Original Research Article

DYNAMICS OF AREA CHANGE UNDER COMMERCIAL CROPS IN TAMIL NADU

ABSTRACT

The area under commercial crops has been fluctuating over the years in Tamil Nadu. However, the change in area is not same for all the crops. Hence the present study was conducted to assess the growth rates and the dynamics of area change of cash crops in Tamil Nadu by using the secondary data for the period of five decades from 1971 to 2020. Among cash crops oilseeds had highest area under production followed by coconut, sugarcane and vegetables. All commercial crops, with the exception of sugarcane, tea, coffee, and vegetables, have a negative growth rate. The transitional probability matrix for area under cash crops was obtained using Markov chain analysis. By simulating this transitional probability matrix, the area under major cash crops in Tamil Nadu for the next decade has been projected. Sugarcane is the only crop with a positive trend for the projected area, while cotton, spices, coffee, and vegetable group exhibit a declining over the period.

Keywords**:** Cropped area, Cash crops, Compound growth rate, Markov chain, Transition probability matrix

1. INTRODUCTION

Agriculture is an important sector of the Indian economy and contributes significantly to the growth of the country as it is the main source of income, employment and export earnings. A total of 54.6% of the country's workforce is engaged in agriculture and allied activity (Census 2011) and accounts for 17.8% of the country's Gross Value Added (GVA). India has achieved significant advances in the production of food grains, particularly wheat and rice, but non-food crops such as oilseeds, fibres and sugarcane have not kept pace. The average area under cultivation of major commercial crops such as oilseeds, coffee, cotton, sugarcane, and tea increased in India has been reported by Mukesh Kumar *et al..,* in his study. However, the average area of raw jute and Mesta cultivation has decreased. Commercial crops also known as cash crops are important in both the domestic, national and international markets. These crops help the Indian economy thrive by fulfilling local oil, fibre, and sugar needs while also generating foreign cash through exports or import substitution. Recently, the commercial agriculture of the country has become largely oriented to the domestic market (Joseph & George, 2010).

Tamil Nadu is one of India's most developed states in terms of economic and social development. The state has a diverse landscape as well as many agro-climatic zones. The western, southern, and north-western regions are bordered by steep terrain with abundant flora. It has a cultivable area of 79.16 lakh hectares of which the Net Cultivated Area is about 48.33 Lakh hectare. Tamil Nadu has a wide range of land use patterns and it been changed dramatically during the last several decades due to urbanization and industrialization and being one of the leading commercial crops growing State contributes about three per cent to the total countries production. Cotton, sugarcane, oilseeds, coconut, spices, tobacco, tea, coffee and vegetables are the major commercial crops grown in Tamil Nadu which contribute significantly to the state's income and provide employment opportunities. However commercial agriculture sector faces many challenges in the present era of globalization. The area under this crop is not stable and it changes due to many reasons. Price instability is one of the most serious problem which not only affects farmers' incomes but also has long-term effects on commercial agriculture sector (Maizels, 1992; Maizels, 1999; DFID, 2004; FAO, 2002). Rangachary, C. (Ministry of Commerce and Industry 2006) reported that cash crop volatility hinders the investment in this sector and causes earnings to be unstable for small holders. Hence estimating the area change of various commercial crops is thus vital to create the necessary regulations. With this background the present study was conducted with the objective to determine the pattern of area allocation for commercial crops and to estimate area under various crops in the future. Likewise, the growth and disparity of vegetable area in Karnataka has been assessed by Afrin Zainab BI *et al.,* (2020) using Markov chain analysis.

2. MATERIALS AND METHODS

2.1 Study area and data source

The study area encompasses all the districts of Tamil Nadu. The secondary data for the major commercial crops including cotton, sugarcane, oilseeds, spices, tobacco, vegetables, tea, coffee and vegetables of Tamil Nadu from the year 1971 to 2020 had been collected from various sources like Season and Crop Report of Tamil Nadu, Directorate of Economics and Statistics, India stat and Statistical Handbook of Tamil Nadu.

2.2 Methodology

For the purpose of the analysis, the entire study period can be split into five sub-periods including; Period I: 1970-1971 to 1979-1980; Period II: 1980-1981 to 1989-1990; Period III: 1990-1991 to 1999-2000; Period IV: 2000- 2001 to 2009-2010; Period V: 2010- 2011 to 2019-2020. The sub-periods have been divided based on ten years (decades).

2.2.1 Compound growth rate

The compound growth rate for cash crops in Tamil Nadu were estimated to investigate the growth in area of major cash crops. The growth rates were determined by using the exponential function as follows

$Y=ab^t$

$\log y = \log a + t \log b$

CGR(%)=(Antilog b-1)*100

Where,

CGR = Compound growth rate

Y = Area of cash crops

t = Time in year

a = Constant

b = Regression coefficient

2.2.2 Markov Chain Analysis

Markov chain analysis was used to estimate the dynamics of area change of major cash crops in Tamil Nadu. The Markov chain approach is less restrictive in its assumptions and delivers more information than regression (Matis, 1985).

The structural changes within the agricultural industry are the result of a large number of individual small forces, the system can be treated as a stochastic process in which there are a finite number of possible states (Buckwell and Shucksmith, 1979). Whereas the probability distribution of allocating agricultural land to one of the cash crops in any period is dependent on the probability distribution of allocating agricultural land to one of the cash crops in the previous period's distribution and the dependencies are consistent across time. The representation of this process of structural change is called first - order Markov chain.

Moreover, the transition probabilities have been assessed under the premise of constancy, which means that all of the forces that drove agricultural structural change in the past would continue to influence it in the future (Gaffney, 1992)

For a stochastic process, it is assumed that the movements (transitions) of objects from one state (possible outcome) to another are governed by a probabilistic mechanism or system. A finite Markov process is a stochastic process whereby the outcome of a given trial t (t = 1, 2... T) depends only on the outcome of the preceding trials (t-1) and this dependence is the same at all stages in the sequence of trials (Lee et al., 1965)

Consistent with this definition,

S_i denotes the i^{th} cash crop or possible outcomes; i = 1, 2… r.

W_{it} is the probability that cash crop S_i occurs on trial t or proportion of cash crop S_i observed in trial t, in alternative outcome state i of multinomial distribution based on sample size n (n represents the total number of cash crop categories), i.e. Pr (S_{it}).

P_{ij} represents the transitional probability which denotes the probability of movement of area under cash crop from state i at trial t to state j at trial (t + 1), i.e.

$$P_{ij} = Pr\ (S_{j,\ t+1} / S_{it},) \quad \text{.....(1)}$$

P = [P_{ij}] represents the probability transition matrix or stochastic matrix with a transitional probability of every pair of cash crops (i, j = 1, 2…r)

$$P = \begin{bmatrix} P_{ij} & \cdots & P_{is} \\ \vdots & \ddots & \vdots \\ P_{sj} & \cdots & P_{ss} \end{bmatrix}$$

Where, $0 \leq P_{ij} \leq 1$ and $\sum_j P_{ij}=1$ .....(2)

Given this set of notations and definitions for a first-order Markov chain the probability of a particular sequence S_i on trial t and S_j on trial t+1 may be represented by

$$Pr\ (S_{it},\ S_{j,\ t+1}) = P_r\ (S_{it})\ Pr\ (S_{j,\ t+1}/S_{it}) = W_{it}P_{ij} \quad \text{.....(3)}$$

And the probability of being in division j at trial t+1 may be represented by

$$Pr\ (S_{j,\ t+1}) = \sum W_{it}P_{ij} \text{ or } W_{j,\ t+1} = \sum W_{it} \quad \text{.....(4)}$$

The proportion of area under cash crops in Tamil Nadu was taken as data for this study. These proportions fluctuate from year to year owing to a range of variables or circumstances such as cost of cultivation, commodity market price, climatic change, and so on (Madhuri K Manwar and SC Nagpure,2017). It is reasonable to think that the combined influence of these various systematic factors resembles a stochastic process, and that farmers' proclivity to move from one crop to another is based on their adaptability and profitability. The dynamics of area change under cash crops may be described as a matrix P of first-order transition probabilities if these requirements are met. Estimating the transitional probability matrix (P) is the main focus of this study. The diagonal element P_{ij} indicates the likelihood of retaining the proportional share of the cash crop 'i'. The chance that the probability of movement of area under i^{th} crop to the j^{th} crop was represented by the P_{ij} element of the matrix

Estimation of the transition probability matrix

Equation (4) could be used to define the statistical model which will be used to compute the transition probabilities. If errors are incorporated in Equation (4) to account for the difference between the actual and estimated occurrence of W_j (t+1), the sample observations may be assumed to be generated by the following linear statistical model

$$W_{jt} = \sum W_{i,\ t-1}Pij + U_{jt} \quad \text{..... (5)}$$

or in matrix form it can be written as:

$$Y_j = X_jP_j + U_j \quad \text{.....(6)}$$

Where,

Y_j = (Tx1) vector of observations reflecting the proportion in land use pattern j in time t,

X_j = (TxR) matrix of realized values of the proportion in land use pattern j in time t-1,

P_j = (Rx1) vector of unknown transition parameters to be estimated and

U_j = Vector of random disturbances.

3. RESULTS AND DISCUSSION

3.1 Compound Growth Rate

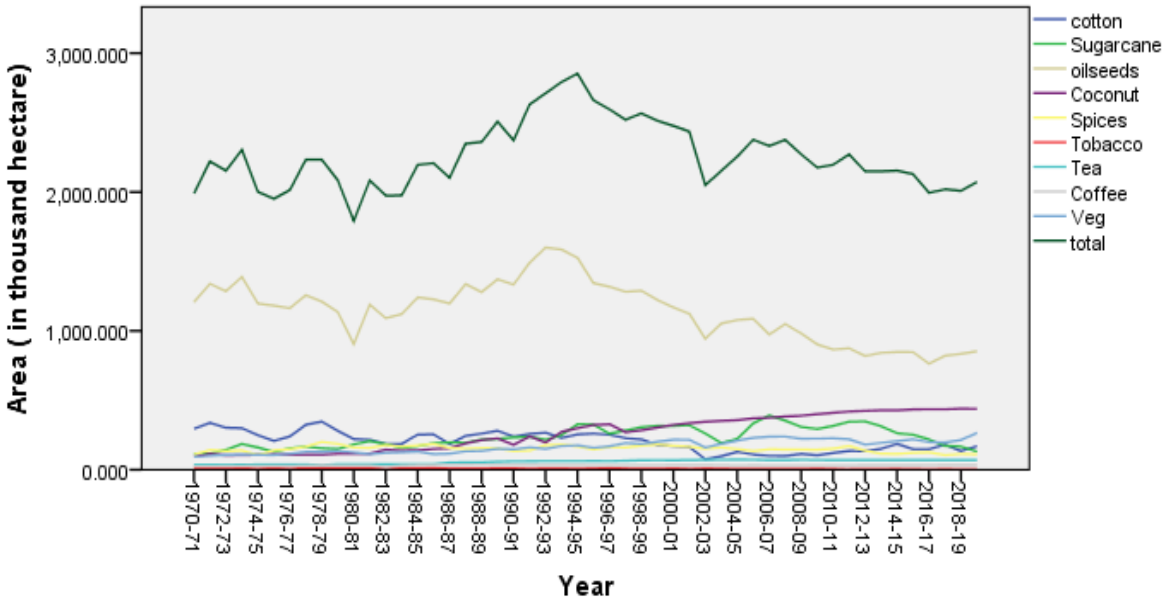
CAGR (Compound Annual Growth Rate) measures the average annual growth (or decline) over a given period. From the Table 1 it can be inferred that for the period 1971-2020, the growth rate for most commercial crops does not seem to be particularly outstanding. All commercial crops, with the exception of sugarcane, tea, coffee, and vegetables, have a negative growth rate. Almost all crops experienced positive area development in the 1980s as a result of technological advancements. Cotton has a positive growth rate in period V after a long time of decline due to the discovery of Bt cotton. In addition, Swaminathan, B. *et al.,* (2017) also concluded that cotton growth rate after Bt introduction (2001-2015) was higher in terms of area (3.70 per cent), production (9.89 per cent) and productivity (5.98 per cent) than the overall study period. Sugarcane shows a fluctuating growth and a sudden drop in period V (-10.17 per cent). Coconut, vegetables and coffee show a fluctuating trend. Further, the growth rate of oilseeds, spices and tobacco follow a declining trend for the study periods. Among cash crops, oilseeds had highest area under production followed by coconut, vegetable, sugarcane and cotton (Fig. 1).

Table 1: Compound growth rate of Area under commercial crops in Tamil Nadu

Crop	Period I (1971-1980)	Period II (1981-1990)	Period III (1991-2000)	Period IV (2001-2010)	Period V (2011-2020)	Overall (1971-2020)
Cotton	-0.49	3.00*	-2.57**	-3.37	2.62*	-0.83***
Sugarcane	2.69	1.92	3.70**	1.92	-10.17***	0.60***
Oilseeds	-1.15	3.36**	-2.15**	-1.78**	-0.45	-0.39***
Coconut	1.11*	7.62***	5.06**	2.26***	0.70***	1.58***
Spices	5.38***	-0.83	2.02	-1.81***	-3.98***	-0.15***
Tobacco	0.36	-4.48*	-1.24	-2.78	-9.12**	-1.42***
Tea	1.05***	4.88***	1.28***	0.18	-0.01	0.74***
Coffee	2.94***	3.65*	-0.78***	-1.16***	0.94***	0.17***
Vegetables	3.81***	1.82*	3.05***	2.05	1.08	0.79***

***significance at 1%, ** significance at 5%, *significance at 10%

Fig 1: Area under commercial crops in Tamil Nadu (in thousand hectare)



3.2 Markov Chain Analysis

Markov chains are stochastic processes (Halmy et al., 2015; Subedi et al., 2013) and the annual transition probability matrix denotes the probability of movement of area under commercial crops from one state to another state. The diagonal components P_{ij} (i=j) show the degree of stability of area under cash crop (retaining the same crop for future). The area under a particular crop becomes less

and less stable when the diagonal components approach zero, but as they approach one, the area under that crop tends to become more and more stable over time. The non-diagonal element P_{ij} ($i \neq j$) represents the probability of moving between various cash crops. The rows in the transition probability matrix indicate the current status of the area under the cash crop being examined and the columns identify the chance of movement of the crops. Here the elements in the i^{th} row (Tables 2-6) give the proportions of the previous period's area of i^{th} cash crop which is likely to lose to other crops in the current period. The element of i^{th} column gives the proportion of the area of i^{th} crop which is likely to gain in the current period. The results of transition probability matrix in Table (2-6) displays a more detailed picture of variations in the area under major cash crops in Tamil Nadu during the last five decades.

It is evident from Table 2 that during Period I oilseeds were the most stable crop among cash crops in Tamil Nadu followed by cotton and sugarcane with a retention capacity of about 90 per cent, 63 per cent, and 33 per cent respectively. Tobacco, tea, coffee, vegetables and coconut were found to be the most unstable crops as they had at most zero percent share and this area was mostly gained by cotton and spices. Spices retained one-fourth (25 per cent) of their area from the previous year.

In Period II oilseeds, coconut and sugarcane were found to be the most stable crops as these crops had highest area share of 63 per cent, 58 per cent and 34 per cent. The Area share for cotton had decreased from 63 per cent to 26 per cent while, the coconut share had increased from 0.2 to 58 per cent. As like period I tobacco, tea, coffee and vegetables were the most unstable crops with zero share.

It can be seen from Table 4 that during period III there was a drastic change in share for the vegetable groups and tea from 0.9 per cent and 0 per cent to 35 per cent and 38 percent respectively. In contrast to this, the proportion of cotton and sugarcane area had dropped to zero percent and 14 per cent. The area among the crops in periods was dispersed in period III.

Based on Tables 4 and 5 it is concluded that throughout periods IV and V, coconut, oilseeds, and sugarcane were the crops that retained the majority of its area from the previous year. The vegetable group had retained around 50% of its shares from the previous year. The crops with the lowest area proportions were tobacco, tea, and coffee.

Table 2. Transitional Probability Matrix for change in area under cash crops for Period - I (1971-1980)

1971-80	Cotton	Sugarcane	oilseeds	Coconut	Spices	Tobacco	Tea	Coffee	Vegetables
Cotton	**0.63**	0.00	0.35	0.00	0.01	0.00	0.00	0.00	0.00
Sugarcane	0.00	**0.33**	0.05	0.18	0.00	0.00	0.11	0.08	0.23
oilseeds	0.00	0.06	**0.90**	0.04	0.00	0.00	0.00	0.00	0.00
Coconut	0.34	0.13	0.00	**0.02**	0.00	0.10	0.15	0.07	0.19
Spices	0.07	0.12	0.00	0.01	**0.25**	0.01	0.04	0.06	0.44
Tobacco	1.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00
Tea	1.00	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00
Coffee	0.00	0.00	0.00	1.00	0.00	0.00	0.00	**0.00**	0.00
Vegetables	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	**0.00**

Table 3. Transitional Probability Matrix for change in area under cash crops for Period-II (1981-1990)

1981-90	Cotton	Sugarcane	oilseeds	Coconut	Spices	Tobacco	Tea	Coffee	Vegetables
Cotton	**0.26**	0.39	0.33	0.00	0.00	0.00	0.00	0.02	0.00
Sugarcane	0.00	**0.34**	0.62	0.00	0.00	0.00	0.00	0.00	0.04
oilseeds	0.10	0.00	**0.63**	0.06	0.08	0.00	0.03	0.02	0.09
Coconut	0.32	0.00	0.00	**0.58**	0.00	0.00	0.10	0.00	0.00
Spices	0.00	0.00	0.72	0.00	**0.23**	0.04	0.00	0.01	0.00
Tobacco	0.00	0.00	0.00	0.00	1.00	**0.00**	0.00	0.00	0.00
Tea	0.00	0.00	1.00	0.00	0.00	0.00	**0.00**	0.00	0.00
Coffee	0.05	0.93	0.02	0.00	0.00	0.00	0.00	**0.00**	0.00
Vegetables	0.00	0.00	0.77	0.00	0.11	0.02	0.00	0.00	**0.09**

Table 4. Transitional Probability Matrix for change in area under cash crops for Period-III (1991-2000)

1991-2000	Cotton	Sugarcane	oilseeds	Coconut	Spices	Tobacco	Tea	Coffee	Vegetables
Cotton	**0.00**	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Sugarcane	0.16	**0.14**	0.00	0.62	0.05	0.00	0.02	0.00	0.00
oilseeds	0.10	0.00	**0.76**	0.06	0.06	0.00	0.00	0.01	0.00
Coconut	0.18	0.34	0.09	**0.13**	0.02	0.01	0.05	0.02	0.15
Spices	0.00	0.54	0.00	0.00	**0.00**	0.00	0.06	0.00	0.40
Tobacco	0.00	0.00	0.00	0.00	0.00	**0.00**	0.00	0.00	1.00
Tea	0.00	0.00	0.00	0.00	0.35	0.00	**0.38**	0.21	0.06
Coffee	0.00	0.00	0.98	0.00	0.00	0.00	0.00	**0.02**	0.00
Vegetables	0.00	0.32	0.00	0.00	0.28	0.00	0.05	0.00	**0.35**

Table 5. Transitional Probability Matrix for change in area under cash crops for Period-IV (2001-2010)

2001-10	Cotton	Sugarcane	oilseeds	Coconut	Spices	Tobacco	Tea	Coffee	Vegetables
Cotton	**0.06**	0.41	0.00	0.37	0.05	0.00	0.00	0.00	0.11
Sugarcane	0.00	**0.52**	0.21	0.16	0.07	0.00	0.01	0.02	0.00
oilseeds	0.10	0.00	**0.69**	0.03	0.11	0.00	0.03	0.02	0.01
Coconut	0.00	0.00	0.00	**0.67**	0.00	0.00	0.10	0.00	0.22
Spices	0.00	0.00	1.00	0.00	**0.00**	0.00	0.00	0.00	0.00
Tobacco	0.00	0.00	0.00	0.00	1.00	**0.00**	0.00	0.00	0.00
Tea	0.00	0.00	0.93	0.00	0.00	0.07	**0.00**	0.00	0.00
Coffee	0.00	0.00	1.00	0.00	0.00	0.00	0.00	**0.00**	0.00
Vegetables	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	**0.57**

Table 6. Transitional Probability Matrix for change in area under cash crops for Period - V (2011-2020)

2011-20	Cotton	Sugarcane	oilseeds	Coconut	Spices	Tobacco	Tea	Coffee	Vegetables
Cotton	**0.00**	0.00	0.32	0.39	0.00	0.00	0.00	0.00	0.28
Sugarcane	0.01	**0.82**	0.12	0.00	0.04	0.01	0.00	0.00	0.00
oilseeds	0.16	0.00	**0.62**	0.07	0.00	0.00	0.04	0.00	0.11
Coconut	0.00	0.00	0.32	**0.58**	0.00	0.00	0.07	0.04	0.00
Spices	0.00	0.21	0.04	0.52	**0.21**	0.00	0.02	0.00	0.00
Tobacco	0.00	1.00	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00
Tea	0.00	0.00	1.00	0.00	0.00	0.00	**0.00**	0.00	0.00
Coffee	0.00	0.00	1.00	0.00	0.00	0.00	0.00	**0.00**	0.00
Vegetables	0.10	0.00	0.00	0.00	0.43	0.00	0.04	0.07	**0.36**
Steady state probability	0.08	0.08	0.41	0.21	0.06	0.00	0.04	0.02	0.11

From Table 7, it is seen that when decade goes, the retaining capacity of sugarcane area increases from 33 per cent in period - I to 82 per cent in period-III and most of its area had been shared with oilseeds and vegetables. The retaining capacity of oilseeds and coconut are fluctuating from decade to decade. Oilseeds and cotton have the maximum area share in period III (85per cent) and IV, (61per cent) respectively. Spices, tobacco, tea and coffee show almost zero shares in all the decades. Cotton being an important commercial crop in Tamil Nadu as well as in India it shows a declining trend and almost zero shares in retaining area in last three decades. Most of its area was shifted to oilseeds, coconut and vegetables.

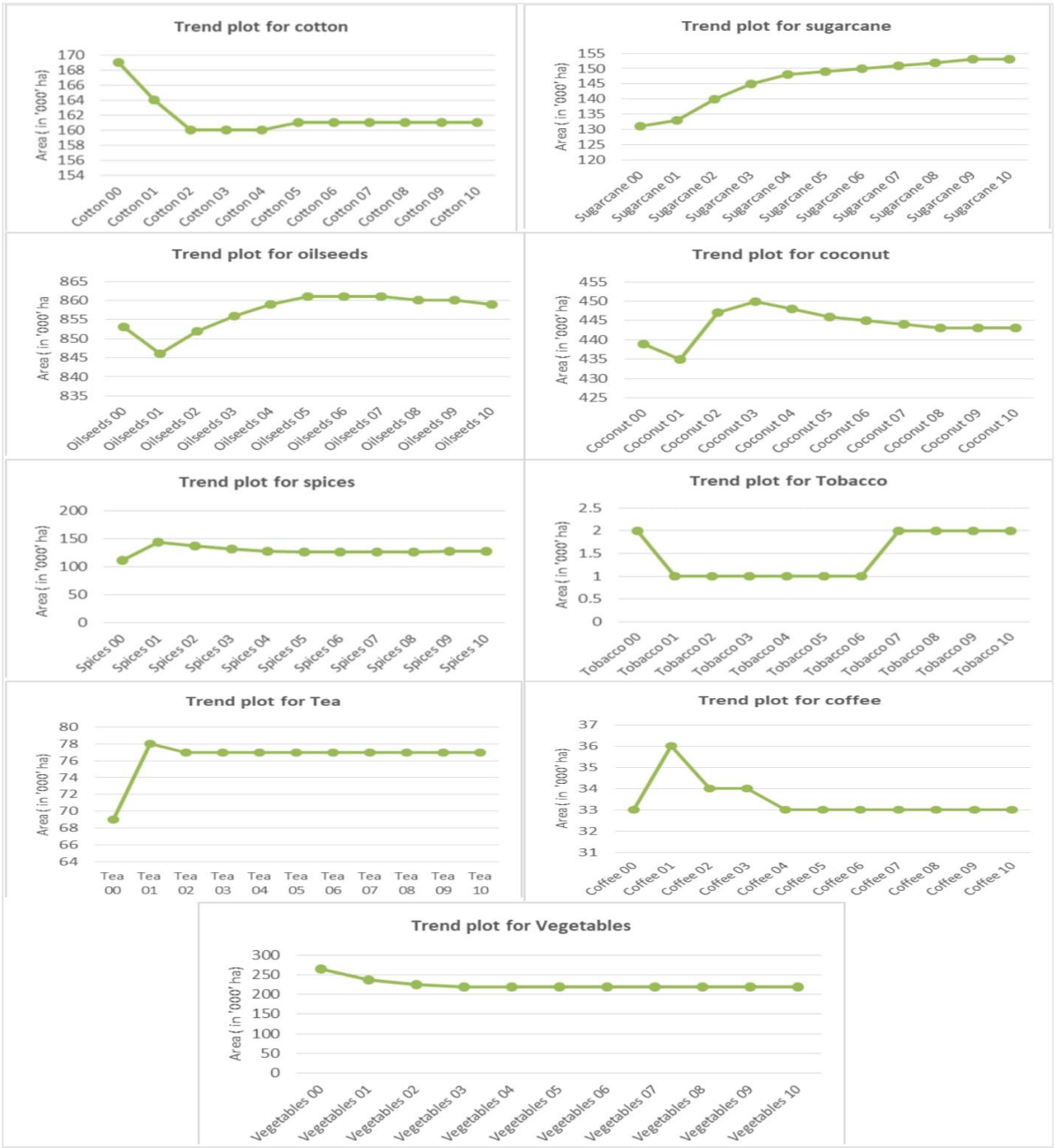
Table 7. Combined table for area share among cash crops for last five decades

Crop	Period I (1971-1980)	Period II (1981-1990)	Period III (1991-2000)	Period IV (2001-2010)	Period V (2011-2020)
Cotton	Oilseeds (0.35)	Sugarcane (0.39) Oilseeds (0.33)	Oilseeds (1)	Sugarcane (0.41) Coconut (0.37)	Oilseeds (0.32) Coconut (0.39)
Sugarcane	Sugarcane (0.33) Vegetables (0.23)	Oilseeds (0.62) Sugarcane (0.34)	Coconut (0.62) Cotton (0.16)	Sugarcane (0.52) Oilseeds (0.21)	Sugarcane (0.82) Oilseeds (0.12)
Oilseeds	Oilseeds (0.9) Sugarcane (0.06)	Oilseeds (0.63) Cotton(0.1)	Oilseeds (0.76) Cotton (0.1)	Oilseeds (0.69) Spices (0.11)	Oilseeds (0.62) Cotton (0.16)
Coconut	Cotton (0.34) Tea (0.15)	Coconut (0.58) Cotton (0.32)	Sugarcane (0.34) Vegetables (0.15)	Coconut (0.67) Vegetables(0.22)	Coconut (0.58) Oilseeds (0.32)
Spices	Spices (0.25) Sugarcane (0.12)	Oilseeds (0.72) Spices (0.23)	Sugarcane (0.54) Vegetables (0.4)	Oilseeds (1.0)	Coconut (0.52) Spices (0.21)
Tobacco	Cotton (1.0)	Spices (1)	Vegetables (1)	Spices (1.0)	Sugarcane (1.0)
Tea	Cotton (1.0)	Oilseeds (1)	Tea (0.38) Spices (0.35)	Oilseeds (0.93)	Oilseeds (1.0)
Coffee	Coconut (1.0)	Sugarcane (0.93)	Oilseeds (0.98)	Oilseeds (1.0)	Oilseeds (1.0)
Vegetables	Spices (1.0)	Oilseeds (0.77) Spices (0.11)	Vegetables (0.35) Spices (0.28)	Vegetables (0.57) Sugarcane (0.43)	Vegetables (0.36) Spices (0.43)

By taking the transition matrix of Period V as a start vector, the area under major cash crops in Tamil Nadu was forecasted for the next decade (2021-2030). Fig.2 illustrates a series of graphs depicting the forecasted area for major commercial crops based on the assumption that total area under cultivation remains constant in future. This result shows that the sugarcane shows a positive trend for forecasted area and the crops like cotton, spices, coffee and vegetable group show a declining trend over the period. In further the crops like oilseeds, coconut and tea show a fluctuating trend for the projected area.

Crops like tobacco, tea and coffee shows uncertainty in the forecasted area which might be due to discrepancy in the time series data for area of certain cash crops. However, the forecasted area for crops like sugarcane, tobacco appeared to be more reliable since the data follow a clear trend.

Fig 2. Forecasted area for cash crops in Tamil Nadu by simulating TPM for Period-VI (2021-2030)



CONCLUSION

It is apparent that the area under cash crops is fluctuating over the last two decades. Nonetheless, within the cash crop groups, there is a disparity in growth rates. As a result, the goal of this research is to determine the pattern of area allocation for cash crops and to estimate area under various crops in the future. From the Markov chain techniques, all commercial crops, except sugarcane, tea, coffee, and vegetables have a negative growth rate. By seeing the trend and Markov chain it states that oilseed crop had highest area and highest share among cash crops followed by vegetables, coconut, and sugarcane. Tobacco, spices, coffee and tea crops are not exist and have at most zero share

among cash crops. The forecasted area for cash crops for Period V (2021-2030) also shows an unbalanced growth among the crops. Sugarcane is the only crop with a positive trend for the projected area, while cotton, spices, coffee, and vegetable group exhibit a declining over the period. Unbalanced growth within the cash crops is indicated by an increase in the area of one crop relative to the others. This imbalance in area of cash crops leads to economic consequences and increase import dependency of cash crops. To avoid this imbalance in cash crops the government should act to ensure consistent promotion of all cash crops in order to gain export potential and avoiding negative economic implications. For commercial crops, the most significant factors influencing crop area are relative price and price stability. Hence, reviving and stabilizing these commodities requires a long-term pricing policy backed by an effective procurement system and market clearance. However, the comparative economic disadvantage is now rather severe, and it may be unable to significantly raise the prices of these commodities. As a result, greater efforts should be devoted on improving their manufacturing technology as well as job simplification technology.

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