterprise becomes risky for investment due to the undetectable solution of rotten leaf diseases. Pathologists may research for controlling diseases of betel leaf. The capital shortage was one of the major threats faced by the betel leaf growers. Without institutional credit support, it is difficult for the farmers to devote a large area to the betel leaf production. It is, therefore, necessary that credit on easy terms and conditions may be provided to the farmers for betel leaf production. The policymakers should pay immediate attention to this matter. It is also imperative to carry out more research on developing high yielding varieties of betel leaf and to develop appropriate production technologies for maximizing the yield as well as profit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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