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Dynamics of cropping pattern in north Karnataka district of Karnataka: A markov chain approach

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Abstract

The assessment of shift in cropping pattern in several regions is crucial for much better insight into the agricultural development method. The present study was undertaken to examine the dynamics of cropping pattern in 13 districts of North Karnataka. The data was collected from Directorate of Economics and Statistics, Government of Karnataka from 1998 to 2020 and total 22 years data were analysed with the help of Markov chain. Major finding from the study revealed area of the crops was shifting from one district to another district throughout the period and results showed that area under Jowar crop was more stable in Bagalkot and Ballari districts, Maize crop in Belagavi, Dharwad and Gadag districts, Redgram crop in Kalaburgi and Bidar districts, Cotton crop in Uttara Kannada district and Groundnut crop in Vijayapura district. Maize followed by Jowar crops were gain higher retention in North Karnataka Districts.

Keywords: Cropping pattern, dynamics, markov chain

Introduction

The cropping pattern of a region reveals the proportion of area of land 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. Cropping patterns are the yearly sequence of crops grown and the spatial arrangement of crops. A change in cropping pattern implies a change in proportion of area under different crops. It has significant bearing on widening the geographical inequalities in income distribution. Cropping pattern refers to adoption of particular type of crops by the farmers in a particular region. It is expressed at macro level, that is, district, taluk or village level. Hence, present study was conducted with the specific objective to analyze the structural changes in cropping pattern over the years in north Karnataka districts of Karnataka.

Materials and Methods

Identification of shifts in cropping system

Markov chain model

The structural change in cropping pattern of selected *Kharif* crops in North Karnataka districts in terms of area under major rainfed crop retention and switching was examined by using the Markov Chain approach. The analysis was carried out in LINGO software. Transition probability matrix for each crop was prepared and shifts in cropping area were identified for each district and crop.

Results part

Identification of shifts in cropping systems

The area of selected *Kharif* crops over north Karnataka was analysed by estimating transitional matrix using stochastic Markov Chain Model. The relationship among different crops is shown in Table 1 to Table 13 for thirteen districts of north Karnataka in the form of transitional probability matrix.

From Table 1, it is noticed that for Bagalkot district the highest retention area was noticed for Jowar (93%) followed by Maize (91%), cotton (52%), groundnut (50%) and redgram (34%). In this process, cotton gained 12% area from groundnut and lost 48% share to Jowar; groundnut gained 7% area from Jowar and 2% area from maize, but lost 39% area to maize. On the other hand, redgram gained 7% area from maize and lost major area of 66% to maize.

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Maize retained its 91% share of area by gaining 66% area from redgram and 39% area from groundnut. Jowar lost 7% area to groundnut and gained 1% area from maize.

Transitional probability matrix for Belagavi district (Table 2) indicated that highest area of retention was in maize (94%) followed by those in Jowar (90%), cotton (70%) and groundnut crop (63%) and least retention area was noticed in redgram (8%). In this process, cotton gained 7% area from groundnut and 6% area from maize and lost its area 22% area to groundnut and 8% to redgram. Groundnut crop gained 10% area from Jowar and 22% from cotton and lost 17% area maize, 9% area to Jowar and 4% are to redgram. Redgram lost 68% area to Jowar and 24% area to maize. Retention of area by Maize was possible by losing only 6% area to cotton. The high retention percentage of Jowar was due to gaining 68% area from redgram and 9% area from groundnut. Transitional probability matrix for Ballari district indicated retention area was by Jowar (80%) followed by maize (76%), cotton (75%) and least area was contributed by redgram (3%). In this process cotton gained 20% area from redgram and 9% area from maize, but it also lost 24% area to maize. Groundnut crop gained 34% area from redgram, 20% area from Jowar and 10% area from maize, while it also lost 11% area to Jowar and 21% area to maize.

Redgram lost 34% area to groundnut crop, 28% area to Jowar and 20% area to cotton. Maize maintained its highest contributing area by gaining 24% area from cotton, 21% from groundnut crop and 14% from redgram. Jowar even-though maintained higher area but lost 20% area to groundnut crop (Table 3).

Transitional probability matrix for Bidar district indicated highest retention area was by redgram (89%) followed by that of Jowar (79%), groundnut (55%) and maize (15%) and least contribution in area was by cotton (4%). In this process cotton lost 86% area to Jowar while it gained 24% area from groundnut. Groundnut crop lost 21% area to Jowar and 24% to cotton. Redgram gained 75% area from maize and 5% area from Jowar and cotton. Maize maintained low contributed area by losing 75% area to redgram meanwhile gained 6% area from cotton and 8% area from redgram. Jowar maintained second highest area by gaining 86% area from cotton, with slight loss of area to cotton and groundnut (7% each) and redgram (5%) (Table 4).

Transitional probability matrix for Dharwad district noticed that highest retention area was by maize (76%) followed by that in Jowar (75%), cotton (68%) and groundnut (32%) and least area was by redgram (4%). In this process cotton gained 36% area from groundnut and 25% area from Jowar, while it lost 22% area to groundnut and 8% area to Jowar. Groundnut gained 24% area from maize, but lost 36% area to cotton and 27% area to maize. Redgram lost 61% area to maize and 35% area to Jowar. Maize gained 61% area from redgram and 27% area from groundnut. Jowar gained 35% area from redgram and 8% area from cotton, while it lost 25% area to cotton (Table 5).

From the transitional probability matrix for Gadag district, it is noticed that highest retention area was by maize and Jowar (83%) followed by cotton (52%) and groundnut (33%). Least retention of area was by redgram (11%). In this process, cotton lost 46% area to groundnut and 2% to redgram, while it gained 32% area from groundnut and five% area each from maize and Jowar. Groundnut gained 80% area from redgram, 10% area from maize and 12% area from Jowar, whereas it lost 21% area to maize and 12% area to Jowar.

Redgram lost 80% area to groundnut, but it gained 2% each area from cotton, groundnut and maize. Maize lost only 10% area to groundnut, 5% area to cotton and 2% area to redgram. Jowar also lost only 12% area to groundnut and 5% area to cotton (Table 6).

Transitional probability matrix for Kalaburgi district indicated that highest retention area by redgram (91%) was followed by that of Jowar (76%) and least area retained by cotton (20%), groundnut (11%) and maize (11%). In this process, cotton lost 75% to redgram and 4% area to groundnut, while it gained 8% area from redgram. Groundnut crop gained 17% area from Jowar, but it lost 89% area to Jowar. Redgram gained 75% area from cotton and 7% area from Jowar. Maize lost 69% to Jowar and 20% area to redgram. Jowar gained 69% area from maize and 89% area from groundnut crop, whereas it lost 7% area to redgram and 17% to groundnut (Table 7).

From the transitional probability matrix for Haveri district, it is noticed that highest retention area was contributed by Jowar (86%) followed by maize (85%), groundnut (81%) and cotton (73%) and least area by redgram (3%). In this process cotton maintained fourth highest area by gaining 13% area from groundnut and 15% area from maize and it lost 22% area to maize. Groundnut gained 8% area from redgram. Redgram maintained least area by losing 75% area to Jowar and 13% area to maize. Maize contributed second highest area by gaining 2% from cotton and 13% from redgram. Jowar contributed highest area by losing only 12% area to maize and 2% area to redgram (Table 8).

Transitional probability matrix for Koppal district indicated that highest retention shared by maize (83%) was followed by Jowar (69%), redgram (43%) and groundnut (36%), while the least area of retention was by cotton (17%). In this process, cotton lost 36% area to groundnut and 31% redgram, but gained 28% area from groundnut and 3% area from maize. Groundnut gained 41% area from redgram and 31% from Jowar, while it lost 28% area to cotton and 26% area to Jowar. Redgram gained 31% area from cotton and 7% area from maize, but it lost 41% area to groundnut. Maize retained highest area by losing only 7% to Jowar and redgram and 3% area to cotton. Jowar lost 31% area to groundnut (Table 9).

Transitional probability matrix for Raichur district indicates that the highest retention area by Jowar (76%) was followed by groundnut (74%), maize (68%), cotton (67%) and redgram (56%). In this process, cotton gained 35% from redgram, 18% each from groundnut and Jowar, but lost its area of 33% to redgram. Groundnut gained 32% from maize, 9% from redgram and 6% from Jowar, whereas it lost 8% to Jowar and 18% to groundnut. Retention percentage of redgram area was by gaining 33% area from cotton, but losing 35% area to cotton and 9% to groundnut. Maize area lost its 32% area to groundnut. Jowar lost 18% area to cotton and 6% to groundnut, but it gained 8% area from groundnut (Table 10).

From the transitional probability matrix for Uttara Kannada district, it is noticed that highest retention area was for cotton (76%) followed by that for groundnut (75%), maize (68%) and Jowar (35%). Least area retained by redgram (6%). In this process, cotton retained highest area by gaining 58% area from Jowar, 15% area from maize, 6% area from groundnut and 9% area from redgram. It also lost 6% area to groundnut, 3% area to redgram and maize and 2% area to Jowar. Groundnut gained 14% area from redgram and 7% area from maize and 3% area from Jowar and it lost 10% area to redgram, 6% area to maize and 3% area to Jowar. Redgram retained lowest area by losing 71% area to maize, 14% area to

groundnut and 9% area to cotton. On the other hand it gained 3% area from cotton, 10% from groundnut, 8% area from maize and 5% are from Jowar. Maize gained 71% area from redgram, 6% area from groundnut and 3% area from cotton and lost its major area of 15% to cotton, 7% area to groundnut and 8% to redgram. Jowar lost 58% area to cotton, 3% area to groundnut and 5% area to redgram, but it gained 2% area from cotton and maize and 3% from groundnut (Table 11).

Transitional probability matrix for Vijayapura district indicates that the highest retained area was by groundnut (75%) followed by redgram (70%) and cotton (40%) and least area contributed by Jowar (14%). In this process cotton lost 30% area to groundnut, 27% area to redgram and 3% area to maize, while it gained 10% area from redgram. Groundnut gained 30% area from cotton, but it also lost 20% area to redgram and 5% area to maize. Redgram gained 27% area from cotton and 20% area from groundnut and 86% area from maize. Maize lost 86% area to redgram, whereas it gained 20% area from redgram, 5% area from groundnut and 3% area from cotton (Table 12).

From the transitional probability matrix for Yadgir district, it is noticed that the highest area was retained by cotton (66%) followed by groundnut (64%) and least area retained by maize and Jowar (9% each) followed by redgram (3%). In this process cotton retained highest area by gaining 28% area from groundnut and 60% area from maize and 10% area from Jowar. It lost 26% area to groundnut. On the other hand, groundnut gained 87% area from redgram, 31% from maize, 26% area from cotton and 80% from Jowar, but it lost 28% area to cotton. Redgram retained lowest area by losing 87% area to groundnut and 8% area to cotton. Maize lost 60% area to cotton and 31% to groundnut, while it gained 7% area from groundnut and 1% from Jowar. Jowar retained lowest area by losing 80% area to groundnut and 10% area to cotton (Table 13).

Table 1: Transitional probability matrix for shifts in crops area in Bagalkot district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.52	0.00	0.00	0.00	0.48
Groundnut	0.12	0.50	0.00	0.38	0.00
Redgram	0.00	0.00	0.34	0.66	0.00
Maize	0.00	0.02	0.06	0.91	0.01
Jowar	0.00	0.07	0.00	0.00	0.93

Table 2: Transitional probability matrix for shifts in crop area in Belagavi district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.70	0.22	0.08	0.00	0.00
Groundnut	0.07	0.63	0.04	0.17	0.09
Redgram	0.00	0.00	0.08	0.24	0.68
Maize	0.06	0.00	0.00	0.94	0.00
Jowar	0.00	0.10	0.00	0.00	0.90

Table 3: Transitional probability matrix for shifts in crop area in Ballari district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.75	0.00	0.01	0.24	0.00
Groundnut	0.00	0.62	0.06	0.21	0.11
Redgram	0.20	0.34	0.03	0.15	0.28
Maize	0.09	0.10	0.05	0.76	0.00
Jowar	0.00	0.20	0.00	0.00	0.80

Table 4: Transitional probability matrix for shifts in crop area in Bidar district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.04	0.04	0.00	0.06	0.86
Groundnut	0.24	0.55	0.00	0.00	0.21
Redgram	0.01	0.01	0.89	0.08	0.01
Maize	0.05	0.06	0.75	0.14	0.00
Jowar	0.07	0.07	0.05	0.02	0.79

Table 5: Transitional probability matrix for shifts in crop area in Dharwad district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.68	0.22	0.02	0.00	0.08
Groundnut	0.36	0.32	0.04	0.27	0.01
Redgram	0.00	0.00	0.04	0.61	0.35
Maize	0.00	0.24	0.00	0.76	0.00
Jowar	0.25	0.00	0.00	0.00	0.75

Table 6: Transitional probability matrix for shifts in crop area in Gadag district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.52	0.46	0.02	0.00	0.00
Groundnut	0.32	0.33	0.02	0.21	0.12
Redgram	0.01	0.80	0.11	0.06	0.02
Maize	0.05	0.10	0.02	0.83	0.00
Jowar	0.05	0.12	0.00	0.00	0.83

Table 7: Transitional probability matrix for shifts in crop area in Kalaburgi district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.20	0.04	0.75	0.01	0.00
Groundnut	0.00	0.11	0.00	0.00	0.89
Redgram	0.08	0.00	0.91	0.01	0.00
Maize	0.00	0.00	0.20	0.11	0.69
Jowar	0.00	0.17	0.07	0.00	0.76

Table 8: Transitional probability matrix for shifts in crop area in Haveri district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.73	0.04	0.01	0.22	0.00
Groundnut	0.13	0.81	0.06	0.00	0.00
Redgram	0.00	0.08	0.03	0.14	0.75
Maize	0.15	0.00	0.00	0.85	0.00
Jowar	0.00	0.00	0.02	0.12	0.86

Table 9: Transitional probability matrix for shifts in crops area in Koppal district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.17	0.36	0.31	0.02	0.14
Groundnut	0.28	0.36	0.00	0.10	0.26
Redgram	0.00	0.41	0.43	0.05	0.11
Maize	0.03	0.00	0.07	0.83	0.07
Jowar	0.00	0.31	0.00	0.00	0.69

Table 10: Transitional probability matrix for shifts in crop area in Raichur district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.67	0.00	0.33	0.00	0.00
Groundnut	0.18	0.74	0.00	0.00	0.08
Redgram	0.35	0.09	0.56	0.00	0.00
Maize	0.00	0.32	0.00	0.68	0.00
Jowar	0.18	0.06	0.00	0.00	0.76

Table 11: Transitional probability matrix for shifts in crop area in Uttarakhand district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.76	0.06	0.13	0.03	0.02
Groundnut	0.06	0.75	0.10	0.06	0.03
Redgram	0.09	0.14	0.06	0.71	0.00
Maize	0.15	0.07	0.08	0.68	0.02
Jowar	0.57	0.03	0.05	0.00	0.35

Table 12: Transitional probability matrix for shifts in crop area in Vijayapur district

	Cotton	Groundnut	Redgram	Maize
Cotton	0.40	0.30	0.27	0.03
Groundnut	0.00	0.75	0.20	0.05
Redgram	0.10	0.00	0.70	0.20
Maize	0.00	0.00	0.86	0.14

Table 13: Transitional probability matrix for shifts in crop area in Yadgir district

	Cotton	Groundnut	Redgram	Maize	Jowar
Cotton	0.66	0.26	0.08	0.00	0.00
Groundnut	0.28	0.64	0.00	0.07	0.01
Redgram	0.00	0.87	0.03	0.10	0.00
Maize	0.60	0.31	0.00	0.09	0.00
Jowar	0.10	0.80	0.00	0.01	0.09

Discussion Part

Identification of shifts in cropping system.

From the transitional probability matrix changes shifts in cropping systems over north Karnataka districts was identified over a period of twenty years (1998-2017) (Tables 24 to 36).

From Bagalkot district it is noticed that highest retention of area was for Jowar (93%) which was followed by Maize (91%). Considerable reduction was noticed for retention of Cotton (52%), groundnut (50%) and redgram (34%). In Belagavi district highest retention area was noticed in maize (94%) followed by Jowar (90%), cotton (70%) and groundnut (63%). Extremely low retention area was noticed for redgram (8%). In Ballari district highest retention was noticed in Jowar (80%) followed by maize (76%), cotton (75%) and groundnut (62%) and least retention area contributed from redgram 3%). In Bidar district highest retention area for redgram (89%) followed by Jowar (79%) and groundnut (55%). Extremely low retention was noticed for maize (15%) and cotton (4%).

In Dharwad district highest area was retained by maize (76%) followed by Jowar (75%), cotton (68%). Retention area of groundnut (32%) and redgram (4%) was low. In Gadag district highest retention was noticed in maize (83%) and Jowar (83%) followed by that cotton (52%) and groundnut (33%). The least retention area was by redgram (11%). In Kalaburgi district highest area contributed by redgram (91%) followed by Jowar (76%). Very low retention was noticed for cotton (20%), groundnut (11%) and maize (11%).

In Haveri district highest retention area was for Jowar (86%) followed by maize (85%), groundnut (81%) and cotton (73%), while lowest area of retention was for redgram (3%). In Koppal district highest area of retention was for maize (83%) followed by Jowar (69%), redgram (43%) and groundnut (36%) and least area contributed by cotton (17%). In Raichur district highest retention area was noticed for Jowar (76%) followed by groundnut (74%), maize (68%), cotton (67%) and redgram (56%).

In Uttara Kannada district highest area for retention was

contributed by cotton (76%) followed by groundnut (75%), maize (68%), Jowar (35%) and least area retained by redgram (6%). In Vijayapur district highest retention area was noticed in groundnut (75%) followed by redgram (70%), cotton (40%) and least area of retention was noticed in Jowar (14%). In case of Yadgir district highest retention area was noticed for cotton (66%) followed by groundnut (64%) and least area of retention was noticed for maize (9%), Jowar (9%) and redgram (3%).

Similar study with shifts in the cropping system was conducted by Gurulingappa (2018) [3].

Conclusion

- From the results of shifts in cropping system over north Karnataka districts, it was noticed that in case of Jowar area highest retention was noticed in Bagalkot district (93%), in Haveri district (86%) in Ballari district (80%) and in Raichur district (76%).
- In case of maize area highest retention was noticed in Belagavi district (94%), in Gadag district (83%), in Koppal district (83%) and in Dharwad district (76%).
- In case of redgram area highest retention was identified in Kalaburgi district (91%) and in Bidar district (89%). In case of cotton area highest retention was noticed in Uttara Kannada district (76%) and in Yadgir district (66%).
- In case of groundnut area highest retention was noticed in Vijayapura district (75%).
- The similar work with weekly rainfall probabilities supports from the analysis conducted by Venkatesh (2003) [6] and Venkatesh *et al.* (2008) [7].

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