

## A Study on Cropping Pattern Changes in Southern Zone of Andhra Pradesh – A Markov Chain Approach

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### ABSTRACT

Cropping pattern means the proportion of area under different crops at a point of time. The change in cropping pattern in particular span of time clearly indicates the changes that have taken place in the agricultural development. The assessment of shift in cropping pattern in several regions is crucial for a much better insight into the agricultural development method. The present study was undertaken to examine the dynamics of cropping pattern in southern zone of Andhra Pradesh using Markov chain analysis. Time series data on area under different crops grown from the period 2001-02 to 2019-20 were collected and analyzed for 3 districts in Southern zone separately. The results revealed that cotton had highest probability of retention (0.806) in Y.S.R Kadapa district. In Nellore district, rice had highest probability of retention to an extent of 0.921, in Chittoor district groundnut had highest probability of retention (0.551) and rice had highest probability of retention (0.678) at zonal level.

**Keywords:** *Cropping pattern, Markov chain analysis, Southern zone and Transition probability matrix.*

Agriculture plays a crucial role in the economy of Andhra Pradesh. This sector contributes 34.12% of the total Gross State Domestic Product (GSDP) at current price and 29.51% at constant price 2020-21. A large segment of the population is dependent on the agriculture sector for employment and income. About 66% population of Andhra Pradesh lives in rural areas and depends on agriculture and its allied activities.

The cropping pattern of a region reveals the proportion of area of land under different crops at a point of time, the rotation of crops and the area under different crops. The cropping pattern plays a vital role in determining the level of agricultural production and reflects the agricultural economy of an area or region. Cropping pattern is defined as a combination of agricultural crops that are grown in a particular

geographical area. The change in cropping pattern in particular span of time clearly indicates the changes that have taken place in the agricultural development. These changes are brought about by socioeconomic influence (Surendra, 2015).

The long-term changes in the cropping pattern in the study area could be due to the development of irrigation infrastructure, whereas the vagaries of nature including rainfall and other institutional factors could lead to short term fluctuations in the cropped area as well as productivity. These fluctuations, short term or long term, could have implications on the economic returns to the farmer as well as on the environment. The cropping patterns are determined in large measures by agro-climatic factors such as soil, temperature and rainfall distribution, i.e., the physical conditions of the region.

A dynamic change has been witnessed in agricultural sector in our country, particularly during post-green revolution period. In order to develop an agricultural planning strategy for a region, it is very much essential to know the type of crops grown and area having less or more concentration of a crop. Besides, it is equally important for a planner to know about the level of specialization or diversification of a region in terms of crop growing in it. Both land use and cropping pattern are dynamic aspects of an agricultural landscape, as they gradually undergo a change. It is perhaps more pertinent to take a sufficiently longer interval of time to study the changing pattern as it will help in detecting the change, as well as its magnitude and direction. Hence, present study was conducted with the specific objective to analyze the structural changes in cropping pattern over the years in southern zone of Andhra Pradesh.

**MATERIAL AND METHODS**

The current study was carried out in three districts in the southern zone namely Y.S.R. Kadapa, Nellore, and Chittoor. Time series data on the area under different crops grown in these districts from 2001-02 to 2019-20 were gathered from publications of the Directorate of Economics and Statistics, Govt. of Andhra Pradesh. Using Markov chain analysis, a Transition Probability Matrix (TPM) was created for each of the three districts as well as for the zonal level.

**Markov Chain Analysis**

Markov Chain Analysis is an application of dynamic programming to the solution of a stochastic decision process. 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 a immediate preceding trial (t-1) and this dependence is the same at all stages of the sequence of trials (Lee *et al.*, 1965). Consistent with this definition, let the  $S_i$

represent  $i^{th}$  state or possible outcomes;  $i = 1, 2, \dots, r$ ,  $W_{it}$  represent the probability that state  $S_i$  occurs on trial t or proportion observed in trial 't', in alternative outcome state i of a multinomial population based on sample size n, i.e.  $Pr (S_{it})$ .  $P_{ij}$  represent the transitional probability which denotes the probability that if for any time t the process is in state  $S_i$ , it moves on next trial to state  $S_j$ ,

$$i.e., P_r(S_j, t + 1 / S_{it}) = P_{ij}$$

$P_r = ( P_{ij} )$  represent transitional probability matrix which denotes transitional probability for every pair of states (i, j = 1, 2, ....., r ) and has the following properties;

$$0 \leq P_{ij} \leq 1 \dots\dots\dots(1)$$

$$\sum_{j=1}^r P_{ij} = 1 \dots\dots\dots(2)$$

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

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

and the probability of being in state j at trial t + 1 may be represented by

$$P_r(S_{j,t+1}) = \sum_i W_{it} P_{ij} \text{ or } W_{j,t+1} = \dots\dots\dots (4)$$

The data for study are the proportion of area under crops. The proportion changes from year to year as a result of factors like weather, technology, price and institutional changes etc. It is reasonable to assume that the combined influence of these individually systemic forces approximates to a stochastic process and propensity of farmers to move from one crop to another differs according to the crop state involved. The process of cropping pattern change may be described in form of matrix P of first order transition probabilities. The element  $P_{ij}$  indicates the probability of a crop state i in one period will move to crop state j during the following period. The

diagonal element  $P_{ij}$  measures the probability that the proportion share of  $i^{th}$  category of crop will be retained.

**Estimation of Transitional Probability Matrix (TPM)**

Equation (4) can be used as a basis for specifying the statistical model for estimating transitional probabilities. If errors are incorporated in equation (4), it becomes,

$$W_{it} = P_{ij} + U_{jt} \dots\dots(5)$$

or in matrix form it can be written as,

$$Y_j = X_j P_j + U_j \dots\dots\dots(6)$$

Where,  $Y_j = (T * 1)$  vectors of observations reflecting the proportions in cropping pattern  $j$  in time  $t$ ,

$X_j = (T * r)$  matrix of realized values of the proportions in cropping pattern in time  $t - 1$ ,

$P_j = (r * 1)$  vectors of unknown transition parameters to be estimated and

$U_j =$  vectors of random disturbances.

**RESULTS AND DISCUSSION**

**Y. S. R. Kadapa district**

The results of the transition probability matrix (TPM) for crops in Y.S.R. Kadapa of Southern Zone for the period of 2001-02 to 2019-20 are presented in the Table 1. The crops considered in the study were groundnut, paddy, red gram, cotton, bengal gram, sunflower and chillies.

It is inferred from the Table 1 that red gram had shown instability. Red gram had lost about 37.90 per cent of its area to cotton and 46.50 per cent to rice. Sunflower had retained 33.10 per cent of area and lost about 62.70 per cent to groundnut and 4.20 per cent to red gram. However, sunflower gained 35 per cent area from groundnut. Rice had retained only 37 per cent of its area and lost about 36.10 per cent of its area to bengal gram, 21.40 per cent of its share to groundnut and 5.60 per cent to red gram. But it gained its share of 46.50 per cent from red gram, 21.60 per cent from bengal gram, 11.90 per cent from groundnut and 11.40 per cent from cotton. Groundnut retained about 50.40 per cent of its area and lost about 35 per cent of its area to sunflower, about 11.90 per cent to rice and about 2.60 per cent to red gram. Groundnut gained about 62.70 per cent of area share from sunflower and about 21.40 per cent of area share from rice. Chillies had shown stability by retaining 72.30 per cent of its share. Meanwhile it lost its area share to red gram (27.70 per cent). Bengal gram retained about 78.40 per cent of its area and lost about 21.60 per cent of its area to rice. Bengal gram gained about 36.10 per cent of area share from rice. Cotton had shown highest stability by retaining 80.60 per cent of its share. Meanwhile it lost its area share to rice (11.40 per cent), red gram (6.50 per cent) and chillies (1.40 per cent).

**Table 1. TPM for shift in cropping pattern for Kadapa district of Southern zone.**

	Rice	Bengal Gram	Red gram	Groundnut	Sunflower	Chillies	Cotton
Rice	0.370	0.361	0.056	0.214	0.000	0.000	0.000
Bengal Gram	0.216	0.784	0.000	0.000	0.000	0.000	0.000
Red gram	0.465	0.000	0.155	0.000	0.000	0.000	0.379
Groundnut	0.119	0.000	0.026	0.504	0.350	0.001	0.000
Sunflower	0.000	0.000	0.042	0.627	0.331	0.000	0.000
Chillies	0.000	0.000	0.277	0.000	0.000	0.723	0.000
Cotton	0.114	0.000	0.065	0.000	0.000	0.014	0.806

**Table 2. TPM for shift in cropping pattern for Nellore district of Southern zone.**

	Rice	Bengal Gram	Red gram	Groundnut	Sugarcane	Chillies	Cotton
Rice	0.921	0.018	0.003	0.040	0.000	0.003	0.014
Bengal Gram	0.550	0.450	0.000	0.000	0.000	0.000	0.000
Red gram	0.266	0.000	0.000	0.051	0.184	0.307	0.191
Groundnut	1.000	0.000	0.000	0.000	0.000	0.000	0.000
Sugarcane	0.000	0.000	0.000	0.000	0.879	0.002	0.119
Chillies	0.000	0.000	0.231	0.496	0.000	0.273	0.000
Cotton	0.633	0.000	0.000	0.205	0.000	0.000	0.161

**Nellore district**

The results of the transition probability matrix for crops in Nellore district of Southern Zone for the period of 2001-02 to 2019-20 are presented in the Table 2. The crops considered in the study were groundnut, paddy, red gram, cotton, bengal gram, sugarcane and chillies.

The results in the Table 2 revealed that red gram and groundnut have shown instability. Red gram lost its majority of area share to chillies (30.70 per cent), rice (26.60 per cent), cotton (19.10 per cent), sugarcane (18.40 per cent) and groundnut (5.10 per cent). But it had gained mainly from chillies (23.10 per cent). Ground nut was unable to retain its acreage and lost about 100.00 per cent of area to rice. However, it gained its area mainly from chillies (49.60 per cent) and from cotton (20.50 per cent). Cotton had retained only 16.10 per cent during the study and lost about 63.30 per cent of its area share to rice and 20.50 per cent area to groundnut. Rice crop had shown highest stability by retaining 92.10 per cent

during the study. Meanwhile it had lost its area share to red gram (0.30 per cent), chillies (0.30 per cent), cotton (1.40 percent), bengal gram (1.80 percent) and groundnut (4 per cent). Sugarcane retained 87.90 per cent during the study period and gained about 18.40 from red gram. It lost its share to cotton (11.90 per cent) and chillies (0.20 per cent). Bengal gram retained about 45 per cent area and lost about 55 per cent of its area to rice. Chillies retained about 27.30 per cent of its area and lost about 49.60 per cent to groundnut and about 23.10 per cent to red gram.

**Chittoor district**

The results of the transition probability matrix for crops in Chittoor district of Southern Zone for the period of 2001-02 to 2019-20 are presented in the Table 3. The crops considered in the study were groundnut, paddy, red gram, sunflower, horse gram, sugarcane and chillies.

**Table 3. TPM for shift in cropping pattern for Chittoor district of Southern zone.**

	Rice	Sunflower	Red Gram	Horse Gram	Groundnut	Chillies	Sugarcane
Rice	0.050	0.000	0.069	0.000	0.763	0.006	0.112
Sunflower	0.000	0.277	0.000	0.000	0.723	0.000	0.000
Red Gram	1.000	0.000	0.000	0.000	0.000	0.000	0.000
Horse Gram	0.464	0.000	0.015	0.488	0.029	0.003	0.000
Groundnut	0.246	0.006	0.022	0.041	0.551	0.012	0.122
Chillies	0.000	0.000	0.000	0.000	1.000	0.000	0.000
Sugarcane	0.117	0.007	0.000	0.000	0.496	0.009	0.371

From the Table 3, it is observed that rice retained only about 5 per cent during the study period and lost about 0.60 per cent of its area share to chillies, about 6.90 per cent to red gram, about 11.20 per cent to sugarcane and about 76.30 per cent to groundnut. It had gained about 100.00 per cent of area share from red gram, 46.40 per cent from horse gram, 24.60 per cent from groundnut and 11.70 per cent from sugarcane. Red gram was unable to retain its area share. However, it had lost about 100.00 per cent of area to rice and gained about 6.90 per cent of area from rice, 2.20 per cent from groundnut and 1.50 per cent from horse gram. Chillies had shown instability, lost about 100.00 per cent of area share to groundnut and gained only about 0.30 per cent of area from horse gram, about 0.06 per cent from rice and about 1.20 per cent from groundnut. Sunflower had retained about 27.70 per cent during the study period and gained about 7 per cent of area share from sugarcane and 6 per cent share from groundnut. But it had lost about 72.30 per cent of its area share to groundnut. Sugarcane retained about 37.10 per cent and lost about 49.60 per cent of its area to groundnut, about 11.70 per cent to rice, about 9 per cent to chillies and about 7 per cent to sunflower. Sugarcane gained about 12.20 per cent of area share from groundnut and about 11.20 per cent of area share from rice. Horse gram retained about 48.80 per cent of its area share and lost about 46.40 per cent of its area to rice, about 2.90 per cent to groundnut, about 1.50 per cent to red gram and about 0.30 per cent to chillies. Horse gram gained about 4.10 per cent of area share from groundnut. Groundnut had shown highest stability by retaining 55.10 per cent during the study period. Meanwhile it had gained 100.00 per cent of area from chillies, about 76.30 per cent from rice, about 72.30 per cent from sunflower, about 49.60 per cent from groundnut and about 2.90 per cent from horse gram and lost about 24.60 per cent to rice, about 12.20

per cent to sugarcane, about 4.10 per cent to horse gram, about 2.20 per cent to red gram, about 1.20 per cent to chillies and about 0.60 per cent to sunflower.

### **Southern Zone**

The results of the transition probability matrix for crops of Southern Zone for the period of 2001-02 to 2019-20 are presented in the Table 4. The crops considered in the study were groundnut, paddy, red gram, bengal gram, horse gram, sunflower, horse gram, sugarcane, cotton and chillies.

The results in the Table 4 indicated that horse gram shown instability. It was unable to retain its area and retained only 10.30 per cent. It lost about 89.70 per cent of its area share to rice and gained only 0.50 per cent of area share from bengal gram, 0.50 per cent from cotton and 2.90 per cent from rice. Chillies retained only 15 per cent during the study period. It lost about 85 per cent of its area share to groundnut. Red gram retained 20.30 per cent of its area share. It had gained area from rice (2.20 per cent), groundnut (2.30 per cent) and sunflower (3.20 per cent). Red gram had lost its area share to cotton (25 per cent) and groundnut (54.70 per cent). Sugarcane had retained about 40.60 per cent during the study period and it had gained about 7.30 per cent of area from groundnut and about 3.20 percent from rice. But it had lost its area share to groundnut (49.60 per cent), sunflower (7.20 per cent), cotton (2 per cent) and chillies (0.70 per cent). Similarly sunflower retained about 48.70 per cent of its area share. It had gained area from groundnut (10.80 per cent) and sugarcane (7.20 per cent). Meanwhile it lost area to red gram (3.20 per cent) and groundnut (48.10 per cent). Groundnut as one of the major commercial crop had stability by retaining about 53 per cent of its area share.

**Table 4. TPM for shift in cropping pattern for Southern zone.**

	Rice	Bengal Gram	Red gram	Horse gram	Groundnut	Sunflower	Chillies	Sugarcane	Cotton
Rice	0.678	0.097	0.022	0.029	0.135	0.000	0.006	0.032	0.000
Bengal Gram	0.345	0.626	0.000	0.005	0.000	0.000	0.000	0.000	0.024
Red gram	0.000	0.000	0.203	0.000	0.547	0.000	0.000	0.000	0.250
Horse gram	0.897	0.000	0.000	0.103	0.000	0.000	0.001	0.000	0.000
Groundnut	0.259	0.000	0.023	0.000	0.530	0.108	0.007	0.073	0.000
Sunflower	0.000	0.000	0.032	0.000	0.481	0.487	0.000	0.000	0.000
Chillies	0.000	0.000	0.000	0.000	0.850	0.000	0.150	0.000	0.000
Sugarcane	0.000	0.000	0.000	0.000	0.496	0.072	0.007	0.406	0.020
Cotton	0.351	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.643

Meanwhile it had lost its area share to chillies (0.70 per cent), red gram (2.30 per cent), sugarcane (7.30 per cent), sunflower (10.80 per cent) and rice (25.90 per cent). However, it had gained about 85 per cent of area from chillies, about 54.70 per cent from red gram, about 49.60 per cent from sugarcane, about 48.10 per cent from sunflower and about 13.50 per cent from rice. Bengal gram retained 62.60 per cent of its area. It had gained area only from rice (9.70 per cent). Bengal gram had lost its area share to cotton (2.40 per cent), horse gram (0.50 per cent) and rice (34.50 per cent). Cotton had retained about 64.30 per cent during the study period and it had gained about 25 per cent of area from red gram, about 2.40 per cent from bengal gram and about 2 per cent from sugarcane. But it had lost its area share to rice (35.10 per cent) and horse gram (0.50 per cent). Rice had shown highest stability by retaining 67.80 per cent of its area share. Meanwhile it had gained 89.70 per cent of area from horse gram, about 35.10 per cent from cotton, about 34.50 per cent from bengal gram and about 25.90 per cent from groundnut and lost about 13.50 per cent to groundnut, about 9.70 per cent to bengal gram, about 3.20 per cent to sugarcane, about 2.90 per cent to horse gram, about 2.20 per cent to red gram and about 0.60 per cent to chillies.

## CONCLUSION

In Y. S. R Kadapa district, cotton and bengal gram were more stable, whereas red gram was the most unstable crop which was replaced by cotton and rice. Cotton showed highest retention of nearly 80 per cent and it gained its maximum share from red gram crop. In Nellore district, rice was the most stable crop, whereas red gram and groundnut were the most unstable crops, thus those cultivars are moving towards the rice crop. Rice showed highest retention of nearly 92 per cent and it gained maximum from groundnut, moderately from cotton and bengal gram and marginally from red gram. From the results it was inferred that in Chittoor district, among the stable crops groundnut was the crop that gained most, from the shares of remaining crops, but the distinction was that it gained more than three fourth of the share of rice (76.3 per cent) and chillies (100 per cent) and more than half of the share of sunflower (72.3 per cent). Among the unstable crops, paddy appears to have grabbed 24.6 per cent of the share of groundnut and sugarcane grabbed 12.2 per cent share of groundnut. However, Rice being the most important crop of Andhra Pradesh, its retention was only 5 per cent and 37 per cent in Chittoor and Kadapa districts respectively and it was lost majorly to groundnut, 76.3 per cent and

21.4 per cent respectively because of the suitability of climatic conditions, the socio-economic conditions of the farmers and their expertise in crop management with minimum resources, which undoubtedly made groundnut the stable crop in these districts of the Southern zone. But in Nellore District, the increase in irrigation facilities made the farmers go for rice (92.1 per cent retention), which is a highly procured and remunerative crop. At Zonal level, almost all crops showed retention capacity. Rice was the most stable crop with highest retention capacity of 67.8 per cent and gained majorly from horse gram, cotton, groundnut and bengal gram. Horse gram was the most unstable crop at zonal level and lost its major shares to rice. Shift in one crop to various crops is a sign of crop diversification. Hence, there is huge scope for decision-making in the selection of crops to put agriculture on the pedestal of sustainable growth which needs to be considered in research and extension programs.

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