International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Forecasting Area, Production and Productivity of Mulberry Silk in India

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Abstract: ***The silk trade has a very small role in global market but it contributes substantially to Indian economy and employment generation. Using time series data on mulberry silk production parameters as available in technical reports of Central Silk Board, Govt. of India for the period 1971-72 to 2014-15, the study attempted to forecast the future silk production inclination trend in India. The trend analysis shows that the series under study follows cubic polynomial for all three parameters. The highest growth rate was recorded for mulberry raw silk production (5.48%) followed by mulberry raw silk productivity (3.72%) and mulberry plantation area (1.70%). Forecasting of area, production and productivity of silk were estimated using Box-Jenkins ARIMA models for the period under study. Based on the model identification and diagnostic analysis, ARIMA (0,2,2), ARIMA(0,2,1) and ARIMA (0,1,0) were found best fitted models for area, production and productivity. Data for the period 2013-14 to 2014-15 are taken for model validation whereas forecast was made for the year 2015-16 and 2020-21 which shows increasing trend to take annual production to 29000 metric tons mulberry raw silk in 2020 with estimated productivity of 120 kg^{-1}ha inspite of slow growth in mulberry plantation area.***

Keyword: Area, Production, Productivity, Compound Growth Rate, ARIMA Model

1. Introduction

India is only country in the world producing four types of silk: Mulberry, Tasar, Eri and Muga silk. Mulberry silk contributes 72 per cent and 18 per cent contributed by non-mulberry silk of total production in India. The Indian silk industry still harbours potential and long term role for employment generation and export. India is the 2nd largest silk producer with annual production of 28708 metric tons (2014-15) contributing 16% of the total world raw silk production and also the largest consumer of silk in the world. Geographically, Asia is the main producer of silk in the world and manufactures over 95% of the total global output [10]. Among 40 silk producing countries in the world, China and India are major producers, followed by Japan, Brazil and Korea. The Raw silk production for the world is 178039 metric tons out of which China contributed 146000 metric tons during 2014 [1]. In India, mulberry silk is produced mainly in five traditional states of Karnataka, Andhra Pradesh, Tamil Nadu, Jammu & Kashmir and West Bengal and these states together contribute 95% of the total production and remaining 5% gets contributed by non-traditional states. Among traditional states, Karnataka is the leading state in mulberry cultivation and Raw silk production having respective share of 40% & 45% share in area & production at national level followed by Andhra Pradesh with 21% and 30%. Karnataka being the leading state shows declining trend in mulberry area for the period 2001-02 to 2014-15 (Fig.1&2) which may be due to industrial development and shortage of labor force.

Silk productivity recorded during 1960 and 1970 was very low and ranged between 14 to 20 kg per hectare, however, significant increase in productivity was observed in the eighties and nineties (*Mote, et al. 2014)* and it reached up to 80 kg^{-1}ha during 2014-15. Since Sericulture stands next to agriculture for rural employment in India it becomes a matter of priority to examine the sericulture production trend over the years and reasons for growth fluctuation. Whether the fluctuation is statistically normal or is under the influence of some of the factors getting changed due to one or the other reason of temporary or permanent native.

This study will enable to comprehend the growth pattern & prepare the planners to take effective measures for streamlining the growth area and the growth rate. The present study is based on long term data of 44 years (1971-2014) to ascertain the nature of the series under consideration, compound annual growth rate, instability index analysis, trend analysis to enable forecasting of area, production and productivity of mulberry silk.

In context of the present study, literature reviewed for application of growth function and trend analysis conducted by several authors in the area of sericulture **(** *Manjunath et al. 2015; Bhat, T.A. et al 2014; Lakshmanan, S. 2007;Mote, T.S., et al. 2014; Rai, S. et al 2012)* reveal that mulberry area cultivation is in declining trend at different time interval which needs to be reversed under the intervention of planners and programme executors to accelerate the sericulture industry in competitive world market. For the purpose forecasting of Silk production in India on long term data basis is the need for which ARIMA forecasting models are used in this study for future planning of the industry. Several statistical and econometric forecasting models have been developed that could be suitable for forecasting various issues including agricultural productivity and other allied field [1], [8], [11], [12]. The present study is based on the concepts of the above finding to forecast area, production and productivity of Mulberry Silk in India.

2. Material and Methods

Data related to area, production and productivity of mulberry silk in India since 1971-72 to 2014-15 were collected from statistical Biennials and Annual Reports of Central Silk Board [2], [3]. The whole period was divided into two equal periods of 22 years viz; period-I from 1971-

72 to 1992-93 and period-II from 1993-94 to 2014-15 to compare in area, production and productivity between the two halves of the study period. Besides that decade wise contribution of mulberry silk and its growth rate has also been incorporated in present study. In order to examine the nature of change, instability and degree of relationship various statistical measures such as mean, range, kurtosis, skewness, and coefficient of variation were worked out. Box-Jenkins ARIMA modeling has been used to forecast characters under consideration.

2.1. Descriptive Statistics

To examine the nature of data descriptive statistics such as minimum, maximum, average, standard deviation, skewness and kurtosis were applied. Descriptive statistics are typically distinguished from inferential statistics [11]. With descriptive statistics one simply describes what is or what the data shows. With inferential statistics, one tries to reach the conclusions that extend beyond the immediate observation without its future projection.

2.2. Parametric Trends Models

To study the overall movement of the time series data, trend equations are fitted. In the present study different idea about the models like, polynomial exponential, linear, compound logarithmic and growth etc are used for the purpose [11].

Models		Form
Polynomial	:	$Y_t = b_0 + b_1 t + b_2 t^2 + \cdots + b_k t^k$
Linear	:	$Y_t = b_0 + b_1 t$
Quadratic	:	$Y_t = b_0 + b_1 t + b_2 t^2$
Cubic	:	$Y_t = b_0 + b_1 t + b_2 t^2 + b_3 t^3$
Compound	:	$Y_t = b_0 b_1^t$
Exponential	:	$Y_t = b_0 e^{b_1^t}$
Logarithmic	:	$Y_t = b_0 + b_1 \ln(t)$
Growth	:	$Y_t = e^{b0+b1\ln(t)}$

The growth rates of area, production and productivity of mulberry silk were worked out by fitting a semi-log function of the following type:

$$y = e^{a+bt} \; or \ln y = a + bt$$

Where y = Area (ha.), Production (t), Productivity (kg / ha.), t = time period (year). An index of instability was computed using the index formula given by Cuddy and Della (1978) for examining the nature and degree of instability in area, production and productivity of silk in India.

$$CV_t = (CV) \times \sqrt{(1 - R^2)}$$

Where, C.V. $= \frac{\sigma}{\bar{x}} \times 100$

Where σ = standard deviation, CV_t = CV around trend and $\bar{X}$ = mean

More general option is to use ordinary CV value but in presence of trend, ordinary CV fails to explain the inherent trend component in a time series properly (Hasan et al., 2008). As such, this study obtained for CV around trend i.e. CV_t After evaluation of trend and instability of the series under study, the next step is to forecast the series for the years to come. For the purpose the study adopted the Box – Jenkins (1976) methodology. Data for the period 1971-72 to 2014-15 has been used for the model building, while data for year 2013-14 to 2014 are taken for model validation. On the basis of best fitted model forecasting has been made for the year 2015-16 to 2020-21.

2.3. Box-Jenkins (ARIMA) model

Autoregressive Integrated Moving Average (ARIMA) is the most general class of models for forecasting a time series. Different series appearing in the forecasting equations are called "Autoregressive" process. Appearance of lags of the forecast errors in the model is called "moving average" process. The ARIMA model is denoted by ARIMA (p,d,q) where "p" stands for the order of the auto regressive process, „d" stands for the order of differencing and „q" is the order of the moving average process. Hence ARIMA model is jointly know by term AR, I, and MA models. The approaches of Box-Jenkins methodology in order to build ARIMA models are based on the following steps: (1) Model Identification, (2) Parameter Estimation and Selection, (3) Diagnostic Checking [5], [6]. The mathematical form of AR, MA and ARMA models are as follows:

2.3.1. Autoregressive (AR) model

The autoregressive or AR component of an ARMA model can be written in the form:

$$X_t = \alpha_1 X_{t-1} + \ldots.. \alpha_p X_{t-p} + Z_t \; or$$

$$X_t = \sum_{i=i}^{p} \alpha_i X_{t-i} + Z_t$$

Where the terms in α are autocorrelation coefficients at lags 1,2...p and z_t is a residual error term. If a first order process, p=1 then we have the model:

$$X_t = \alpha X_{t-1} + Z_t$$

$$X_{t-1} = \alpha X_{t-2} + Z_{t-1}$$

These expressions state that the estimated value of x at time=t is determined by the immediately previous value of x (i.e. at time=t-1) multiplied by a measure, α, of the extent to which the values for all pairs of values at time periods lag 1 apart are correlated (i.e. their autocorrelation), plus a residual error term, z, at time t.

2.3.2. Moving Average (MA) models:

The moving average (MA) models can be used to provide a good fit to some datasets, and variations on these models that involve double or triple exponential smoothing can handle trend and periodic components in the data. Furthermore, such models can be used to create forecasts that mimic the behavior of earlier periods. A simple form of such models, based on prior data, can be written as:

$$X_t = \beta_0 X_t + \beta_1 X_{t-1} \ldots.. \beta_q X_{t-q}, \; or$$

$$X_t = \sum_{i=0}^{q} \beta_i X_{t-i}$$

Where the β_i terms are the weights applied to prior values in the time series, and it is usual to define β_i=1, without loss of generality. If a first order process, q=1 then we have the model:

$$\ddot{X}_t = \beta_0 X_t + \beta_1 X_{t-1} \quad or$$

$$\ddot{X}_t = X_t + \beta_1 X_{t-1} \quad Where\ \beta_0 = 1$$

i.e. the moving average value is estimated as a weighted average of the current and immediate past values.

2.3.3. Autoregressive Moving average (ARMA) Models:

After adding AR (p) and MA (q) models together, we can write ARMA model of order (p,q) as:

$$X_t = \alpha_1 X_{t-1} + \cdots \alpha_p X_{t-p} + Z_t + \beta_1 Z_{t-1} \ldots . \beta_q Z_{t-q},$$

In general, this form of combined ARMA model can be used to model a time series with fewer terms overall than either an MA or an AR model by themselves. It expresses the estimated value at time t as the sum of q terms that represent the average variation of random variation over q previous periods (the MA component), plus the sum of p AR terms that compute the current value of x as the weighted sum of the p most recent values.

As with the MA and AR processes, the differencing process is described by the order of differencing, for example 1, 2, 3.... Collectively these three elements make up a triple: (p,d,q) that defines the type of model applied. In this form, the model is described as an ARIMA model. The mean, variance, autocorrelation function (ACF) and partial autocorrelation function (PACF) of the time series can be calculated for given set of series. The estimated ACF and PACF give an idea about the correlation between observations, indicating the sub-group of models to entertain. This process is done by looking at the cutoffs in the ACF and PACF. At the identification stage, one would try to match the estimated ACF and PACF with the theoretical ACF and PACF as a guide for tentative model selection [10].

2.3.4. Diagnostic Check

The diagnostic check is a procedure that is used to check residuals. The residuals should fulfill the models assumption of being independent and normally distributed. If these assumptions are not fulfilled, then another model is chosen for the series. We will use the Ljung-Box test statistic for testing the independency of the residuals. Also, statistical inference of the parameters and the goodness of fit of estimated statistical models will be made.

$$Q = T(T+2)\sum_{k=1}^{s}\frac{r_k^2}{T-k}$$

Where T: number of observation, S: length of coefficient to test autocorrelation, r_k : Autocorrelation coefficient (for lag k)

2.3.5. Bayesian Information Criterions (BIC):

In statistics, the Bayesian information criterion (BIC) or Schwarz criterion (also SBC, SBIC) is a criterion for model selection among a finite set of models. It is based, in part, on the likelihood function, and it is closely related to Akaike"s (1973) information criterion (AIC). AIC is mathematically defined as:

AIC = -2 log (maximum likelihood) + 2K

Where k = p+q+1 (if model includes intercept) otherwise k = p+q, model specified well if its AIC value is minimum as other fitted models (*Tsay, 2005*). On the other hand BIC is computed as;

SBIC = -2log (maximum likelihood) + 2k log (n)

Model which has minimum SBIC value specified well as other fitted models (*Tsay, 2005*) [7].

2.3.6. Forecasting Accuracy Measuring Techniques:

After model selection, a next important step is to measure the accuracy to verify the reliability of forecasted value based on selected model. Models are compared according to the minimum values of Root mean square error (RMSE), mean absolute error (MAE), mean absolute percentage error (MAPE), mean percentage error (MPE) and maximum value of Coefficient of determination(R^2).

$$MAE = \frac{\sum_{i=1}^{n}|X_i - \ddot{X}_i|}{n}$$

$$R^2 = \frac{\sum_{i=1}^{n}(\hat{X}_i - \bar{X})^2}{\sum_{i=1}^{n}(X_i - \bar{X})^2}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \hat{X}_i)^2}{n}}$$

$$MAPE = \frac{\sum_{i=1}^{n}|X_i - \ddot{X}_i|}{n} \times 100$$

3. Result and Discussion

The descriptive statistics calculated for the area (hec), production (metric tons) and productivity ($Kg^{-1}ha$) of mulberry silk in India for the period 1971-72 to 2014-15 (Table 1) shows that area varied between 104885 hectare to 350059 hectare with an average of 210042 hectare, registering compound growth rate of almost 1.70% per annum. The value of positive skewness (0.48) indicates that there has been shift of area in favor of mulberry cultivation during the mid phase of study period. So far production is concerned; an average production was recorded 10777.4 metric tons with growth rate of about 5.48% per annum for the study period. The negative Skewness and kurtosis indicate that production has been increasing and it remains steady for a longer period. The average productivity of mulberry silk in India is 51.26 kg^{-1} ha and rages between 19.51 kg^{-1} ha to 100.94 kg^{-1} ha. By and large productivity of mulberry silk has recorded 3.72% compound growth rate during the whole period under study. The positive skewness (0.59) and negative kurtosis (-1.24) shows increasing tendency in productivity upto later part of the study and it decreases in last phase of study period. The highest coefficient of variation (54.55%) was noticed in productivity followed by Production (52.34%) and Area (31.80%) which may be uneven distribution of the series under consideration (Table 1).

On the other hand decade wise breakup study of mulberry contribution in total silk and growth rate for area, production and productivity indicated in Table 2 reveals that mulberry silk contributed positively with 84.23%, 90.04% & 91.72% during initial three decades 1971-80, 1981-90 and 1991-00 and further it declined 3% and 9% in 2001-10 and 2011-14 with consecutive periods. So far growth rate is concern, mulberry area increased by 4.95% and 5.70% annually in initial two decades and decreased by -4.18% and -3.05% annually during 1991-00 and 2001-10, whereas production and productivity both have positive growth during four decades (Table 2). The increasing growth rate during four years of last decade (2011-20) for area and production may be due to positive impact of several developmental programmes (CDP / CSS, CPP, MKSP, TSP, SGSY etc.) implemented by Central and State governments (Table 2).

Table 1: Per se performance of Area, Production and Productivity of Mulberry Silk in India during 1971-2014

Parameters	Minimum	Maximum	Mean	S.D.	Skewness	Kurtosis	CV%	Growth Rate %
Area (ha.)	104885	350059	210041.5	66783.2	0.48	-0.453	31.8	1.7
Production (MT)	2046	21390	10777.4	5641.27	-0.174	-1.237	52.34	5.48
Productivity (kg/ha.)	19.51	100.94	51.26	27.96	0.589	-1.24	54.55	3.72

Table 2: Decadal growth rate of Area, Production and Productivity of Mulberry silk in India

Decadal period	Average Production and share of mulberry silk			Growth Rate (%)		
	Mulberry silk	Total Silk	% Share of mulberry silk	Area (ha.)	Production (MT)	Productivity / Ha (kg)
1971-80	3006.70	3534.00	84.23	4.95	8.42	3.31
1981-90	7795.40	8651.50	90.04	5.7	9.11	3.23
1991-00	13218.00	14408.50	91.72	-4.18	3.08	7.57
2001-10	15615.30	17907.70	87.42	-3.05	0.68	3.85
2011-14	19463.25	25481.75	76.58	5.00	4.02	-0.93

India"s mulberry area and raw silk production mainly concentrated in the states of Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu and Kashmir constituting about 80% in mulberry cultivation and 95% of the total mulberry silk production during 2014-15 which is less than the period 2001-02 particularly in Karnataka state (Fig.1&2). Karnataka being the traditional state contributes 45% in mulberry cultivation and 55% in Raw silk production and known as "Silk Bowl" of the country. However Andhra Pradesh and West Bengal being potential area of mulberry silk, showing declining tendency in mulberry cultivated area which needs to be checked by planners and executors. The contribution of major states in raw silk production is positive except Karnatka state during 2014-15 in comparison to 2001-02.

Fig. 1: Percentage share of Major States in Mulberry area (ha.)

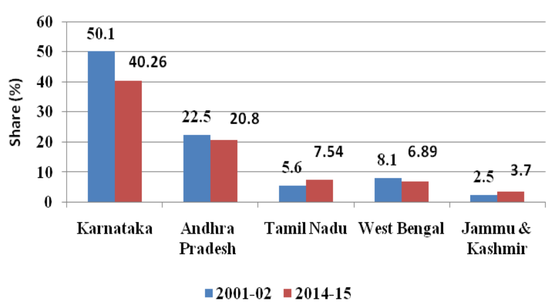
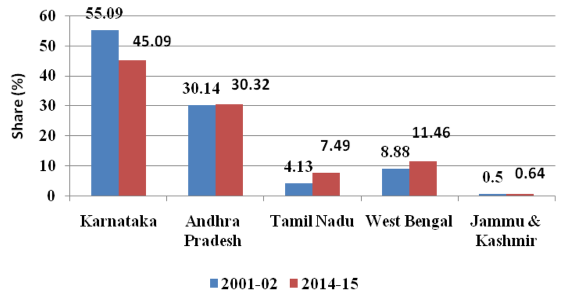


Fig. 2 :Percentage share of Major States in Mulberry Raw Silk production (MT)



Knowing the above overall performance, path of movement of the series was traced through parametric trends models (Table 3). A wide range of models has been explored, among the competitive models the best fitted models are selected based on the maximum Adj. R^2 along with significance of coefficients. Among the competitive models, in all cases cubic models are found best fitted to the series under study. The Adj. Coefficient of determination (R^2) based on cubic model for area, production and productivity are 0.664, 0.969 and 0.970 respectively. Based on the fitted trend model, 1992-93 has been considered the turning point in case of mulberry cultivation which is directly related with production of mulberry silk. Accordingly the series under study has been divided in two half"s (Period I: 1971-92 & Period II 1993-14) to study the changes in area, production and productivity of mulberry silk in India (Table 5). The two sets of series for I and II periods were analyzed using t-test and found that production and productivity are significantly different at $p<0.01$ level except area over the periods. The compound growth rate for area is positive (5.51%) in Period-I and negative (-1.99%) in period-II. However growth for production and productivity were positive in both periods (Table 4). This change over analysis has directly or indirectly influenced the forecasting of mulberry silk components.

Table 3: Trend in Area, Production and Productivity of Mulberry Silk in India

Model	R^2	Adj R^2	F	Constant	b1	b2	b3
Area (ha.)							
Linear	0.084	0.062	3.85	1506.03	156155.70		
Logarithmic	0.264	0.246	15.03	399116.27	38946.81		
Quadratic	0.664	0.647	40.45**	5518.62	17202.18**	-348.80**	
Cubic	0.687	0.664	29.28**	25126.64	24954.51**	-774.69	6.31**
Compound	0.153	0.132	7.56	159998.27	1.010		
Growth	0.153	0.132	7.56	11.98	0.010		
Exponential	0.153	0.132	7.56	159998.27	0.010		
Production (MT)							
Linear	0.965	0.964	1153.77**	1071.13	431.39**		
Logarithmic	0.822	0.818	194.54**	-5774.14	5811.39**		
Quadratic	0.971	0.969	675.26**	66.76	562.39	-2.91**	
Cubic	0.971	0.969	443.85**	359.67	488.41**	1.15	-0.06
Compound	0.886	0.884	327.43**	2744.64	1.05**		
Growth	0.886	0.884	327.43**	7.92	0.05**		
Exponential	0.886	0.884	327.43**	2744.64	0.05**		
Productivity (kg/ha.)							
Linear	0.912	0.910	436.97**	4.477	2.079**		
Logarithmic	0.619	0.610	68.12**	-19.890	24.980**		
Quadratic	0.969	0.967	635.99**	20.200	0.028	0.046**	
Cubic	0.972	0.970	468.69**	25.206	-1.236	0.115**	-0.001*
Compound	0.969	0.968	1296.04**	17.154	1.043**		
Growth	0.969	0.968	1296.04**	2.842	0.042**		
Exponential	0.969	0.968	1296.04**	17.154	0.042**		

**-Significant at 1%, *-Significant at 5% and NS-Non-significant

Table 4: Change in Area, Production and Productivity of Mulberry silk

Parameters	Period –I (1971-1992)	Period –II (1993-2014)	Change over period (II-I)	T- test	F-test	Growth Rate (%)	
						Period-I	Period-II
Area (ha.)	196622.68	223460.23	26837.55	1.35NS	1.81NS	5.51	-1.99
Production MT)	5985.41	15569.41	9584	10.89**	118.52**	8.77	2.45
Productivity (Kg/ha))	28.33	74.18	45.85	9.62**	92.58**	3.09	4.53

**-Significant at 1%, *-Significant at 5% and NS-Non-significant

With the above scenario of production behavior of mulberry raw silk, now it is imperative to assess the future behavior of area, production and productivity of mulberry silk in India using ARIMA technique. Among the competitive models, best fitted models have been identified based on the criteria given in material and methods using SPSS 20.0 package. Table 5 depicts the best fitted model for area, production and productivity of mulberry silk. Data for the period 1971-2014 was used for sample period forecast which is obtained simply by plugging the actual values of the explanatory variables in the estimated equation mentioned in Table 6, whereas period for 2015-2020 was used for post sample forecast based on the same estimates (Table 6).

The model verification was done through examining the autocorrelations and partial autocorrelations of the residuals of various orders. For this purpose, the correlations up to 24 lags were computed and same was tested by Box-Ljung test and results indicated that none of these correlations were significantly different from zero at a reasonable level. This proved that the selected ARIMA model is an appropriate model. The ACF and PACF of the residuals for area, production and productivity also indicated „goodness of fit" of the models (Fig.3-5). Each and every series is checked for stationarity before developing the model, if not, differencing or transformation technique is used to make these stationary. For Area ARIMA (0,2,2) model without constant was best fitted with maximum R^2 (0.983), and lower value of BIC and non-significant value of Ljung-Box Q statistics (23.29 with p-value 0.106). ACF and PACF residuals are non-significant. For production, ARIMA (0,2,1) model without constant was found best fitted with maximum R^2 (0.984), lower value of BIC (13.27) and non-significant value of Ljung-Box Q statistics (11.14 with p-value 0.849). On the other hand productivity was best fitted with ARIMA (0,1,0) model with constant with maximum R^2 (0.988), lower value of BIC (2.44) and non-significant value of Ljung-Box Q statistics (12.33 with p-value 0.830)

Table 5: Best ARIMA model fitted to Area, Production and Productivity of Mulberry Silk in India

Parameters	Model	R^2	RMSE	MAPE	MAE	MaxAPE	MaxAE	BIC	Ljung-Box Q(18)	
									Statistics	P value
Area (Ha)	ARIMA (0,2,2)	0.983	8836.49	3.314	6802.92	8.824	18477.94	18.628	23.286	0.106
Production (MT)	ARIMA (0,2,1)	0.984	696.97	4.528	513.16	12.996	1899.67	13.271	11.141	0.849
Productivity (kg/ ha)	ARIMA (0,1,0)	0.988	3.10	4.281	2.260	13.393	8.66	2.440	12.326	0.830

Table 6: Estimates of ARIMA Models

Parameters	Model Type	Coefficients	Estimate	SE	t	Sig.
Area (Ha.)	ARIMA (0,2,2)	MA(1)	0.643	0.124	5.194	0.000
		MA(2)	0.092	0.127	0.723	0.474
Production (MT)	ARIMA (0,2,1)	MA(1)	0.789	0.109	7.248	0.000
Productivity (kg/ha.)	ARIMA (0,1,0)	Constant	0.037	0.008	4.481	0.000

Model validation for the period 2013-14 and 2014-15 and forecasting for 2015-16 and 2020-21 of area, production and productivity of mulberry silk shown in table 7 indicates that there will be increasing trend in all the parameters under study. India is supposed to produce 28736 metric tons of mulberry Raw Silk from 283644 hectare of mulberry cultivation with productivity of 122.75 kg^{-1} ha (fig. 6-8).

Table 7: Model validation and forecasting of area, production and productivity of Mulberry silk in India

Year	Area (ha.) – ARIMA (0,2,2)		Production (MT) – ARIMA (0,2,1)		Productivity (Kg/ha.) - ARIMA (0,1,0)	
	Obs.	Pred.	Obs.	Pred.	Obs.	Pred.
2013-14	203000	187360	19476	19318	95.94	104.60
2014-15	220000	210123	21390	20145	97.23	99.74
2015-16		229843		22415		101.08
2020-21		283644		28736		122.75

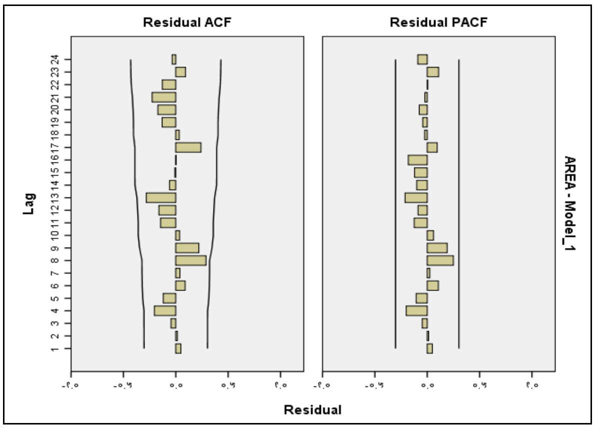


Figure 3: ACF and PACF Residuals of Area (Ha.)

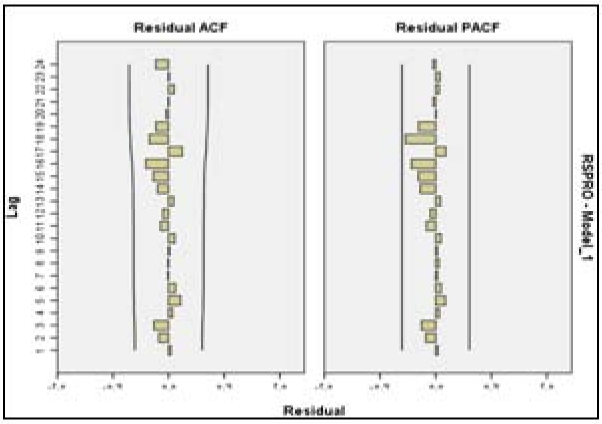


Figure 4: ACF & PACF Residuals of Production (MT)

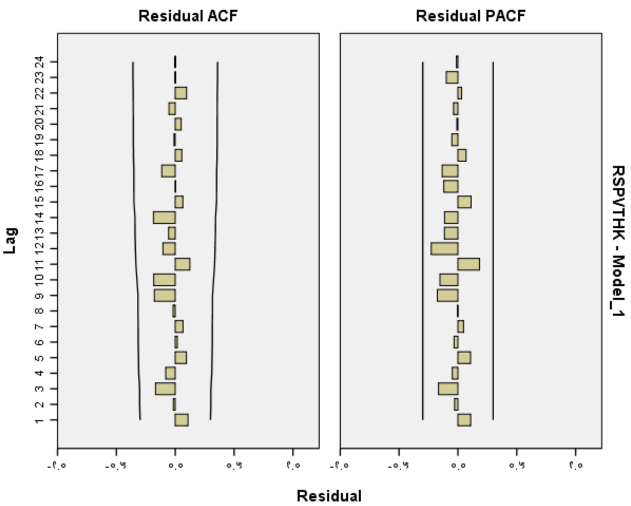


Figure 5: ACF & PACF Residuals of Productivity (kg^{-1}ha)

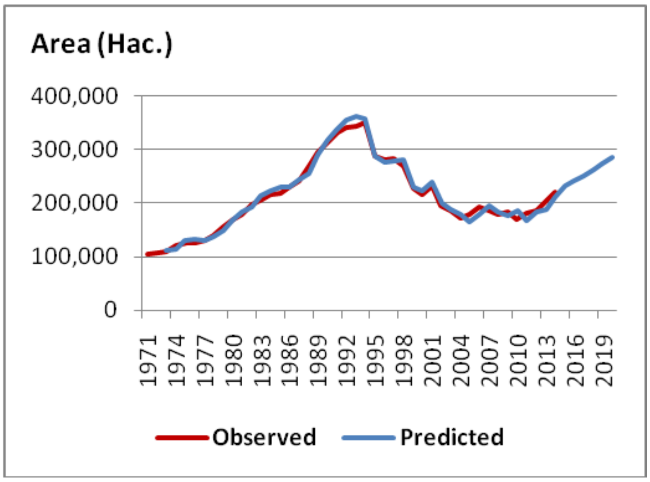


Figure 6: Observed and forecasted Area (ha)

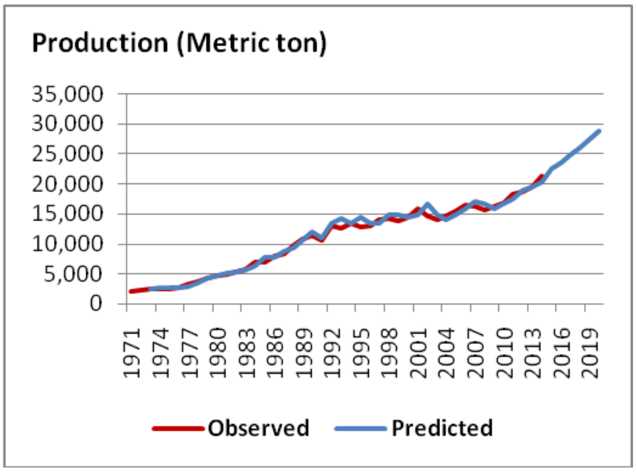


Figure 7: observed and forecasted production (MT)

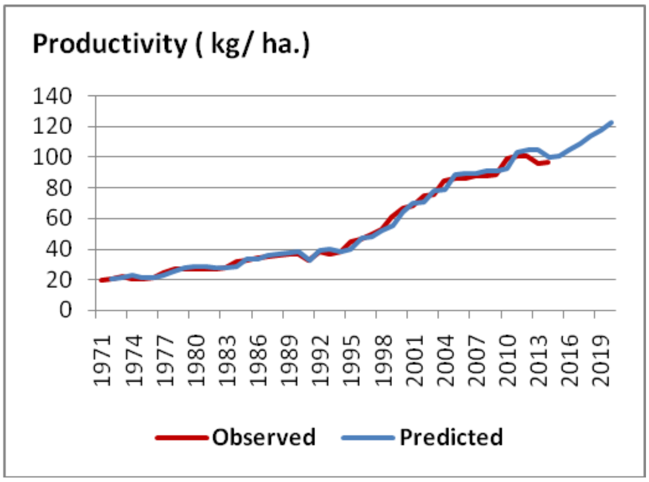


Figure 8: observed and Forecasted productivity (Kg/ha)

4. Conclusion

In this study, the growth analysis shows that mulberry cultivated area is on gradual decline in all the major silk producing states. The reason varies. Planners need to consider the growth trend & the associated reasons to streamline the silk industry in view of employment & foreign exchange generation. They also need to intensify the sericulture activity specific to area in order to maximize the productivity. We applied time series ARIMA models to forecast mulberry cultivated area, production and productivity of silk in India on the basis of past data 1991-2014. Models were selected on the basis of maximum R^2 value, lower value of BIC (Bayesian Information Criterions) and non-significant value of Ljung-Box Q statistics which is used for examining the autocorrelations and partial autocorrelations of the residuals of various orders. Based on the above criteria, it was found that best fitted models for area, production and productivity were ARIMA (0,2,2), ARIMA (0,2,1) and ARIMA (0,1,0). The forecast predict that in the year 2020 the mulberry cultivated area in India may increase to 283644 hectare i.e. about 29% more as compared to the year 2014-15. The estimated area may produce 28736 metric tons mulberry raw silk with productivity level of 122.75 Kg^{-1} ha. The model can be used by researchers for making area specific forecasts on different components of production in both mulberry & non-mulberry. However, it needs to be updated continuously with the incorporation of recent data and other components affecting production.

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