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Growth Performance of Major Crops – An Economic Analysis

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ABSTRACT: Agriculture is the backbone of Indian economy and the better performance of the agriculture sector is crucial for inclusive growth. Tamil Nadu has been historically an agriculture state, while its advances in other fields transformed into being an industrialized and innovation based economy, leading to competition for land and its resources. The village economy has changed from subsistence to cash economy. Farmers now cultivate commercial crops and produce more by adopting new agricultural innovations. Given the importance of the changing scenarios in the cropping pattern, this study was undertaken to analyse the growth performance of major crops, in terms of area, production, productivity over the years and to examine the dynamic changes in the cropping pattern in the study area. This study has been confined to the *erstwhile* South Arcot district and the major crop categories have been considered for the analysis. All the required time series data was collected from the published sources for a period of 47 years, from 1970-71 to 2016-17. The compound growth rates of area under major crops, production and productivity were estimated by using exponential function and Markov chain analysis was also used to study the dynamic changes in the cropping pattern.

The results indicated that in general, the performance of many crops in terms of area, production and productivity, had a declining trend in the post-liberalization period in the district. Also, cereals were found to be highly stable in the district and could retain as high as 39 per cent followed by oilseeds, millets, sugar crops and horticultural crops.

The study also revealed that the area under horticultural crops is increasing at a faster rate over the periods in the study area, which is a good sign of development. Therefore, it is necessary to subsidize the cultivation expenses of farmers and motivate them by continuing some of the existing programmes. Such a measure would help in increasing the production and enhance the export potentials of these crops.

KEYWORDS: Area, Production, Productivity, Dynamic changes.

I. INTRODUCTION

Agriculture is the backbone of Indian economy and the better performance of the agriculture sector is crucial for inclusive growth (World Bank, 2006). This sector at present contributes only 17.32 per cent of the GDP, while it provides employment to 42.74 per cent of the Indian work force. Moreover, the forward and backward linkage effects of agriculture growth have positive effects on other sectors as well. A good performance of the agriculture sector is viewed as an effective instrument for attainment of inclusive economic growth and poverty reduction.

Tamil Nadu has been historically an agriculture state, while its advances in other fields transformed into being an industrialized and innovation based economy, leading to competition for land and its resources. In Tamil Nadu, the per capita availability of land is only 0.18 ha, while the per capita net sown area is only 0.07 hectare. Even though the share of agricultural sector in the State Domestic Product of Tamil Nadu has declined from about 52 per cent to 7.93 per cent between 1960-61 and 2016-17, agriculture continues to be a major source of livelihood for the rural people. The village economy has changed from subsistence to cash economy. Farmers now cultivate commercial crops and produce more by adopting new agricultural innovations. Given the importance of changing scenarios in the cropping pattern, this



study was undertaken to analyse the growth performance of major crops, in terms of area, production, productivity over the years and to examine the dynamic changes in the cropping pattern in the study area.

II. MATERIALS AND METHODS

This study has been confined to the *erstwhile* South Arcot district and the major crop categories, namely, cereals, millets, pulses, oilseeds, fiber crops, sugar crops, tuber crops, vegetables, fruits, flowers, plantation crops, spices and tree crops have been considered to evaluate the performance of major crops. All the required time series data was collected from the published sources for a period of 47 years, from 1970-71 to 2016-17, and it has further been divided into two sub periods, namely, pre-liberalisation period (1970-71 to 1991-92) and post-liberalisation period (1992-93 to 2016-17). The time series data for the period before 1993 (i.e., before bifurcation of districts) was pertaining to the *erstwhile* South Arcot district and for the period after 1993 (i.e., after bifurcation of districts), the clubbed data of Cuddalore and Villupuram districts was considered.

III. TOOLS OF ANALYSIS

Growth Rate Analysis

The compound growth rates of area under major crops, production and productivity were estimated to capture the changes in the agrarian structure. Exponential function of following form was used to estimate the growth rates.

$$Y_t = Y_0 (1+r)^t \text{----- (1)}$$

Where,

Y_t = Area under the crop at time t (ha)

r = Compound rate of growth of Y

Y_0 = Initial year area under the crop (ha)

By taking natural logarithm of (1),

$$\ln Y_t = \ln Y_0 + t \ln (1+r) \text{----- (2)}$$

Now letting,

$$\beta_1 = \ln Y_0$$

$$\beta_2 = \ln (1+r)$$

Equation (2) can be written as

$$\ln Y_t = \beta_1 + \beta_2 t \text{----- (3)}$$

Adding the disturbance term to (3), it can be written as

$$\ln Y_t = \beta_1 + \beta_2 t + U_i$$

Y_t = Area under crop at time 't' (ha)

t = time in years

β_1 = constant term

β_2 = regression co-efficient

This log linear function was fitted by using Ordinary Least Square (OLS) method. The compound growth rate (r) was obtained using the formula.

$$r = (\text{Antilog of } \beta_2 - 1) \times 100$$

In the same way, the growth rates were estimated for production and productivity of these major crop categories also.

Markov Chain Analysis

The dynamics in direction of area under crop categories were analyzed using the first order Markov chain approach using LINGO software. Central to Markov chain analysis is the estimation of the transitional probability



matrix ‘P’ whose elements, P_{ij} indicate the probability (share) of crop categories switching from i^{th} crop category to j^{th} crop category over time. The diagonal element P_{ij} , where $i=j$, represents the retention share of respective crop category in terms of area under crops.

This can be denoted algebraically as

$$E_{jt} = \sum_{i=1}^n (E_{it-1}) P_{ij} + e_{jt} \quad (4)$$

Where,

E_{jt} = Area under crop category to the j^{th} crop in the year t

E_{it-1} = Area under i^{th} crop category during the year t-1

P_{ij} = The probability of shift in area under i^{th} crop category to j^{th} crop category e_{jt} = The error term which is statistically independent of E_{it-1}

n = The number of crop categories

The transitional probabilities P_{ij} , which can be arranged in a (m x n) matrix, have the following properties:

$$\sum_{i=1}^n P_{ij} = 1 \quad \text{And} \quad 0 \leq P_{ij} \leq 1$$

Thus, the expected share of each crop category during period ‘t’ is obtained by multiplying the share of these crop categories in the previous period (t-1) with the transitional probability matrix.

The transitional probability matrix is estimated using linear programming (LP) framework by a method referred to as minimization of Mean Absolute Deviation (MAD), the formulation is stated as

$$\text{Min, } OP^* + I e$$

Subject to,

$$X P^* + V = Y$$

$$GP^* = 1$$

$$P^* \geq 0$$

Where,

P^* is a vector of the transitional probabilities P_{ij} to be estimated

O is the vector of zeros

I is an appropriately dimensional vector of areas

e is the vector of absolute errors

Y is the proportion of area to each crop category.

X is a block diagonal matrix of lagged values of Y

V is the vector of errors

G is a grouping matrix to add the row elements of P arranged in P^* to unity.

IV.RESULTS AND DISCUSSION

1. PERFORMANCE OF MAJOR CROP CATEGORIES

Performance of crops is usually expressed at macro level and it has a significant bearing on the social and economic aspects of rural households. The technological advancement in crop varieties and other yield increasing factors of production influence the farmers’ decision to go for high value crops. Hence, the performance of different crops in the study area is discussed in terms of area, production and productivity. The major crop categories considered for the analysis were cereals, millets, pulses, oilseeds, fiber crops, sugar crops, tuber crops, vegetables, fruits, flowers, plantation crops, spices and tree crops.

Growth Performance of Area under Major Crop Categories

The results of the growth rates in area under major crop categories are presented in Table 1.

It could also be observed from Table 1 that the growth rates of area under tuber crops (9.97 per cent), tree crops (6.72 per cent), pulses (5.97 per cent), sugar crops (5.55 per cent), fiber crops (4.81 per cent) and fruits (4.60 per cent) were found to be positively significant in the *erstwhile* South Arcot district, during pre-liberalisation period, whereas the growth in area under millets (8.61 per cent) was negatively significant. Cereals have also decreased marginally by one per cent. The area under oilseeds, vegetables, plantation crops, flowers and spices showed marginal

increasing growth rates by, i.e., 0.30 per cent, 0.60 per cent, 2.02 per cent, 3.05 per cent and 4.19 per cent, respectively, during pre-liberalisation period.

Table 1. Growth Rates in Area of Major Crop Categories, 1970-71 to 2016-17

S. No	Major Crop Categories	Pre- Liberalisation Period (1970-71 to 1991-92)	Post- Liberalisation Period (1992-93 to 2016-17)	Over all Period (1970-2017)
1.	Cereals	-1.00	1.31	1.05
2.	Millets	-8.61**	-10.42**	-4.87**
3.	Pulses	5.97**	2.22	3.04***
4.	Oilseeds	0.30	-6.76**	-2.95***
5.	Fiber crops	4.81**	-18.13**	0.70
6.	Sugar crops	5.55**	3.15***	4.08**
7.	Tuber crops	9.97**	0.20	3.56**
8.	Vegetables	0.60	-2.96	0.70
9.	Fruits	4.60**	1.71	4.49**
10.	Flowers	3.05	3.87**	4.18**
11.	Plantation crops	2.02	13.43**	9.85**
12.	Spices	4.19	-3.92	0.01
13.	Tree crops	6.72**	4.39**	2.63***

(** and *** indicate significance at 5 per cent and 1 per cent levels respectively)

In the post-liberalisation period, the growth in the area under plantation crops (13.43 per cent), tree crops (4.39 per cent), flowers (3.87 per cent) and sugar crops (3.15 per cent) were positively significant. While, the growth in area under fiber crops (18.13 per cent), millets (10.42 per cent) and oilseeds (6.76 per cent) were negatively significant in the district. The area under cereals, pulses, tuber crops and fruits has increased by 1.31 per cent, 2.22 per cent, 0.20 per cent and 1.71 per cent, while the area under vegetables and spices has decreased by 2.96 per cent and 3.92 per cent, respectively, during the post-liberalisation period in the *erstwhile* South Arcot district.

During the overall period, the growth trends in area under plantation crops (9.85 per cent), fruits (4.49 per cent), flowers (4.18 per cent), sugar crops (4.08 per cent), tuber crops (3.56 per cent), pulses (3.04 per cent), and tree crops (2.63 per cent) were found to be positively significant, while the growth in the area under millets (4.87 per cent) and oilseeds (2.95 per cent) were negatively significant. Also, the area under spices has increased marginally by 0.01 per cent, cereals by 1.05 per cent, fiber crops and vegetables by 0.70 per cent each, in the district.

Based on the growth rate estimates of area under major crop categories in the study area, it is evident that the crops which are having the major share in the total cropped area, viz., millets and oilseeds have grown negatively in the district, almost in all the periods. The cereal crops which are having the highest share in the total cropped area had a negligible positive growth rate during the study period. However, the crops having the least share like sugar crops, tuber crops, vegetables, fruits, flowers, plantation crops and tree crops have grown positively over the years. Hence, it could be concluded that the cropping pattern has been changed in favour of these horticultural crops in the study area. Among these crops, the plantation crops had a significant growth rate in the study area.

So also, the growth in area under sugar crops was highly significant in the *erstwhile* South Arcot district, might be due to the increase in the number of sugar mills located in the area and also the increase in the procurement price of sugarcane over the years. It is also noted that the crops like oilseeds, fibers and millets were given less importance, as it had a sharp decline in the area.

Growth Performance in Production of Major Crop Categories

The results of the growth rates in production of major crop categories in the study area are presented in Table 2.

In the *erstwhile* South Arcot district, the growth rates in the production of tuber crops, fiber crops, pulses, sugar crops, plantation crops, fruits and vegetables were 8.65 per cent, 8.44 per cent, 6.22 per cent, 6.08 per cent, 4.88 per cent, 2.94 per cent and 2.74 per cent, respectively, and found to be positively significant, during the pre-liberalisation period. The growth in the production of flowers (2.69 per cent) and spices (1.86 per cent) were negative and significant, during the pre-liberalisation period. However, the growth in the production of cereals, millets, oilseeds and tree crops were positive and had marginal increasing trend by 1.40 per cent, 1.01 per cent, 1.51 per cent and 1.28 per cent, respectively, during this period.

During the post-liberalisation period, the growth in the production of sugar crops (4.81 per cent), fiber crops (4.40 per cent), and plantation crops (3.34 per cent) were found to be positively significant. Contrary to this, oilseeds and tuber crops (5.82 per cent), cereals (3.92 per cent), fruits (2.96 per cent) and millets (2.61 per cent) had shown significant negative growth trend during the post-liberalisation period. The growth in the production of trees, vegetables, flowers and spices (2.74 per cent, 2.24 per cent, 1.21 per cent, 1.06 per cent and, respectively) indicated a positive growth rate, where as pulses (1.98 per cent) showed a negative growth rate.

Table 2. Growth Rates in Production of Major Crop Categories, 1970-71 to 2016-17

S. No	Major Crop Categories	Pre- Liberalisation Period (1970-71 to 1991-92)	Post- Liberalisation Period (1992-93 to 2016-17)	Over all Period (1970-2017)
1.	Cereals	1.40	-3.92**	2.95***
2.	Millets	1.01	-2.61***	-1.60
3.	Pulses	6.22**	-1.98	5.91**
4.	Oilseeds	1.51	-5.82**	-3.92***
5.	Fiber crops	8.44**	4.40**	5.95**
6.	Sugar crops	6.08**	4.81**	3.01***
7.	Tuber crops	8.65**	-5.82**	6.71**
8.	Vegetables	2.74***	2.24	2.53
9.	Fruits	2.94***	-2.96***	3.35**
10.	Flowers	-2.69**	1.21	2.45
11.	Plantation crops	4.88***	3.34**	5.12**
12.	Spices	-1.86**	1.06	-1.03
13.	Tree crops	1.28	2.74	4.22**

(** and *** indicate significance at 5 per cent and 1 per cent levels respectively)

The growth rates in the production of almost all the crop categories in the *erstwhile* South Arcot district were positive during the overall period, except for millets, oilseeds and spices, which had negative growth rates and could be correlated with the negative growth rates in the area under these crops. It is also evident that even these crops also had a positive growth rates in the pre-liberalisation period in the district.

Thus, it could also be interpreted that most of major crop categories in the *erstwhile* South Arcot district had a declining growth rate in production, in the post- liberalization period. The reason could be the importance given to the horticultural crops in the study area. Contrary to this, almost all the crops had a positive growth trend except flowers and spices in the pre- liberalization period, which might be due to availability of vital inputs, location specific soil and climatic condition, introduction of high yielding varieties, extended irrigation facilities, adoption of new technologies and awareness of cultivation practices, etc.

It could be concluded that the production of fruits, flowers and plantation crops had negative growth rates in the pre-liberalisation period and turned out to be positive in the post-liberalisation period. While, millets, oilseeds, fibers and spices had negative growth trends in the post-liberalisation period and in the overall period, which clearly shows the shift in the production pattern of these crops in the study area.

Growth Performance in Productivity of Major Crop Categories

The growth rates in the productivity of major crop categories in the study area are presented in Table 3.

Table 3. Growth Rates in Productivity of Major Crop Categories, 1970-71 to 2016-17

S. No	Major Crop Categories	Pre- Liberalisation Period (1970-71 to 1991-92)	Post- Liberalisation Period (1992-93 to 2016-17)	Over all Period (1970-2017)
1.	Cereals	2.33	-2.96***	1.98
2.	Millets	1.11	2.22	3.92**
3.	Pulses	2.12	-3.92**	-2.95***
4.	Oilseeds	1.82	1.21	0.99
5.	Fiber crops	3.46**	2.63***	1.95
6.	Sugar crops	0.50	-2.45	3.95**
7.	Tuber crops	7.90**	-5.82**	-3.99**
8.	Vegetables	2.43	5.09**	6.08**
9.	Fruits	4.00**	7.47**	3.46
10.	Flowers	2.74***	3.94***	1.78
11.	Plantation crops	-3.52***	1.61	1.92
12.	Spices	3.46**	1.78	2.04
13.	Tree crops	8.97**	14.88**	12.07**

(** and *** indicate significance at 5 per cent and 1 per cent levels respectively)

It could also be observed from Table 3 that the growth rates in the productivity of most of the crop categories namely, tree crops (8.97 per cent), tuber crops (7.90 per cent), fruits (4.00 per cent), fiber crops and spices (3.46 per cent) and flowers (2.74 per cent) were positively significant in *erstwhile* South Arcot district, during the pre-liberalisation period. Contrary to this, the productivity of plantation crops alone (3.52 per cent) was negatively significant during the same period. Moreover, the productivity of cereals, millets, pulses, oilseeds, sugar crops and vegetables also has increased by only 2.33 per cent, 1.11 per cent, 2.12 per cent, 1.82 per cent, 0.50 per cent and 2.43 per cent, respectively, during this period.

In the post-liberalisation period, the productivity of tree crops (14.88 per cent), fruits (7.47 per cent), vegetables (5.09 per cent), flowers (3.94 per cent) and fiber crops (2.63 per cent) had positively significant growth rates in the district. While, the growth in the productivity of major crops, viz., cereals (2.96 per cent), pulses (3.92 per cent) and tubers (5.82 per cent) were negatively significant. The productivity of millets, oilseeds, plantation crops and spices has increased by 2.22 per cent, 1.21 per cent, 1.61 per cent and 1.78 per cent, respectively. Whereas, the productivity of sugar crops has decreased by 2.45 per cent, during this period.

During the entire period, the growth rates in the productivity of tree crops (12.07 per cent), vegetables (6.08 per cent), sugar crops (3.95 per cent), and millets (3.92 per cent) were positively significant in the district, whereas the productivity of tuber crops (3.99 per cent) and pulses (2.95 per cent) were negatively significant. However, the productivity of cereals, oilseeds, fibers, fruits, flowers, plantation crops and spices has increased marginally, over the years.

Hence, it could be concluded that the growth rates in the productivity of millets, oilseeds and spices were almost positive at different points of time, as against the declining growth rates in area and production of these crops in the district. The district had a positive growth trend in the productivity of vegetables, fruits, plantation crops and tree crops, which might be due to the new technologies developed for these crops by the Vegetables Research Station at Palur and Cashew Research Station at Virudhachalam, which are located in the study area.

Also, it could be concluded that inspite of the drastic declining trend in the area under spices, the production could be compensated by the increase in the productivity of spices. It is also important to note that the productivity of pulses had a declining trend in the district, as against the expansion of area and production of



pulses in the study area. From the above discussions, it is also obvious that the performance of many crops in terms of area, production and productivity, had a declining trend in the post-liberalization period in the district.

V. DYNAMIC CHANGES IN THE CROPPING PATTERN

Markov chain analysis was used to study the dynamic changes in the cropping pattern, capturing the shift in the area under different crop categories over a period of 47 years. The probability of retaining the particular crop and the shift was interpreted by studying the diagonal and off diagonal elements of transitional matrix. The transitional probability matrix for the dynamic changes in the cropping pattern in the study area was estimated using the data on area under major crop categories from 1970-71 to 2016-17. The nine major crop categories considered for the analysis were cereals, millets, pulses, oil seeds, fiber crops, sugar crops, tuber crops, horticultural crops (vegetables, fruits, flowers, plantation crops and spices) and tree crops.

The transitional probability matrix for dynamic changes in the area under major crop categories in the *erstwhile* South Arcot district was estimated and the results of Markov chain model are presented in Table 4.

It could be seen from Table 4 that diagonal elements represent the probability of retention of existing area under different crops. For example, the probability of retention of existing area under cereals was estimated at 39 per cent which was the highest, followed by oilseeds (28.72 per cent), millets (17 per cent), sugar crops (14.78 per cent), horticultural crops (14.36 per cent), tree crops (11.13 per cent), pulses (9.73 per cent) and tuber crops (2.17 per cent). But the probability of shift in area from cereals was maximum to oilseeds (20.78 per cent) followed by millets (12.82 per cent), sugar crops (11.82 per cent), pulses (8.07 per cent) and horticultural crops (4.05 per cent) and a negligible area to tuber crops (1.50 per cent), fiber crops (1.21 per cent) and tree crops (0.32 per cent).

However, the cereals gained 38 per cent from millets, 46 per cent from pulses, 43 per cent from sugar crops and horticultural crops, 41 per cent from tuber crops, 33 per cent from fiber crops, 26 per cent from oilseeds and 14 per cent from tree crops.



Table 4. Transitional Probability Matrix for Area under in Major Crop Categories, 1970-71 to 2016-17

Major Crop Categories	Cereals	Millets	Pulses	Oilseeds	Fiber crops	Sugar crops	Tuber crops	Horticultural crops	Tree crops
Cereals	0.3943	0.1282	0.0807	0.2078	0.0121	0.1182	0.0150	0.0405	0.0032
Millets	0.3768	0.1699	0.0764	0.2101	0.0123	0.1005	0.0180	0.0326	0.0034
Pulses	0.4579	0.0334	0.0973	0.1067	0.0039	0.1674	0.0101	0.1220	0.0013
Oilseeds	0.2574	0.2744	0.0464	0.2872	0.0201	0.0579	0.0257	0.0187	0.0124
Fiber crops	0.3308	0.0809	0.1127	0.1030	0.0118	0.1621	0.0580	0.0996	0.0409
Sugar crops	0.4339	0.0689	0.0917	0.1546	0.0072	0.1478	0.0107	0.0844	0.0008
Tuber crops	0.4131	0.0218	0.0925	0.0517	0.0042	0.2149	0.0217	0.1706	0.0094
Horticultural crops	0.4347	0.0365	0.0905	0.1028	0.0040	0.1786	0.0088	0.1436	0.0004
Tree crops	0.1394	0.0168	0.1594	0.0040	0.0199	0.2587	0.1387	0.1518	0.1113
Steady State Probability	0.3746	0.1406	0.0774	0.1988	0.0119	0.1174	0.0176	0.0559	0.0056



The millets were found to be moderately stable and could retain at 21.01 per cent to oilseeds, 19 per cent. Though, the shift in area from millets was 10.05 per cent to sugar crops, 7.64 per cent to pulses, 3.26 per cent to horticultural crops, 1.80 per cent to tuber crops, 1.23 per cent to fiber crops and 0.34 per cent to tree crops.

The probability of retention of fiber crops (1.18 per cent) and tuber crops (2.17 per cent) were negligible in the study area. The major competing category for these crops was cereals, as the farmers in this district primarily depend on paddy cultivation. This would be correlated with the results on the performance of this crops in the study area.

The estimated steady state probability reveals that if the cropping pattern continues, in the future around 37 per cent of area will be under cereals, 20 per cent under oilseeds 14 per cent under millets, 12 per cent under sugar crops 8 per cent under pulses, 5 per cent under horticultural crops, 2 per cent under tuber crops, one per cent under fiber crops and 0.05 per cent under tree crops.

VI.CONCLUSION

Hence, it could be concluded that the performance of many crops in terms of area, production and productivity, had a declining trend in the post-liberalization period in the district. This result has indicated that the agriculture sector became less profitable after the liberalization due to a fall in food grain prices and removal of import restriction, which led to decline in area under cultivation, production and productivity of major crops. The analysis revealed that the cereals was found to be highly stable in the erstwhile South Arcot district and could retain as high as 39 per cent followed by oilseeds, millets, sugar crops and horticultural crops. The reason might be the importance attached to the cereal crops, in the study area for their food security.

The study also revealed that the area under horticultural crops are increasing at a faster rate over the periods in the study area, which is a good sign of development. Therefore, it is necessary to subsidize the cultivation expenses of farmers and motivate them by continuing some of the existing programmes. Such a measure would help in increasing the production and enhance the export potentials of these crops.

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