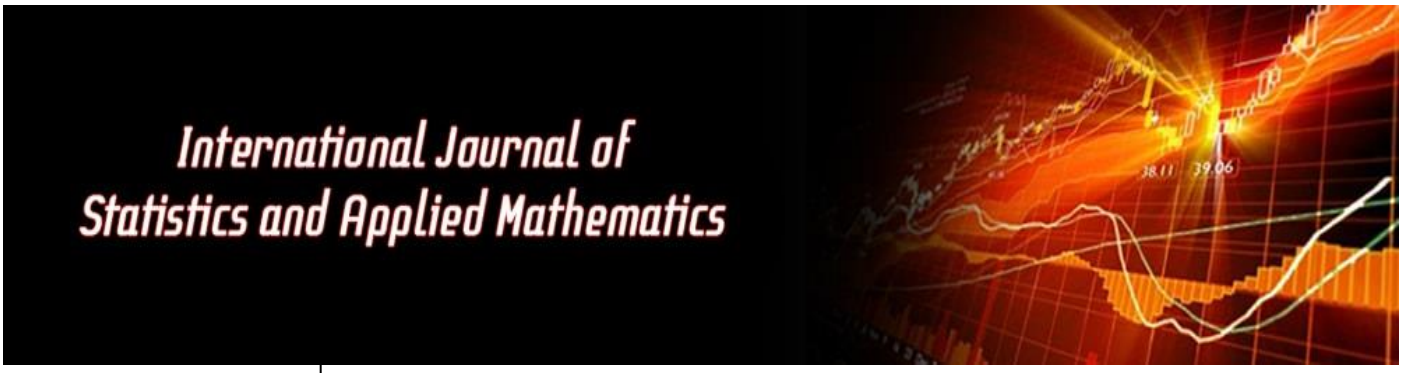
International Journal of Statistics and Applied Mathematics 2024; SP-9(5): 182-184



ISSN: 2456-1452
Maths 2024; SP-9(5): 182-184

www.mathsjournal.com
Received: 14-09-2024
Accepted: 16-10-2024

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The changes in cropping pattern in Chhatrapati Sambhajinagar district of Maharashtra

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Abstract
This study analyzes the shifts in cropping patterns in Chhatrapati Sambhajinagar district, Maharashtra, using a transitional probability matrix derived from Markov chain analysis. The matrix illustrates the stability and changes in the acreage of various crops from 2013-14 to 2022-23. Key findings indicate that the category of "other crops" exhibited the highest retention probability at 0.81, signifying relative stability. Among individual crops, cotton demonstrated a notable retention probability of 0.81, while gram, tur, and soybean showed complete loss of their previous acreage, indicating significant shifts to other crops.
Wheat retained 48 per cent of its area, with notable losses to pigeon pea and sugarcane, yet gained 5per cent from cotton. Maize retained 77 per cent of its acreage but lost 23 per cent to jowar, while green gram and black gram exhibited lower retention rates, with black gram losing 87 per cent of its area to sugarcane. The analysis highlights the dynamic nature of cropping patterns in the region, with substantial transitions impacting staple crops and pulses. The results provide valuable insights for agricultural planning and policy-making in the district.

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 different crops in a specific area over time, influenced by various physical, socio-cultural, and historical factors. (Misra & Puri, 2011) [5]. It is a dynamic concept that reflects how arable land is used for various agricultural practices (Akhtar, 2015) [1]. A diversified cropping pattern can be an effective strategy for managing risks associated with climatic and biological uncertainties. (Seitinthang, 2013) [7].
In India, cropping patterns are significantly impacted by monsoon intensity. For instance, good monsoon years often lead to increased rice cultivation, while drought years shift preferences toward drought-resistant crops like bajra and maize. Other factors, such as land fragmentation, market fluctuations, and environmental risks, can also drive changes in cropping patterns. Technological advancements, particularly the use of High Yielding Variety (HYV) seeds, have intensified crop production, allowing for practices like double rice cropping in regions such as Punjab, Haryana, and Western Uttar Pradesh. (Anderson and Dillon).
In Chhatrapati Sambhajinagar district, agriculture is the main economic activity, with around 65 per cent of the workforce engaged in this sector, which supports nearly 80 per cent of the population. The district's fertile land and sufficient groundwater supply enhance its agricultural productivity, making it particularly known for sugarcane, rice, and wheat production. Therefore, the present study has undertaken with following specific objective:
- To study the changes in cropping pattern in Chhatrapati Sambhajinagar 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 Chhatrapati Sambhajinagar 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:

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

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 is to find out shift in cropping pattern of area under different crops in Chhatrapati Sambhajinagar district of Maharashtra were presented in the form of a transitional probability matrix. The transition probability matrix represented the consistency of the crop's acerage 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 approache 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 acerage 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 acerage 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 Chhatrapati Sambhajinagar district from 2013-14 to 2022-23. Among all the crops studied, the acerage under the other crops retained fairly highest probability to the extents of 0.81. Similar results were identified by Thakare *et al*. (2024) [12].

Among all the crops, total area under Cotton has highest retention probability with 0.81. Gram, Tur and Soyabean retained 0per cent of its previous area and lost 100 per cent of its area to other crops. Wheat retained 48 per cent of its area and lost 23 per cent to Pigeon pea and 29 per cent to sugarcane. Wheat has gained 5 per cent area from cotton.

The acreage under Maize had a retained 77 per cent of its previous area and lost 23 per cent to jowar. Maize grained 1 per cent area from Cotton and 1 per cent area from sugarcane. Green gram retained 46 per cent of its area and lost its 15 per cent area to Black gram and 39 per cent to sugarcane. Among pulses Black gram retained 13 per cent of its previous area and lost 87 per cent area to Sugarcane. Gram retained 0.00 per cent of its previous area and lost its 5 per cent area to Green gram and 2 per cent of its area to Black gram, 87 per cent area to Cotton and 6 Sugarcane. Pigeon pea retain 00 per cent of its previous area and lost its 4per cent of its area to Green gram, 88 percent area to Gram and 8 per cent of its area to Soyabean. Among oilseeds, soybean retain 00 per cent of its previous area and lost its 30 per cent to Gram and 70 per cent area lost to Pigeon pea. Cotton retained its 81 per cent area and lost 3 per cent of its previous area to Wheat, 1per cent area to Maize, 4 per cent area to Gram, 3 per cent area Pigeon pea and 3 per cent area lost to Soyabean. sugarcane retained 00 per cent of its previous area and lost its 100 per cent area to Maize crop.

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

Crops	Jowar	Wheat	Maize	Green gram	Black gram	Gram	Pigeon pea	Soybean	Cotton	Sugarcane
Jowar	0.55	0.00	0.00	0.00	0.00	0.00	0.05	0.04	0.36	0.00
Wheat	0.00	0.48	0.00	0.00	0.00	0.00	0.23	0.0and	0.00	0.29
Maize	0.23	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Green gram	0.00	0.00	0.00	0.46	0.15	0.00	0.00	0.00	0.00	0.39
Black gram	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.87
Gram	0.00	0.00	0.00	0.05	0.02	0.00	0.00	0.00	0.87	0.06
Pigeon pea	0.00	0.00	0.00	0.04	0.00	0.88	0.00	0.08	0.00	0.00
Soybean	0.00	0.00	0.00	0.00	0.00	0.30	0.70	0.00	0.00	0.00
Cotton	0.03	0.05	0.01	0.00	0.00	0.04	0.03	0.03	0.81	0.00
Sugarcane	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

4. Conclusion

The Markov chain analysis of cropping patterns in Chhatrapati Sambhajinagar district (2013-2023) reveals significant shifts in crop areas, as indicated by the transitional probability matrix (TPM). Cotton shows the highest retention probability (0.81), indicating stability in its cultivation. Crops like Gram, Tur, Soybean, and Pigeon Pea exhibit a complete loss of area 0 per cent retention, suggesting a major decline.

Wheat retains 48 per cent of its area but loses significant portions to Pigeon Pea and Sugarcane while gaining from Cotton. Maize retains 77 per cent of its area, losing some to Jowar but gaining from Cotton and Sugarcane. Several crops, particularly pulses, are being replaced by Sugarcane, which has a retention probability of 0 per cent.

5. Acknowledgements

Acknowledgement I extend my special and heartiest thanks to my research guide, teachers, seniors and batchmates for their guidance, genuine interest, activeness and sharp insights. I deeply thank my beloved parents for their unwavering

inspiration, continuous encouragement and steadfast support throughout my academic career.

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