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Dynamics of cropping pattern in Maharashtra: Markov chain approach

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Abstract

The cropping pattern represents the agricultural economy of a region or area and is a key factor in determining the level of agricultural production. The present study was conducted to know the changes in the cropping pattern of Maharashtra using Markov chain analysis. Time series data on the area under different crops grown from the period 2001-02 to 2020-21 were collected and analyzed for four regions of Maharashtra. The results revealed that in the Vidarbha region, during the period 2001-02 to 2010-11 *Kharif* Jowar observed that the most stable crop and retained 88% of its previous area and among the selected crops soybean was observed as the most stable crop and retained 76% of its previous area during the period 2011-12 to 2020-21. In Marathwada region, during the period 2001-02 to 2010-11 and 2011-12 to 2020-21 cotton was observed as the most stable crop and retained 92% and 51% of its previous share in area. While, in Western Maharashtra region, during the period of study i.e. 2001-02 to 2010-11 and 2011-12 to 2020-21 among the selected crops of the study *Kharif* maize was comparatively stable crop over other crops. In Konkan region, during the period of study i.e. 2001-02 to 2010-1, *Kharif* paddy retained 96% of its pervious share in area and in 2011-12 to 2020-21 it was retained 65% of its pervious share in area.

Keywords: Transitional probability matrix, cropping pattern, Markov chain analysis

Introduction

India is a country about one billion people, where agriculture play's an important role in Indian economy in other word to say agriculture has long been the backbone of India's economy during past, present and future. About more than 65% of population directly and indirectly depends on agriculture. According to agricoop.nc.in, the country's GDP (gross domestic product) has decreased from 20 percent in 2003–04 to 18.8% in 2021–2022. The agricultural industry in our nation has seen a significant transformation with the growth of the green revolution. A cropping pattern is characterized by the mix of crops planted in a specific geographic area. A shift in the cropping pattern results in a variation in the percentage of land devoted to various crops. The region's cropping pattern reveals the area under various crops, the rotation of crops, and the percentage of land under various crops at any given time. The cropping pattern represents the agricultural economy of a state or region and is a key factor in determining the level of agricultural production.

According to Vinayak Jalikatti and Poddar (2019) [13, 14], the construction of irrigation infrastructure may be the cause of long-term changes in cropping patterns in any region, while short-term variations in cropped area and productivity were caused by the whims of nature, such as rainfall and other institutional factors. Both the environment and the farmer's financial returns are significantly impacted by these short- and long-term changes. To gain a deeper understanding of the process of agricultural development, it is imperative to evaluate changes in cropping patterns across different regions. Hence, present study was conducted with the specific objectives to analyze the structural changes in cropping pattern over the year or period in different regions of Maharashtra.

Materials and Methods

For the purpose of the present study four regions of Maharashtra *viz.* Vidarbha, Marathwada, Western Maharashtra and Konkan were selected. Time series data on area under different major crops grown in these regions from the two periods from 2001-2002 to 2010-10 and 2011-12 to 2020-21 were collected from state website www.Krishi,maharashtra.gov.in. A transition probability matrix was constructed for four regions of Maharashtra using Markov chain analysis described below.

Markov chain analysis

Structural changes in cropping pattern

Markov chain analysis was used to study the structural changes in cropping pattern. It is an application of dynamic programming to the solution of a stochastic decision process that can be described by a finite number of states to study the changes in the cropping pattern (Dayakar Raoand Parwez, 2005) [3]. The Markov process was used to study the crop shifts in the Rayalaseema region by Reddy and Lalith Achoth (2000) [9] applied it to know the dynamics of the cropping pattern changes in Kerala.

The markov probability model

A stochastic process can analyze a set of trial or experiments probabilistically. 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. 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 preceding trial (t-1) and this dependence is the same at all stages of the sequence of trials (Lee *et al*., 1965) [5]. Consistent with this definition, let the S represent i^{th} state or possible outcomes; i =1,2,...,r, Wit represent the probability that state Si 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 (Sit). Pij represent the transitional probability which denotes the probability that if for any time t the process is in state Si, it moves on next trial to state Sj,

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

Pr = (Pij) represent transitional probability matrix which denotes transitional probability for every pair of states (i,j=1,2,……,r) and has the following properties;

$0 \leq P_{ij} \leq 1$ …….1

$\Sigma^{n}_{j-1} \quad P_{ij} = 1$ …….2

Given this set of notations and definitions for a first order Markov chain, the probability of particular sequence S_i in trial t and Sj on that t + 1 may be represent by

$P_r (S_{j\ t-1}) \Sigma_i W_{it} P_j$ or $W_{j,\ t+1} = \Sigma_i W_{it} P_j$ …….3

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

$P_r (S_{it}, S_{jt+1}) = P_r (S_{it}) P_r (S_{it+1}/S_{it}) = W_{it} P_{ij}$ …….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 Pij indicates the probability of a crop state i in one period will move to crop state j during the following period. The diagonal elements 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 incorporate in equation (4), it becomes,

$W_{it} = \Sigma_i W_{it} W_i t - 1 P_{ij} + \mu_{it}$ ……..(5)

or in matrix form it can be written as, $Y_j = X_j P_j + \mu_j$ ……..(6)

Where,

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

Xj = (T * r) matrix of realized values of the proportions in cropping pattern in time t–1,

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

µj= vectors of random disturbances.

Results and Discussion

The results of Markov chain analysis to find out changes in the direction of different crops in four regions of Maharashtra were presented in the form of a transitional probability matrix. As the diagonal elements approach zero, the crops become less and less stable and as they approach one, implies that they become more and more stable over a period of time. In the transitional probability matrix rows showed the previous period acreage of the corresponding crop lost to the other crops [i] in the current period and columns indicate area gained from the other crops.

The transitional probability matrix (TPM) in Table 1 showed the shift in area of different crops in Vidarbha region for the period 2001-02 to 2010-11 during *Kharif* season. Among all the crops total area under *Kharif* Jowar has highest retention probability with 88%. Soybean retained 72% of its previous area and lost 16% to cotton, 3% to *Kharif* paddy, 8 per to tur and 1% to other crops. Soybean gained 35% area from *Kharif* paddy and 28% from other crops.

Table 1: Transitional probability matrix for shift in cropping pattern in Vidarbha region during the period 2001-02 to 2010-11

Crops	Soybean	Cotton	*Kharif* paddy	Tur	*Kharif* Jowar	Area under other crops
Soybean	0.72	0.16	0.03	0.08	0.00	0.01
Cotton	0.00	0.46	0.02	0.06	0.00	0.46
Kharif paddy	0.35	0.00	0.65	0.00	0.00	0.00
Tur	0.00	0.19	0.00	0.41	0.00	0.40
Kharif Jowar	0.00	0.00	0.12	0.00	0.88	0.00
Area under other crops	0.28	0.43	0.15	0.13	0.01	0.00

Cotton retained 46% of its previous area and lost 6% to tur, 2% to *Kharif* paddy and 46% to other crops. Cotton grabbed 19% of its area from tur, 16% from soybean and 43% from others crops.

Kharif paddy had retained 65% of its previous area and lost 35% to soybean. *Kharif* paddy gained 15% area from other crops, 12 from *Kharif* jowar, 3% from soybean and 2% from cotton, respectively. Tur retained 41% of its area and lost

40% to other crops and 19% to cotton. Tur grabbed 13% of its area from other crops, 8% from soybean and 6% from cotton, respectively. *Kharif* Jowar has highest retention probability with 88% its area and gained 1% from other crops. *Kharif* Jowar lost 12% area to *Kharif* paddy.

The transitional probability matrix (TPM) in Table 2 showed the shift in area of different crops in Vidarbha region for the period 2011-12 to 2020-21. Soybean retained 76% of its previous area and lost 8% to cotton 4% to *Kharif* paddy and 12% to *Kharif* Jowar. Soybean gained 40% area from *Kharif* Jowar, 28% area from other crops and 23% area from tur. Cotton retained 46% area during the study period and lost 37% to other crops, 14% to tur and 3% to *Kharif* paddy. Cotton gained 8% from soybean, 46% from *Kharif* paddy, 19% from tur, 18% from *Kharif* Jowar and 13% from other crops.

Table 2: Transitional probability matrix for shift in cropping pattern in Vidarbha region during the period 2011-12 to 2020-21

Crops	Soybean	Cotton	*Kharif* Paddy	Tur	*Kharif* Jowar	Area under other crops
Soybean	0.76	0.08	0.04	0.00	0.12	0.00
Cotton	0.00	0.46	0.03	0.14	0.00	0.37
Kharif paddy	0.00	0.46	0.54	0.00	0.00	0.00
Tur	0.23	0.19	0.00	0.58	0.00	0.00
Kharif Jowar	0.40	0.18	0.00	0.00	0.00	0.42
Area under other crops	0.28	0.13	0.17	0.11	0.13	0.18

Kharif paddy retained 54% of its previous area and lost 46% to cotton. *Kharif* paddy gained 4% area from soybean, 3% from cotton and 17% from other crops. Tur retained 58% of its previous area and lost 23% to soybean and 19% to cotton. Tur grabbed 14% of area from cotton and 11% of area from other crops. *Kharif* Jowar retained zero% area during the study period. It was a most unstable crop the area under *Kharif* Jowar exponentially decreased during study period and diverted to other crops.

The results of transitional probability matrix for shift in cropping pattern in Marathwada region for the period of 2001-02 to 2010-11 was presented in Table 3 Soybean retained 80% of its previous area and lost 2% to cotton, 17% to tur and 1% to other crops. Soybean gained 17% area from other crops and 8% area from cotton.

Table 3: Transitional probability matrix for shift in cropping pattern in Marathwada region during the period 2001-02 to 2010-11

Crops	Soybean	Cotton	Tur	Area under other crops
Soybean	0.80	0.02	0.17	0.01
Cotton	0.08	0.92	0.00	0.00
Tur	0.00	0.00	0.42	0.58
Area under other crops	0.17	0.10	0.00	0.73

Cotton retained 92% previous area during the study period and lost 8% to soybean. Cotton gained 10% area from other crops and 2% area from soybean. In case of tur retained 42% of its previous area and lost 58% of area to other crops and it was gained 17% area from soybean.

The results of transitional probability matrix for shift in cropping pattern in Marathwada region during the period of 2011-12 to 2020-21 is presented in Table 4. Soybean retained 46% of its previous area and lost 18% to cotton, 16% to tur and 20% to other crops. Soybean grabbed 66% area from tur, 44% area from cotton and 5% area from other crops.

Table 4: Transitional probability matrix for shift in cropping pattern in Marathwada region during the period 2011-12 to 2020-21

Crops	Soybean	Cotton	Tur	Area under other crops
Soybean	0.46	0.18	0.16	0.20
Cotton	0.44	0.51	0.05	0.00
Tur	0.66	0.34	0.00	0.00
Area under other crops	0.05	0.00	0.12	0.83

Cotton retained 51% of its previous area during the study period and lost 44% to soybean and 5% to tur. Cotton gained 34% area from tur and 18% from soybean. On the other hand, tur retained zero% of its area during the study period. It was a most unstable crop the area under tur exponentially decreased during study period and lost 66% to soybean and 34% to cotton and it was gained 16% area from soybean, 12% from others crops and 5% from cotton.

Table 5 presented the results of transitional probability matrix for a shift of cropping pattern in Western Maharashtra region during the period 2001-02 to 2010-11. The results revealed that. Soybean has a retention capacity of 22% during the study period and it had lost its share of 43% to cotton, 18% to *Kharif* maize and 18% to other crops. While soybean gained 39% of area from *Kharif* maize, 13% from *Kharif* bajra and 5% from other crops, respectively.

Table 5: Transitional probability matrix for shift in cropping pattern in Western Maharashtra region during the period 2001-02 to 2010-11

Crops	Soybean	Cotton	*Kharif* paddy	*Kharif* maize	*Kharif* bajra	Sugarcane	Area under other crops
Soybean	0.22	0.43	0.00	0.18	0.00	0.00	0.17
Cotton	0.00	0.15	0.00	0.00	0.00	0.38	0.47
Kharif paddy	0.00	0.53	0.20	0.00	0.27	0.00	0.00
Kharif maize	0.39	0.00	0.00	0.61	0.00	0.00	0.00
Kharif bajra	0.13	0.12	0.22	0.00	0.42	0.11	0.00
Sugarcane	0.00	0.16	0.12	0.00	0.20	0.00	0.52
Area under other crops	0.05	0.32	0.07	0.13	0.08	0.27	0.08

Cotton is the cash crop and it's retained 15% of its previous area and lost 47% to other crops and 38% to sugarcane. Cotton grabbed 53% its area from *Kharif* paddy, 43% from soybean, 32% from other crops, 16% from sugarcane and 12% from *Kharif* bajra, respectively. On the other hand, *Kharif* paddy showed retention of 20% of its previous area

and lost 53% of its area to cotton and 27% to *Kharif* bajra. *Kharif* paddy gained 22% of area from *Kharif* bajra, 12% from sugarcane and 7% from other crops.

Among all the crops total area under *Kharif* maize has highest retention probability with 61% but it lost 39% area to soybean. However, *Kharif* maize gained 18% and 13% of previous year's share of area from soybean and other crops during the year under reference. *Kharif* bajra retained 42% of the previous year's share. They diverted 22%, 13%, 12% and 11 percent of previous year's share to *Kharif* paddy, soybean, cotton and sugarcane, respectively. *Kharif* bajra gained 27%, 20% and 8% of previous year's share from *Kharif* paddy, sugarcane and other crops respectively during the period of study.

Sugarcane was the most unstable crop and lost its area mainly to 4 crops i.e. 52% to other crops, 20% to *Kharif* bajra, 16% to cotton and 12% to *Kharif* paddy, respectively. Sugarcane area showed instability in the Western Maharashtra region during the study period.

Table 6: Transitional probability matrix for shift in cropping pattern in Western Maharashtra region during the period 2011-12 to 2020-21

Crops	Soybean	Cotton	*Kharif* paddy	*Kharif* maize	*Kharif* bajra	Sugarcane	Area under other crops
Soybean	0.17	0.00	0.00	0.15	0.00	0.68	0.00
Cotton	0.17	0.45	0.21	0.00	0.00	0.00	0.17
Kharif paddy	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Kharif maize	0.00	0.27	0.00	0.73	0.00	0.00	0.00
Kharif bajra	0.00	0.00	0.00	0.00	0.49	0.00	0.51
Sugarcane	0.10	0.20	0.00	0.11	0.00	0.59	0.00
Area under other crops	0.05	0.14	0.13	0.00	0.31	0.06	0.31

Table 6 presented the results of transitional probability matrix for a shift of cropping pattern in Western Maharashtra region during the period 2011-12 to 2020-21. It was observed from the Table 6 that, soybean retained 17% of its previous area and lost 68% to sugarcane and 15% to *Kharif* maize. Soybean grabbed 17% of its area from cotton, 10% from sugarcane and 5% from other crops respectively. In case of cotton crop retained 45% of its area and lost 21% to *Kharif* paddy and 17% each of the previous year's share to cotton and other crops during the period of study.

Kharif paddy was the most unstable crop and it lost hundred% of its area to other crops. Among all the crops total area under *Kharif* maize has highest retention probability with 73% but it lost 27% of its area to cotton. However, *Kharif* maize gained 15% and 11% of previous year's share from soybean and sugarcane during the year under reference.

Kharif bajra showed retention of 49% of its previous area and lost 51% of its area to other crops. *Kharif* bajra gained 31% from other crops. Sugarcane is also cash crop and retained 59% of previous years share. Sugarcane area diverted 20%, 11% and 10% to cotton, *Kharif* maize and soybean, respectively.

The transitional probability matrix in Table 7 showed the shift in area of in Konkan region for the period 2001-02 to 2010-11. In Kokan region *Kharif* paddy is a dominated crop therefore it was retained 96% of its previous area and lost 4% to other crops. *Kharif* paddy gained 14% of its area from other crops.

Table 7: Transitional probability matrix for shift in cropping pattern in Konkan region during the period 2001-02 to 2010-11

Crop	*Kharif* paddy	Area under other crops
Kharif paddy	0.96	0.04
Area under other crops	0.14	0.86

Table 8 presented the results of transitional probability matrix for a shift in cropping pattern in Konkan region during the period 2011-12 to 2020-21. *Kharif* paddy had retained 65% of its previous area and lost 35% to other crops.

Table 8: Transitional probability matrix for shift in cropping pattern in Konkan region during the period 2011-12 to 2020-21

Crop	*Kharif* Paddy	Area under other crops
Kharif paddy	**0.65**	0.35
Area under other crops	1.00	0.00

Conclusion

In Vidarbha region during the period 2001-02 to 2010-11 *Kharif* Jowar observed was the most stable crop and retained 88% of its previous area. During the period 2011-12 to 2020-21 among the selected crops soybean was observed as the most stable crop and retained 76% of its previous area. In Marathwada region, during the period 2001-02 to 2010-11 cotton was observed as the most stable crop and retained 92% of its previous share in area. During the period 2011-12 to 2020-21, again cotton was comparatively most stable crop and retained 51% of its previous area. In Western Maharashtra region, during the period of study i.e. 2001-02 to 2010-11, *Kharif* maize was comparatively stable crop over other crops and retained 61% of its previous area share. During the period 2011-12 to 2020-21, again *Kharif* maize was the most stable crop and retained 73% of its previous Area. While, in Konkan region, during the period of study i.e. 2001-02 to 2010-11, *Kharif* paddy retained 96% of its pervious share in area and in 2011-12 to 2020-21 it was retained 65% of its pervious share in area.

Policy implication

- Since the Jowar crop in the Vidarbha region was unstable during the study period, farmers may be encouraged to increase their cultivation through price support mechanisms.
- *Kharif* paddy is mono crop in Konkan region, hence the government should form policy for crop diversification to introduce suitable cash crops to avoid mono cropping.
- The global market's persistent price increases and growing demand for organic cotton could encourage the growth of this crop

References

1. Kammar A, Basavaraja H. Structural Changes in Cropping Pattern in Northern Transitional Zone of Karnataka. International Research Journal of Agricultural Economics and Statistics. 2012;3(2):197-201.
2. Ardeshna NJ, Shiyani RL. Dynamics of Cropping Pattern in Gujarat State: A Markov Chain Approach. Asian Academic Research Journal of Social Sciences & Humanities. 2013;1(9):56-66.
3. Rao D, Parwez S. Dynamics of Cropping Pattern in Sorghum growing States of India. Indian Journal of Agricultural Economics. 2005;60(4):644-659.
4. Mohan G. Determinants of Cropping Pattern Changes in Andhra Pradesh, India. Asian Journal of Agricultural Extension, Economics & Sociology. 2017;20(3):1-15.
5. Lee JC, Judge GG, Takagama T. On Estimating the Transitional Probabilities of Markov Process. Journal of Farm Economics. 1965;47(3):742-762.
6. Madhuri, Manwar K, Nagpure SC. Structural Changes in Cropping Pattern, International Journal of Science, Environment and Technology. 2017;6(5):2885-2892.
7. Rajini Devi DA, Uma Reddy R, Madavi B, Ravi P, Sadvi P. Dynamics of Cropping Pattern in Karimnagar District of Telangana – A Markov Chain Approach. Asian Journal of Agricultural Extension, Economics & Sociology. 2019;37(4):1-5.
8. Ramana MRV, Rekha M. Pricing of paddy: A case study of Andhra Pradesh. Department of Economic and Policy Research, Reserve Bank of India, study no. 2012;38:11-52.
9. Reddy DR, Achoth L. Dynamics of the Cropping Pattern Changes in Kerala: A Markov Chain Approach. Mysore Journal of Agricultural Sciences. 2000;34:376-381.
10. Siva Jyothi V, Prasuna Rani P, Ramana KV, Ratna Prasad P, Sree Rekha M. Cropping pattern changes: A case study in Krishna delta region of Andhra Pradesh. International Journal of Chemical Studies. 2020;8(1):494-500.
11. Suhasini P, Kiresur VR, Rao GDN, Bantilan MCS. Adoption of chickpea cultivars in Andhra Pradesh: Pattern, trends and constraints. Baseline research report for Tropical Legumes- II, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); c2009. p. 1-69.
12. Srivastavaa SK, Sivaramane N, Mathura VC. Diagnosis of Pulses performance of India. Agricultural Economics Research Review. 2010;23:137-148.
13. Jalikatti V, Poddar RS. An Economic Analysis of Changing Cropping Pattern in Almatti Command Area of Karnataka, India. International Journal of Current Microbiology and Applied Sciences. 2019;8(10):1052-1059.
14. Wali VS, Poddar R, Mundinamani SM, Yenagi BS. An Analysis of Cropping Pattern in Malaprabha Project Command Area. International Journal of Agriculture Sciences. 2019;11(2):7739-7742.