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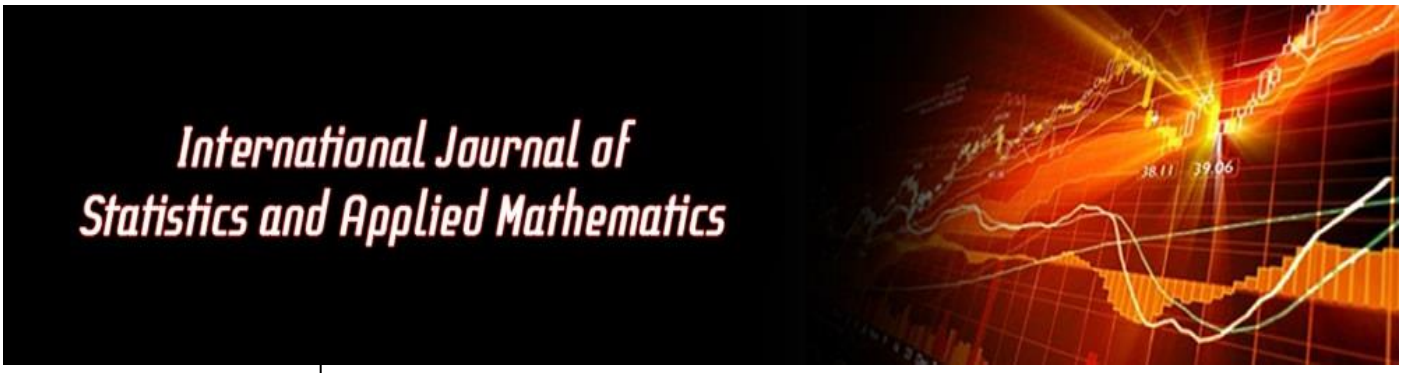


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# The changes in cropping pattern in Nanded district of Maharashtra

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**Abstract**
The Markov chain analysis of cropping patterns in Nanded district, Maharashtra, highlights significant shifts in crop acreage from 2013-14 to 2022-23, as summarized in the transitional probability matrix (TPM). The matrix reveals the stability of different crops based on the proximity of diagonal elements to 0 or 1. Notably, the category of "other crops," including Tur and Cotton, demonstrated high retention probabilities (0.77 and 0.79), with a complete loss of Jowar's acreage (100 per cent) to other crops.
Wheat retained 54 per cent of its area but transferred portions to Maize, Green Gram, Black Gram, and Soybean. In contrast, Maize retained only 2 per cent of its previous area, primarily losing it to Jowar. Green Gram and Black Gram showed substantial area loss, with the latter transferring 97 per cent to Cotton. Tur maintained 77 per cent of its area, while Soybean retained 69 per cent. Cotton emerged as the most stable crop, with a 79 per cent retention probability, whereas Sugarcane exhibited total loss of its acreage, mainly to Soybean and Gram. These findings indicate significant shifts in cropping patterns, influenced by the competitive dynamics among various crops in the region.

**Keywords:** Markov chain analysis, cropping patterns, Transitional Probability Matrix (TPM), retention probabilities, jowar, wheat, maize, green gram, black gram, soybean, cotton, sugarcane, shifts in cropping patterns, area loss, area gain

## 1. Introduction
Cropping pattern refers to the distribution of various crops in a given area at a specific time and the changes in this distribution over time, influenced by various factors (Misra & Puri, 2011) [5]. It is a dynamic concept that evolves due to physical, socio-cultural, and historical influences (Akhtar, 2015) [1]. Understanding cropping patterns involves analyzing how arable land is utilized for different agricultural practices (Seitinthang, 2013) [7]. A diversified cropping pattern is viewed as an effective strategy to manage risks and uncertainties in agriculture, stemming from climatic and biological changes (Shiyani and Pandya, 1998) [9].
The cropping pattern of a region refers to the proportion of area allocated to different crops at a given time, influenced by various factors. In India, the intensity of the monsoon plays a significant role; during good monsoon years, rice cultivation increases, while in drought years, drought-resistant crops like bajra and maize are favoured. Additionally, issues such as land fragmentation due to population growth, market fluctuations, and environmental risks can lead to shifts in cropping patterns. Advances in technology and the use of High Yielding Variety (HYV) seeds have also intensified crop production, enabling practices like double rice cropping in semi-arid regions such as Punjab, Haryana, and Western Uttar Pradesh through improved irrigation methods.
Agriculture is the primary economic activity in Nanded district, with the 2011 Indian Census indicating that about 65 per cent of the workforce is engaged in agriculture. This sector supports nearly 80 per cent of the population, highlighting the community's heavy reliance on agriculture. Therefore, the present study has undertaken with following specific objective:
- To study the changes in cropping pattern in Nanded district of Maharashtra.

## 2. Materials and Methods
For the estimation of structural changes of cropping pattern, Markov Chain analysis was used for time period from 2013-14 to 2022-23, for Nanded district.

Kammar and Basvaraja (2012) [4], also have used similar model to study the structural changes in cropping pattern in northern transitional zone of Karnataka. The changes in cropping pattern will be studied through Markov chain Analysis. Markov Chain Analysis is the estimation of the transitional probability matrix 'P' whose elements, $P_{ij}$ indicate the probability of shifting area from one crop 'i' to another crop 'j' over time. The diagonal element $P_{ij}$ where i=j, measures the probability of a crop retaining its share. The average area shifted to a particular crop was considered to be a random variable which depends only on the area under past crop, which can be denoted algebraically as:

$$E_{jt} = \sum_{i=1}^{n} \left[E_{i(t-1)}\right] P_{ij} + e_{jt}$$

Where,
$E_{jt}$ = Area of the crop shifted towards the particular jth crop in the year t
$E_{it}$-1 = Area lost by ith crop during the year t-1
$P_{ij}$ = the probability the area lost will shift from ith crop to jth crop
$e_{jt}$ = The error term which is statistically independent of $E_{it}$-1
n = the number of crops.
The transitional probabilities $P_{ij}$, which can be arranged in a (c*n) matrix, have the following properties:

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

## 3. Results and Discussion

The results of Markov chain analysis are to find out shift in cropping pattern of area under different crops in Nanded district of Maharashtra were presented in the form of a transitional probability matrix. The transition probability matrix represented the consistency of the crop's acreage share and the direction of change over time. As the diagonal elements approaches zero in the transitional probability matrix the crops become less and less stable as the diagonal components go closer to zero and as they approach to one, it implies that they become more and more stable over a period of time. The components of the ith row of the Transitional Probablity Matrix indicate the percentages of the ith crop's acreage from the previous period that are expected to be lost to other crops in current period. The ith column's element provides the percentage of the ith crop's area that is projected to increase during the next duration. In the transitional probability matrix rows showed the previous period acreage of the corresponding crop lost to other crops in the current period and columns indicate area gained from the other crops.

According to the results of the transitional probability matrix (TPM) in Table no.1 showed the shifts in area of different crops in Nanded district from 2013-14 to 2022-23. Among all the crops studied, the acreage under the other crops retained fairly highest probability to the extents of 0.77 and 0.79 the other crops in the district include Tur and Cotton. This retention of area was further reinforced by the gain from Jowar 100 Per cent. The transfer probabilities from other crops to Wheat (53 Per cent), Green Gram 6 Per cent, Black Gram 14 Per cent and Soybean 27 Per cent. Similar results were identified by Thakare *et al*. (2024) [12].

Among all the crops, total area under Cotton has highest retention probability with 79 Per cent. Jowar retained 0 Per cent of its previous area and lost 100 Per cent of its area to other crops.

Wheat retained 54 Per cent of its area and lost 7 Per cent to Maize, Green Gram 3 Per cent, Black Gram 21 Per cent and 15 Per cent to Soybean crop. Wheat has gained 0 Per cent area from Maize, 4 Per cent area from Cotton

The acreage under Maize had a retained 2 Per cent of its previous area and lost 78 Per cent to Jowar, 10 Per cent Green Gram and 9 Per cent to Black Gram. Maize grained 2Per cent area from Wheat 7 Per cent area. Green Gram retained 0 Per cent of its area and lost its area to 60 Per cent to Soybean, 29 Per cent to Tur and Sugarcane 12 Per cent. Among pulses Black Gram retain its 0 Per cent of its previous area and lost 0.03 Per cent area to Tur and 97 Per cent of its area to Cotton. Gram retained 46 Per cent of its previous area and lost its area to 54 Per cent to Soybean and 1 Per cent of its area to Sugarcane. Tur retain 77 Per cent of its previous area and lost 4 Per cent of its area to Cotton and 19 Per cent of its area to green Gram. Among oilseeds Soybean retain area to its previous area of 69 Per cent and lost most of its rea to 7 Per cent Sugarcane and 1 Per cent to other crops. Cotton retained to very highest area 79 Per cent of its previous area. Sugarcane retained 0 Per cent of its previous area and lost its area to Soybean 61 Per cent and 39 Per cent of its area to Gram.

**Table 1:** Transitional probability matrix for shift in cropping pattern for 2013-2023

| Crops | Jowar | Wheat | Maize | Green Gram | Black Gram | Gram | Tur | Soybean | Cotton | Sugarcane |
|---|---|---|---|---|---|---|---|---|---|---|
| Jowar | 0.00 | 0.53 | 0.00 | 0.06 | 0.14 | 0.00 | 0.00 | 0.27 | 0.00 | 0.00 |
| Wheat | 0.00 | 0.54 | 0.07 | 0.03 | 0.21 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 |
| Maize | 0.78 | 0.00 | 0.02 | 0.10 | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Green Gram | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.29 | 0.60 | 0.00 | 0.12 |
| Black gram | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.97 | 0.00 |
| Gram | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.46 | 0.00 | 0.54 | 0.00 | 0.01 |
| Tur | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.77 | 0.00 | 0.04 | 0.00 |
| Soybean | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.19 | 0.03 | 0.69 | 0.00 | 0.07 |
| Cotton | 0.11 | 0.04 | 0.00 | 0.01 | 0.05 | 0.00 | 0.00 | 0.00 | 0.79 | 0.00 |
| Sugarcane | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.39 | 0.00 | 0.61 | 0.00 | 0.00 |

## 4. Conclusion

The transitional probability matrix (TPM) analysis of cropping patterns in Nanded district, Maharashtra, from 2013-14 to 2022-23 reveals significant shifts in crop acreage. Notably, "other crops" (including Tur and Cotton) displayed high retention probabilities of 0.77 to 0.79, indicating stability. Jowar, however, experienced a complete loss of its area, with a retention probability of 0 per cent Wheat retained 54 per cent of its area but lost significant portions to various crops, including Maize and Soybean. Maize retained only 2 per cent of its area, primarily losing to Jowar.

Green Gram and Black Gram showed complete loss of their previous areas, with Green Gram shifting predominantly to Soybean. Tur retained 77 per cent of its area but also lost portions to Cotton and Green Gram. Soybean exhibited a retention of 69 per cent while losing area mainly to

Sugarcane. Cotton had the highest retention at 79 per cent Overall, the results illustrate a trend of instability for several crops, particularly Jowar, Green Gram, and Black Gram, while indicating a strong consolidation around Cotton and Soybean.

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