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Production forecasting of coconut: Variation in number of bearing palms and productivity in selected districts in India

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Abstract

Forecasting of coconut production in the country was attempted for three consecutive years from 2006-07. Stratified multistage sampling design was employed. At district level, forecasting of production was arrived by multiplying average predicted yield of palms with the 'harvested-area' of the crop in that district. Ratio estimator was constructed to obtain forecasting at different administrative levels. The all India forecasts of coconut production in the years 2006-07 to 2008-09 were obtained as 13448, 16331 and 14183 million nuts against the published values of 15840, 14743 and 15729 in order. On observing noticeable reduction in area under coconut in Kerala, the all India forecasting was revised as separately working out the forecasts for Kerala and rest of India and adding. By following this approach, the per cent difference of forecasts with published values were observed to be reduced from 15.1, -10.8, and 9.8 to 10.5, -5.2, and 6.0 in order in the years 2006-07 to 2008-09.

Keywords: Coconut, forecasting, production, yield

Introduction

Coconut is a principal crop in more than 30 districts in India especially those in the western and eastern coasts. The crop, once considered to be an indicator of wealth in these regions, is now largely neglected by the cultivators for lack of remunerative earnings and also owing to many structural and operational problems. Though the Government of India announces minimum support price for copra in the beginning of every crop year, the trade of coconut is observed to be taking place much below the price announced in many of the months in any given year and thereby depriving the benefit to many farmers.The fact that the cultivation of the crop is confined to a limited geographical area in the country affect the livelihood of a substantial proportion of people in these region of around 40 districts in four southern states *viz*., Kerala, Tamil Nadu, Karnataka and Andhra Pradesh. One of the limiting factors of effective market intervention is non-availability of production statistics well in time. There is no scheme in operation for making coconut production forecasting in the country. Further, the coconut statistics are published only after several months from the end of an agricultural-year by the Ministry of Agriculture, Government of India. On the other hand, certain traders and processing companies do engage in assessing the production of coconut in a limited scale/region and take advantage for procurement plans.The need of production forecasting of coconut was thus felt by many agencies and Central Plantation Crops Research Institute (CPCRI), Kasaragod in collaboration with Coconut Development Board, Kochi conducted a series of studies during the period 2006 to 2008. Muralidharan *et al*. (2008) published the results pertaining to the forecasting for the year 2006-07. Forecasting made in the three consecutive years (2006-07 to 2008-09) along with comparison of published statistics are reported in this paper. The

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factors influencing the forecasting as well as the variation observed for yield and number of bearing palms in the selected coconut growing districts are also discussed.

Materials and methods

The study used a stratified sampling design for collecting yield data from selected palms. At district level, forecasting of production was arrived by multiplying average predicted yield of palms with the 'harvested-area' of the crop in that district. Ratio estimator was constructed to obtain forecasting at different administrative levels.

Sampling design

The study was confined to the four southern states *viz*., Kerala, Karnataka, Tamil Nadu, and Andhra Pradesh. These four states account for 90 per cent of total area of 1.9 million hectares under the crop and contribute 94 per cent of coconut production in India. The pattern of area covered under coconut is different among these states. In Kerala, it is a homestead crop and is the principal crop in 12 out of 14 distrcts of the state. The production of coconut in the southern districts of Kerala is adversely affected by the spread of root (wilt) disease. Hence, it was decided to form two strata *viz*., the southern and northern regions, from Kerala. In Tamil Nadu, the crop is cultivated in many districts but within a district the cultivation is chiefly confined to certain specific regions. Around 20 per cent of the state's production is from Coimbatore district. In Karnataka, the crop density varied widely according to the intercrops cultivated by the farmers. The district, Tumkur account for more than 30 per cent of the production in the state. The coconut cultivation in Andhra Pradesh is limited to five districts of which the East Godavari account for over 50 per cent of production from the state. Planting of coconut trees on the bunds of paddy field and sides of fish ponds is very common in Andhra Pradesh. The two regions (southern and northern) of Kerala and the other three states constituted the five strata formed for the study.

Selection of palms was done following multistage sampling. A total of 17 districts were selected in the first stage from the five strata. The sample size for a stratum was allocated according to the area under coconut in that stratum with a restriction that at least 2 districts are selected from a stratum. Accordingly, the sample size was fixed as 4 for the two regions of Kerala and Tamil Nadu, 3 for Karnataka, and 2 for Andhra Pradesh. Selection of districts within a stratum was done with probability proportional to area under coconut for which the procedure of SPSS v.16.0 was used.

In the second stage, a total of 174 panchayats were selected from the 17 districts. The sample size for the second stage was fixed according to area under coconut in the selected districts; 12 panchayats each from districts having more than 80,000 ha area under coconut, 10 panchayats from districts having area between 40,000 and 80,000 ha and 8 panchayats from districts having less than 40,000 ha area under coconut. Number of panchayats selected from the districts is shown in Table 4.

Cluster sampling was followed in the third stage mainly to estimate number of bearing palms ha^{-1}. A group of four adjacent coconut holdings (each holding with atleast 0.2 ha area and having alteast 15 bearing palms) formed a cluster. Four non-overlapping clusters were selected from each panchayat included in the sample. Four wards were selected at random for this purpose and formed one cluster each in the selected ward. Complete enumeration of palms in the cluster was done and numbers of palms under different growth stages (*i.e*., juvenile, bearing palms, and palms in bearing stage but without any nuts on the crown) were obtained.

For assessing the production, from each of the four holdings in a cluster, four palms were selected (*i.e*., 16 palms from a cluster). Selection of palms was done by randomly selecting a bearing palm followed by selecting three more adjacent palms. From these selected palms, number of nuts on all bunches in the crown was recorded starting from the most matured bunch upwards. Bunches having nuts below fist-size is indicated separately. Skilled coconut-climbers were engaged for data collection. In all the three years, sample units of first and second stages remained the same, but clusters were selected afresh every year.

Analysis

The methodology developed by Mathew *et al*. (2001) for predicting the annual yield of coconut

based on number of nuts available in the crown was slightly modified and applied in this study. Modified prediction equation was reported by Muralidharan *et al*. (2001). The prediction equation involves first obtaining the total number of above-fist size nuts and below-fist size nuts and then summing after making certain allowance for probable loss of nuts.

Under normal circumstances, all nuts of above-fist size are likely to be retained in the bunches till maturity. Hence, contribution from such bunches (restricted to first 8 bunches) towards the annual yield was taken as 100 per cent. The mean and standard deviation of number nuts in these bunches will be denoted by Afm and Afcd. In certain palms, more than 8 bunches in the above-fist size category may be available. In that case, contribution towards annual yield was taken as 80 per cent of nuts in such bunches or Afm + 2*Afcd, whichever is the minimum. It is an approximation, keeping in view that such bunches may shed nuts in due course of time. With respect to bunches having nuts of below-fist size, 40 per cent of nuts in that bunch or Afm + 2*Afcd, whichever is the minimum was taken as contribution towards annual yield.

Based on predicted yield of selected palms in a cluster, the average per palm yield expected in that cluster was worked out. Multiplying the predicted yield per palm with the number of bearing palms per ha in that cluster (*i.e*., after excluding adult palms with barren/nil bunches) gives the productivity in that location. The district level estimate of productivity was then obtained as the average for the selected locations across the selected panchayats in that district. Multiplying the average productivity thus obtained with 'harvested-area' (derived from secondary source) gives the production forecast in that district.

Data exploring techniques *viz*., box plot and stem-and-leaves plot and summary statistics as provided in SPSS v.13.0 were used to check errors in the data, if any. The standard errors (SE) of the estimates were worked out based on the assumptions that the population size is constant across districts and contribution to SE from sampling at third stage is negligible (Cochran, 1977).

The all India forecast of coconut production is obtained in two stages. Forecast for the four major coconuts growing states were obtained first and then for the entire country. Ratio estimator was used for estimation. The components of the ratio estimator are: (1) the value obtained from the current years' sample, denoted by y; (2) value at the reference point of time with regard to the sample, denoted by x; and (3) value for the whole population/stratum at the reference point, denoted by X. The ratio estimator is then obtained as X (y/x). The average production for the period 1999-00 to 2003-04 was taken as the known previous value for the construction of ratio estimator for the year 2006-07. For subsequent years the preceding years' forecast constituted the reference value.

Results and discussion

Predicted yield of palm

The average predicted yield per palm along with per cent standard error (% SE) in the selected districts is shown in Table 1. Palms yielding more than 120 nuts in the case of Kerala and 150 nuts in other places were treated as outliers; 8 per cent palms were treated as outliers in the year 2006-07, 10 per cent in 2007-08 and 2.9 per cent in 2008-09.

Table 1. District wise predicted yield per palm in the selected districts (% SE is shown in the parenthesis)

District	Predicted yield (number of nuts) per palm		
	2006-07	2007-08	2008-09
Thiruvananthapuram	42.3 (17.6)	53.2 (54.7)	43.8 (29.5)
Kollam	42.1 (10.3)	37.4 (53.8)	46.2 (18.0)
Alappuzha	51.0 (28.4)	46.3 (58.5)	40.8 (15.9)
Thrissur	50.9 (37.4)	53.8 (40.2)	48.1 (19.6)
Malappuram	45.4 (26.5)	57.1 (42.7)	50.2 (27.8)
Kozhikode	52.0 (12.0)	63.8 (55.5)	54.1 (23.1)
Kannur	49.3 (22.2)	56.1 (78.1)	53.5 (35.4)
Kasaragod	66.6 (29.9)	53.9 (40.5)	52.3 (29.6)
Hassan	80.0 (31.8)	66.6 (56.4)	75.1 (17.0)
Tumkur	78.5 (20.1)	95.0 (24.1)	62.3 (22.7)
Chitradurga	70.0 (28.6)	87.0 (53.9)	94.1 (21.1)
Coimbatore	92.4 (38.2)	87.0 (40.4)	80.3 (17.7)
Tanjavur	90.7 (16.0)	72.0 (66.7)	99.3 (16.9)
Tirunelveli	64.1 (21.5)	68.6 (36.7)	73.1 (26.0)
Dharmapuri	71.6 (44.9)	60.3 (45.9)	67.0 (20.3)
East Godawari	77.5 (22.6)	75.1 (42.4)	65.1 (58.1)
West Godawari	69.7 (24.6)	59.3 (75.2)	70.7 (64.0)

As expected, the average per palm yield varied between years but on ranking it was observed that the position of many districts have not changed much, not beyond four positions. The per cent

standard error (% SE) of average per palm yield varied between 12 per cent (Kozhikode) and 44.9 per cent (Dharmapuri) in the year 2006-07. It varied between 36.7 per cent (Thirunelveli) and 78 per cent (Kannur) in 2007-08. In the year 2008-09 per cent SE varied between 16.9 and 64 per cent. Large value of SE may be attributed from the non-sampling errors (*i.e*., error in prediction as well as recording of observations). It is also observed that the per cent SE at panchayat level is relatively low: Only in 3 panchayats the per cent SE was more than 30 per cent (not shown in the Table). In 40 per cent of the panchayats, per cent SE was less than 10 per cent and in 46 per cent panchayats it was between 10 and 20 per cent. Variation between panchayats was more in Tanjavur, Coimbatore and Dharmapuri districts where the per cent SE ranged up to 41, 34 and 30 per cent respectively.

Table 2. Productivity (number of nuts ha^{-1}) estimated in the selected districts. Figures in the parenthesis are average number of bearing palms per hectare

District	2006-07	2007-08	2008-09
Thiruvananthapuram	6000 (168)	8279 (164)	6080 (105)
Kollam	3953 (114)	4259 (117)	5465 (117)
Alappuzha	4724 (98)	6397 (128)	4283 (139)
Thrissur	7599 (160)	8381 (158)	5992 (126)
Malappuram	5986 (141)	9012 (158)	6953 (136)
Kozhikode	6330 (141)	9700 (152)	7932 (147)
Kannur	6621 (148)	8638 (154)	7872 (147)
Kasaragod	8531 (143)	7717 (143)	7093 (139)
Hassan	7846 (119)	6338 (96)	8266 (109)
Tumkur	9686 (144)	9181 (97)	7019 (112)
Chitradurga	6620 (110)	9477 (109)	9771 (104)
Coimbatore	15657 (163)	14919 (172)	13691 (165)
Tanjavur	15657 (180)	12353 (174)	16607 (173)
Tirunelveli	10588 (202)	12487 (184)	12593 (144)
Dharmapuri	11527 (181)	10304 (172)	9664 (167)
East Godawari	10466 (159)	10442 (146)	10332 (162)
West Godawari	9520 (154)	8009 (136)	10908 (159)

Productivity

As indicated earlier, productivity in a location was worked out by multiplying the number of yielding palms per hectare in that location by respective average per palm predicted yield. For, palm density was first worked out by dividing the total number of palms in the selected holdings in a location with respective area. In general, the palm density was observed to be more in marginal and sub marginal holdings compared to that of medium or large holdings and hence likely to over estimate the same. Therefore, while estimating the palm density in a location, holdings with palm density more than 300 and also holdings with very less number of palms were removed. Percentages of bearing palms, juvenile palms and adult palms without any nuts on the crown were worked out based on the data recorded for 100 palms per location. There was noticeable variation for average number of bearing palms per hectare in certain districts over the years (Table 2); more prominently in five districts *viz*., Thiruvananthapuram, Thriunelveli, Tumkur, Alappuzha, and Thrissur. Sampling error is the major source of this variation besides lack of accuracy while recording the area covered. Area of the plot was recorded by interviewing the farmer.

The average productivity worked out for the selected districts is shown in Table 2. It varied between 3953 nuts ha^{-1} in Kollam to 15657 in Coimbatore and Tanjavur districts in the year 2006-07. In 2007-08 Kollam ranked lowest with a productivity of 4259 nuts ha^{-1} and Coimbatore ranked the highest (14919). The productivity ranged between 4283 (Alappuzha) and 16607 (Tanjavur) in 2008-09.

Comparison of the estimated productivity with that of published productivity by Directorate of Economics and Statistics was attempted and presented in Table 3. In all the years in almost 50 per cent of the districts the estimate was more than that of published values. The productivity in all the three districts of Karanataka was obtained to be much higher than the published values in 2006-07 and 2007-08. The highest difference of -96.3 per cent was observed in Tumkur district in 2006-07. The difference was observed to be less than 10 per cent in five districts in the first two years and three districts in 2008-09.

District level forecasting

The 'harvest-area' of the crop is multiplied with expected productivity to obtain the forecasting of coconut production at district level. The area statistics over the years were made use of to derive the harvest-area. While making the forecast for the year 2006-07 (*i.e*., September 2006), crop statistics for all states/districts was available only up to

Table 3. Percentage difference of estimated productivity over the official statistics published

District	2006-07	2007-08	2008-09
Thiruvananthapuram	22.9	-6.8	27.4
Kollam	49.5	34.0	28.0
Alappuzha	36.1	6.5	39.5
Thrissur	-5.6	-19.1	13.4
Malappuram	21.8	-13.4	22.7
Kozhikode	0.6	-40.1	-1.7
Kannur	5.5	-28.2	-22.3
Kasaragod	-25.8	1.1	15.6
Hassan	-89.0	-32.0	-47.3
Tumkur	-96.3	-66.7	6.4
Chitradurga	-50.8	-86.1	-42.6
Coimbatore	-10.0	0.0	-22.0
Tanjavur	-7.9	19.9	2.8
Tirunelveli	39.9	13.8	-37.5
Dharmapuri	33.0	35.7	30.8
East Godawari	15.3	12.6	-3.2
West Godawari	43.8	10.0	-34.0

2003-04. In other words, data prior to two years were only available for making the forecasting in any year.

Based on the pattern of changes in area under coconut over the years, the harvested area was derived. For the districts of Kerala, where area under coconut is not showing any increasing trend for the past 10 years, the average area for the past five years was taken as the harvested area. In all the other districts, average area for five years prior to 8 years was used as the harvest-area to account for newly established gardens that are not in the bearing stage. With regard to Dharmapuri district, combined area of undivided district was used. The derived harvested area used for arriving the district wise forecasting is shown in Table 4 along with the district wise forecasting of coconut production for the years 2007 to 2008.

The forecasting of production made for the year 2006-07 was found to be lower than the published figures for 12 out of the 17 selected districts. It was more in Dharmapuri (70%), West Godawari (47%) and Kollam (41%). The published statistics was lower than the forecast (-25 to 47%) in all the three selected districts of Karnataka. In the year 2007-08, forecasted values were more in 9 districts and in 2008-09 it was so in 10 districts.

In all the three years the forecast for Dharmapuri district was lower than published statistics (37-70%). The forecast for the year 2008-09 was noticeably high in three districts of Kerala *viz*., Kannur (87%), Thrissur (41%) and Kozhikode (40%). The area under coconut is declining in all the districts of Kerala and the harvested area used for forecasting was not realistic. The harvested area

Table 4. Harvested area used and forecasted production of coconut for the period 2006-07 to 2008-09

District	No. of panchayaths*	Harvested area ('000 ha)#		Forecasting (million nuts)		
		2006 & 2007	2008-09	2006-07	2007-08	2008-09
Thiruvananthapuram	12	89.40	83.65	536.4	740.2	508.6
Kollam	10	76.30	67.30	301.6	325.0	367.8
Alappuzha	10	58.42	54.52	276.0	373.7	233.6
Thrissur	12	86.10	85.68	654.3	721.6	513.5
Malappuram	12	105.64	111.13	632.5	952.1	772.8
Kozhikode	12	129.36	129.11	818.9	1254.8	1024.1
Kannur	12	95.46	93.87	632.0	824.6	739.0
Kasaragod	10	55.47	57.66	473.3	428.1	409.0
Hassan	10	48.00	49.82	376.9	304.5	411.8
Tumkur	12	80.40	92.82	778.5	737.9	651.5
Chitradurga	8	38.20	38.70	252.8	361.8	378.1
Coimbatore	12	74.50	86.26	1166.4	1111.4	1181.0
Tanjavur	8	22.30	22.14	348.7	275.1	367.7
Dharmapuri	8	20.80	14.00	239.4	161.1	176.3
Tirunelveli	8	12.90	20.30	127.1	214.0	196.2
East Godawari	10	48.50	47.94	507.3	506.2	495.3
West Godawari	8	21.30	20.76	203.0	170.8	226.5

*Number of panchayats selected in the second stage.

#For districts from Kerala, average area refers to the period 1999-00 to 2003-04 and 2002-03 to 2006-07 in order. For all other districts it is for the period 1995-96 to 1999-00 and 1998-99 to 2002-03. Dharmapuri district refers to the combined area of Dharmagiri and Krishnagiri districts.

is taken as the average of area reported for the period 2002-03 to 2006-07 to make the forecast for the year 2008-09. In comparison with the aforesaid harvested area, a reduction in area under coconut to the tune of 5 to 40 per cent was noticed in the districts of Kerala in the year 2008-09. A situation of this kind may not be very common in plantation crops and the area under the crop would get stabilized in near future. The production when worked out with the estimated productivity and actual area reported for the year 2008-09 was found to be lower than the published figures by 39.4, 27.9, 27.3, 22.7, 15.5, and 13.3 per cent respectively in Alappuzha, Kollam, Thiruvananthapuram, Malappuram, Kasaragod and Thrissur districts. It was higher by 22.3 and 1.7 per cent in Kannur and Kozhikode districts respectively.

All India forecast of coconut production

The production forecast obtained for the major coconut growing states and India are shown in Table 5. The forecast was 41.2 per cent more than the published production of Karnataka state in 2006-07 and less by 33.7 per cent in Andhra Pradesh. In Tamil Nadu and Kerala it was more by 7.3 and 14.8 per cent respectively. The difference in forecast and published figures narrowed down in the subsequent years. In 2007-08, forecasted production was 5.1 and 25.2 per cent more in Tamil Nadu and Andhra Pradesh but less by 11.6 and 18.1 per cent in Karnataka and Kerala. In the year 2008-09 the forecasting was more close to the published figures. It was more by 10.0, 15.9 and 5.3 per cent in Kerala, Tamil Nadu and Andhra Pradesh and less by 2.4 per cent in Karnataka. One reason for higher value of production forecast for Kerala is the continuous decline in area under coconut. Further, the loss of palms due to bud rot in a few panchayats of Kozhikode, Kannur and Kasaragod districts might not have reflected proportionately while estimating the productivity and production.

With an assumption that the overall change in the entire country is similar to that in the major coconut growing states (which cover 82%), the all India forecasts of coconut production in the years 2006-07 to 2008-09 were obtained as 13448, 16331 and 14183 million nuts against the published values of 15840, 14743 and 15729 in order. On observing considerable reduction in area under coconut in Kerala and its reflection in produciton, it was decided to estimate the production in Kerala and rest of India separately and then added to get the all India production forecast. Accordingly the forecasting for the years 2006-07 to 2008-09 were obtained as 14179, 15510 and 14781 million nuts in order. The per cent difference of forecasts with published values was reduced from 15.1, -10.8 and 9.8 to 10.5, -5.2 and 6.0 in order in the years 2006-07 to 2008-09.

Conclusion

The method of forecasting of coconut production is a function of predicted yield of selected palms, estimated number of 'yielding' palms per hectare, harvested area calculated from past data and the published production statistics available at the time of forecasting (which is a part of ratio estimator). Sampling and non-sampling errors are bound to be associated with values of the aforesaid arguments. It is evident from this study that on using most recent statistics on area and production and employing data exploring techniques to remove outliers from the sample considered, it is possible to arrive forecasting within 10 per cent accuracy (in relation to published statistics).

Table 5. Forecasted and published production of coconut (in million nuts) in the major growing states

State	2006-07		2007-08		2008-09	
	Forecast	Published	Forecast	Published	Forecast	Published
Kerala	5223	6054	6664	5641	5223	5802
Tamil Nadu	4510	5429	4714	4968	4510	5365
Karnataka	2228	1635	2302	2063	2228	2176
Andhra Pradesh	918	1326	837	1119	919	970
India (ratio estimate)	13448	-	16331	-	14183	-
India (sum of two ratio estimates: Kerala and rest)	14179	15840	15510	14743	14781	15729

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