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A statistical study on pineapple in north-eastern states of India for sustainable policy development

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ABSTRACT

Pineapple (Ananas comosus (L.) Merr.) is considered to be one of the most important fruit crop of the world. Total annual world production is estimated at 14.6 million tons of fruits. India is the fifth largest producer of pineapple with an annual output of about 1.2 million tons (2013-14). In India Pineapple is also a very popular fruit crop. The important pineapple producing states are Assam, Kerala, Tripura, Andhra Pradesh, Bihar, Uttar Pradesh, West Bengal, Manipur, Meghalaya, and Mizoram. It is well established that Pineapple is a major agro product in almost all the states in North Eastern India. India producing overall 1736.74 thousand MT (2013-14) of Pineapple while the North Eastern states (Arunachal Pradesh, Assam, Manipur, Meghalaya, Nagaland, Mizoram, and Tripura) are producing 947.19 thousand MT (2013-14) i.e. more than 50 per cent of the total Indian production, even the area under production counts to 70.01thousand hectares which is nearly 64 per cent (approx.) of total Indian coverage which is 109.88 thousand hectares (2013-14). Thus research and analysis on pineapple statistics in the context of sustainable economic development of Northeastern states is very much relevant. The present paper includes a study on statistical information on pineapple for each of the Northeastern states of India. However, the area and production of the states are not much smooth over the time periods due to variations in climatic parameters specially rainfall. Segmented or piecewise regression analysis has been done and models are fitted to overcome the problem of interrupted time series data of pineapple. Such segmented regression analysis can be used to develop sustainable policies for improvement and overall development of entire Northeastern parts of the country.

***Keywords*:** Instability index, piecewise regression

1. Introduction

Pineapple (*Ananas comosus* L. Merr.) is probably originated from Latin American countries like Brazil and Paraguay. Pineapple is a well accepted fruit crop of the world. According to National Horticultural Board, Ministry of Agriculture, Govt. of India, pineapple is a major fruit crop in India and India is contributing nearly 10 per cent of the world pineapple production. More or less 19 to 20 states allover India are producing pineapple. Almost all states in North Eastern part of India are producing pineapple. Agro-climatic conditions of North Eastern part of India favours the most for pineapple production. As a result of that, this part is contributing nearly 54 per cent of the country's total production. The North Eastern Part of India thereby holds a significant position in pineapple scenario in India. In fact pineapple production in this part of the country surpasses the production of other states of India, except West Bengal, the state with highest pineapple production in the country. Excepting a few pockets lying in higher altitudes, pineapple is cultivated all most entirely in the North Eastern states. Predominant pineapple growing states of this part of the country are Assam, Tripura, Manipur, Arunachal Pradesh, Meghalaya and Nagaland. As pineapple is intensively and traditionally cultivated in all states (except Sikkim) of North Eastern India, it is very much relevant to study and examine the statistical dynamics of pineapple production of this area of the country. The statistics of horticultural crops in India has been published every year by National Horticultural Board, Ministry of Agriculture, Govt. of India. The useful data about any horticultural crop in India is available on these databases.

The scientific report through statistical analysis on all major horticultural crops based on such published data will be more relevant for socio- economic development of the country. Despite tremendous potentialities of pineapple in North Eastern states of India, statistical analysis of pineapple cultivation in the area is still lacking a lot. But such type of study is available in literature for many other agricultural crops all over the world which helps the planners and stake holders for future planning and development. Majumder et. al. (2004) reported the scenario of jute cultivation in West Bengal. Wasim (2011) presented an in- depth study on trends, growth and variability of major fruit crops in two different periods of Balochistan, Period I (1989-90 to 1998-99) and Period II (1999-00 to 2008-09). Major fruit crops were apple, grapes, pomegranate, dates, apricot, peach, plums and almonds. Verma *et al.* reported wheat yield modeling using remote sensing and agro- meteorological data in Haryana state.

Keeping in mind the importance of statistical study on pineapple in North Eastern states of India, the present study exposes an in depth statistical analysis on the database of pineapple cultivation (Area, Production and Productivity/Yield) with respect to different pineapple producing states of North Eastern states of India.

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2.0 MATERIALS AND METHODOLOGIES

The database of 23 years of area, production and productivity of pineapple crop in North Eastern states has been used except Mizoram and Tripura. The initial year is 1991-92 and latest is 2013-14. The data of Mizoram are not available and in case of Tripura available data starts from 2001-02 to 2013-14 (Source : Indian Horticultural database, published by National Horticultural Board, Ministry of Agriculture, Govt. of India, 2009 to 2014). The data of each state has undergone for analysis of descriptive statistics.

The instability of trend over years of pineapple area and production of the study states has also been examined through instability index (Wasim, 2011).

Instability Index (IX) is given as follows

IX = CV $(1\text{-}R^2)^{1/2}$, where CV is percentage value of coefficient of variation and R^2 is the adjusted correlation coefficient over the time- period under study. Larger the value of such index signifies that the parameter under study is not stable over the years and it may indicate a steady growth of the parameter under study over the years.

In many cases, crop yield variations over time can be modeled as linear trend, quadratic trend, or polynomial trend that have been explored by researchers (Just and Weninger**,** 1999). Piecewise regression model have been found to be useful (Skees *et al*., 1997) when critical breakpoint is present in yield pattern.

When analyzing a relationship of crop yield over time *t*, it may be apparent that for different ranges of *t*, different linear relationships occur for the yield. In addition to technological changes, these could also be due to government policy change to improve agricultural productivity. In these cases, a single linear function may not provide an adequate specification of the function. Piecewise linear regression may be a better representative function that allows multiple linear (or nonlinear) models to be fit to the data for different ranges of time. Breakpoints are the values of *t* (time) where the slope of the linear function changes. The value of the breakpoint may or may not be known in advance. In this study, breakpoint t (any year) is assumed to be known, although they are not same for all parameters (Area or Production or Productivity).

In other words, relationships that have different direction or magnitude of slopes at different time segments in the response variable with time, can be modeled using piecewise linear segments of models combined together that has different slopes for different time segments.

The parameters under study *i.e*., area, production and productivity of pineapple over all North Eastern states (except Tripura and Mizoram) have been studied by using methodology of segmented regression. The analysis has been done by using software SAS, ver. 9.0 (sponsored by project under NAIP, ICAR).

2.1 Database : A set of area, production and productivity data of pineapple for different states of North Eastern Part of India. Initial year of data is 1991-92 and it ends in 2013-14.

3.0 RESULTS AND DISCUSSION

The analysis is divided into three parts. The first part explains the statistical characteristics of different states of North East part of India for area, production and productivity separately. The second part explains the growth over time for area, production and productivity through instability index (IX) values of the same states mentioned above. Piecewise linear segments of models combined together that has different slopes for different time segments for area, production and productivity of entire North Eastern states together has been presented in the third part.

The production (in thousand MT) statistics of different North Eastern states of India has been presented in table 3.1. Among the states Assam has the maximum mean production. But maximum dispersion has also observed in case of Assam, revealed by Range and Standard Deviation. Coefficient of variation in percentage is maximum for Nagaland and is minimum for Assam and Meghalaya.

Table 3.2 presents the area statistics of the North Eastern States over the study period. Area under pineapple cultivation mean value over the years is the maximum for Assam followed by Manipur and Meghalaya. The reason may be the state with larger area and population. However, it is interesting to observe that despite lower population density Arunachal Pradesh has more area under pineapple cultivation than Nagaland or Tripura or Mizoram.

The results of table 3.3 show that maximum productivity is observed for Nagaland followed by Tripura and Assam. But the coefficient of variation is maximum for Nagaland and minimum for Assam and Meghalaya. It indicates that productivity is static for Assam and Meghalaya over the 23 years of study period.

Table 3.1: Production (in '000MT) statistics of pineapple for North Eastern states of India.

States	Arunachal Pradesh	Assam	Manipur	Meghalaya	Nagaland	Tripura
Mean	31.57	205.49	78.85	84.41	47.42	108.89
Standard Deviation	15.07	48.57	29.88	20.05	32.17	39.78
Kurtosis	1.96	11.22	0.84	8.32	1.92	1.93
Skewness	0.89	-2.60	-0.02	-2.04	1.15	-0.78
Range	64.01	273.00	127.01	107.17	140.09	151.70
Minimum	5.60	15.60	9.30	10.60	2.42	13.30
Maximum	69.61	288.60	136.31	117.77	142.50	165.00
CV(%)	47.73	23.64	37.89	23.75	67.84	36.53

Table 3.2: Area (in '000Ha) statistics of pineapple for North Eastern states of India.

States	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
Mean	7.43	13.36	9.45	9.40	1.23	2.86	5.79
Standard Deviation	2.80	2.04	2.46	0.78	1.02	2.26	2.60
Kurtosis	0.12	14.48	1.33	-0.02	-0.05	4.27	1.88
Skewness	-0.37	-3.39	-0.94	0.39	1.29	2.15	1.56
Range	11.20	11.30	10.50	2.90	2.60	8.00	8.10
Minimum	1.10	4.90	2.60	7.90	0.40	1.00	3.70
Maximum	12.30	16.20	13.10	10.80	3.00	9.00	11.80
CV(%)	37.63	15.27	26.03	8.31	82.90	79.11	44.93

Table 3.3: Productivity (MT Ha^{-1}) statistics of pineapple for North Eastern states of India.

States	Arunachal Pradesh	Assam	Manipur	Meghalaya	Mizoram	Nagaland	Tripura
Mean	4.23	15.15	9.99	9.16	6.44	18.51	16.52
Standard Deviation	0.69	1.39	9.31	0.70	1.00	9.19	5.49
Kurtosis	-0.12	8.56	21.51	-0.13	-1.89	-1.38	-1.40
Skewness	0.33	-2.30	4.57	0.39	-0.83	-0.02	-0.43
Range	2.50	7.50	48.10	3.00	2.13	30.93	14.17
Minimum	3.10	10.00	4.00	7.70	5.17	2.37	8.63
Maximum	5.60	17.50	52.10	10.70	7.30	33.30	22.80
CV(%)	16.24	9.19	93.24	7.62	15.47	49.64	33.26

Table 3.4: Instability index for production of different NE States

States	Period I (1991-2000)		Period II (2001- 2013)		Total Period	
	Cor. Coeff.(r)	IX	Cor. Coeff.(r)	IX	Cor. Coeff.(r)	IX
Arunachal Pradesh	0.94	13.53	0.35	40.67	0.65	36.97
Assam	0.93	2.70	0.02	32.12	0.12	24.02
Manipur	0.70	15.88	0.16	37.08	0.55	32.50
Meghalaya	0.54	7.02	0.06	31.02	0.22	23.72
Nagaland	0.96	19.05	0.47	69.82	0.40	63.58
Tripura			0.39	35.17		

Table 3.5: Instability index for area of different NE States

States	Period I (1991-2000)		Period II (2001- 2013)		Total Period	
	R^2	IX	R^2	IX	R^2	IX
Arunachal Pradesh	0.88	15.88	0.96	5.60	0.95	36.97
Assam	0.65	3.59	0.54	7.88	0.50	24.02
Manipur	0.88	8.96	0.46	25.25	0.59	32.50
Meghalaya	0.92	1.76	0.85	3.92	0.91	23.72
Nagaland	0.88	15.88	0.92	17.67	0.92	35.17
Tripura			0.96	5.60		

Table 3.6: Instability index for productivity of different NE States

States	Period I (1991-2000)		Period II (2001- 2013)		Total Period	
	R^2	IX	R^2	IX	R^2	IX
Arunachal Pradesh	0.69	8.07	0.22	17.08	0.53	14.05
Assam	0.75	3.04	0.54	4.17	0.80	3.66
Manipur	0.04	22.26	0.10	105.09	0.18	94.73
Meghalaya	0.07	6.56	0.65	5.62	0.56	6.09
Nagaland	0.77	26.52	0.54	41.96	0.42	45.56
Tripura			0.81	11.48		

Table 3.7: Piecewise regression analysis of NE states for pineapple production

Source	DF	Sum of Squares	Mean Square	F Value	Approx Pr > F
Model	3	259245	86414.9	72.62	<.0001
Error	19	22610.5	1190.0		
Corrected Total	22	281855			

Table 3.8: *Piecewise regression analysis of NE states for area under pineapple cultivation.*

Source	DF	Sum of Squares	Mean Square	F Value	Approx Pr > F
Model	3	828.1	276.0	20.58	<.0001
Error	19	254.8	13.4116		
Corrected Total	22	1083.0			

Table 3.9: Piecewise regression analysis of NE states for productivity of pineapple.

Source	DF	Sum of Squares	Mean Square	F Value	Approx Pr > F
Model	3	16.4273	5.4758	7.79	0.0014
Error	19	13.3635	0.7033		
Corrected Total	22	29.7908			

Instability index values of production of pineapple for different North Eastern states has been displayed in table 3.4. The results show that for the period-I (1991- 2000), the production of pineapple for all the North Eastern states is more or less static for Assam and Meghalaya. But Nagaland, Manipur and Arunachal Pradesh have much higher index values. But the indices increase rapidly in period-II (2001- 2013) for all the states. In comparison to the results of table 3.5, the area under pineapple is more or less similar to table 3.4.

Table 3.6 shows that productivity of pineapple increases abruptly for Manipur from period-I to Period-II. Changes are also observed for Arunachal Pradesh and Nagaland. But the index values are more or less same for Assam and Meghalaya.

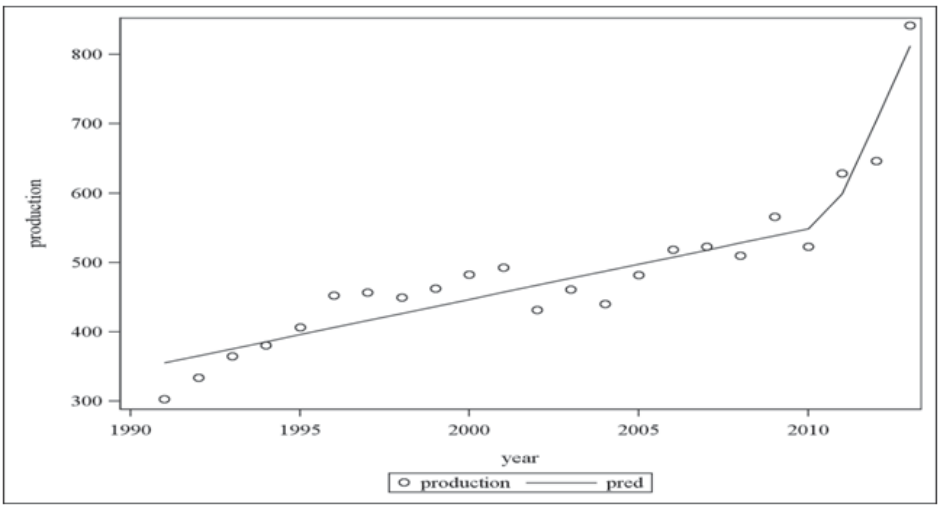

Fig. 1: Piecewise Regression lines for pineapple production of NE states

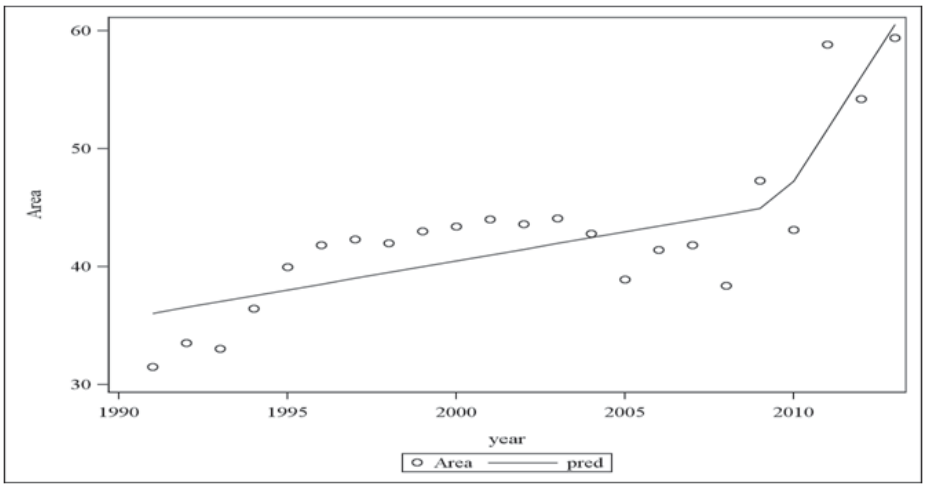

Fig. 2: Piecewise Regression lines for area under pineapple cultivation of NE states.

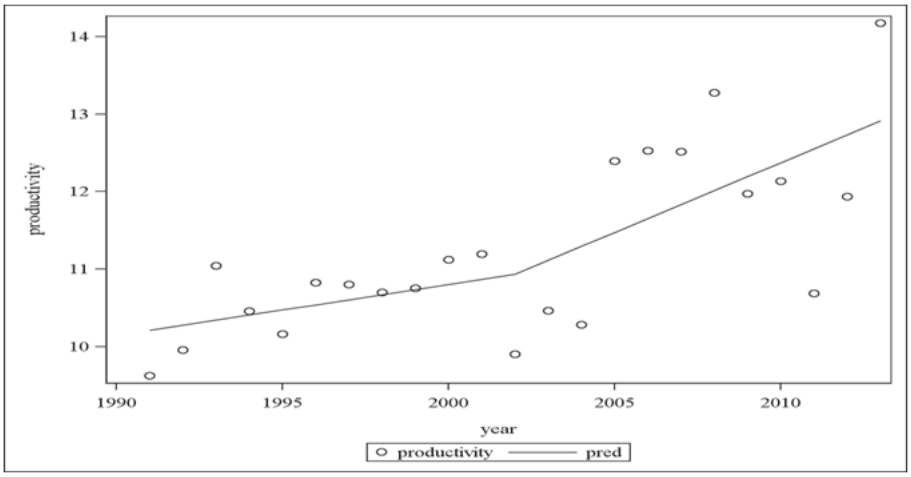

Fig. 3: Piecewise Regression lines for productivity of pineapple of NE states.

Table 3.7 shows the piecewise regression analysis of all North Eastern states for pineapple production. Model is significantly fit with observed data. The figure-1 shows that production of pineapple for entire North Eastern states jumps after 2010.

Table 3.8 shows the piecewise regression analysis of all North Eastern states for area under pineapple cultivation. Model is significantly fit with observed data. The figure-2 shows that area under pineapple for entire North Eastern states jumps also after 2010 similar to figure-1.

Table 3.9 shows the piecewise regression analysis of all North Eastern states for area under pineapple cultivation. Model is significantly fit with observed data. The figure 3 shows that productivity of pineapple for entire North Eastern states jumps also after 2002.

4.0 CONCLUSION

Pineapple is a well accepted crop of entire North Eastern part of India. Natural climatic conditions favour the cultivation of pineapple. However, the productivity of pineapple is far lower than other pineapple growing parts of the country. Improved varieties and improved cultivation practices will improve the total production of pineapple of the region which in turn will help the economic development of the entire area.

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