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Dynamics of Cropping Pattern and Crop Diversification in Southern Dry Zone of Karnataka – An Econometric Analysis

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ABSTRACT

The paper has examined the dynamics of cropping pattern and crop diversification in Southern Dry Zone of Karnataka for the period 2001-02 to 2015-16 using compound growth rate, crop diversification indices and Markov chain analysis. The results revealed that the area under vegetables and spices and fruits and nuts has shown significant positive growth rate at both district and taluk level. The area under sugarcane and coconut had shown significant positive growth rate of 2.38 per cent and 3.11 per cent, respectively at district level. Whereas, the area under sugarcane (9.51 %) had shown significant positive growth rate and area under horsegram (-5.36 %) had shown significant negative growth rate at taluk level. The crop diversification indices indicated shift in cropping pattern towards diversification in both areas. The transition probability matrix indicated that the horticultural crops in general and coconut crop in particular have retained a higher share in terms of area under crops.

Keywords: Crop diversification, growth rate, markov chain analysis, transition probability matrix

THE changes in cropping pattern are basically the result of the adoption of new crops and the intensification of cultivation through multiple cropping. The changes in cropping pattern over time are also a function of changes in the extent and quality of irrigation and the relative costs of and returns to competing crops and crop combinations (Gairhie, 2011). The change in cropping pattern in particular span of time clearly indicates the changes that have taken place in the agricultural development (Sikandar, 2014). The availability of inputs for intensive agriculture, the cropping system in some state has undergone a paradigm shift, from a much diversified cropping pattern to a mono-cropped one. Crop diversification provides the farmers with a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to bring down the possible risk. Diversification of crops has immense potential as an economic driver within the agricultural sector (Kumar and Gupta, 2015). In view of this, the present study was undertaken in southern dry zone of Karnataka to assess the changes in cropping pattern and crop diversification using time series data.

METHODOLOGY

The Cauvery command area coming under Southern dry zone of Karnataka was purposively selected for the study. Based on net irrigated area which is a proxy for greater degree of mechanization, the Mandya taluk of Mandya district was selected. The analysis was carried out at both district and taluk levels in the present study.

Nature and sources of data

The study is mainly based on the time series data obtained from Directorate of Economic and Statistics (DES), Bengaluru. The data pertaining to area under different crop groups and principal crops for a period from 2001-02 to 2015-16 (15 years) was considered. The annual compound growth rates and instability index (Cuddy and Valle, 1978) for area were computed for the study period.

To assess the extent of crop diversification, the following indices were used

a) Herfindahl Index (HI) - It is the sum of square of the proportion of acreage under each crop to the total cropped area and is given by the equation:

$$\mathbf{HI} = \sum_{i=1}^{N} P_i^2 \text{ ——————— (1)}$$

Where, P_i represents acreage proportion of the i^{th} crop in total cropped area. The Herfindahl index takes the value of one when there is specialization and approaches zero when there is diversification.

b) Simpson Index (SI) - It is the most suitable index for measuring diversification of crops in a particular geographical region and is calculated by equation:

$$SI = 1 - \sum_{i=1}^{N} P_i^2 \text{ ———— (2)}$$

Where, $P_i = A_i / \Sigma A_i$ is the proportion of the i^{th} activity in acreage. Simpson index of near zero, indicates that the zone or region is near to specialization in growing of a particular crop and if it is close to one, then the zone is fully diversified in terms of crops.

Markov Chain Analysis

To assess the shift in cropping pattern of area under crops during 2001-02 to 2015-16, transitional probabilities were calculated based on linear programming (LP) approach using LP SOLVER IDE software. To know the shift in cropping pattern, different crops like paddy, ragi, other cereals (maize and millets), horsegram, cowpea, other pulses (redgram, blackgram, avare and greengram), sesamum, other oilseeds (groundnut, niger seed and castor), sugarcane, coconut, horticulture crops (vegetables, spices and fruits) and other crops (chilly, mulberry etc.,) were considered. Markov chain analysis develops a transitional probability matrix 'P', whose elements P_{ij} indicate the probability (share) of crop switching from the i^{th} crop to the j^{th} crop over time. Its diagonal elements represent retention share of respective crop in terms of area under crops. This can be algebraically expressed as Equation:

$$E_{jt} = \Sigma [E_{it} -_1] P_{ij} + e_{jt} \text{ ———— (3)}$$

$i=1,...,n$

where,

E_{jt} = Area under j^{th} crop in the year 't'

E_{it}-1 = Area under i^{th} crop during the year 't-1'

P_{ij} = The probability of shift in area under i^{th} crop to j^{th} crop

e_{jt} = The error-term statistically independent of E_{it}-1, and

n = The number of crops.

The transitional probabilities P_{ij} arranged in (m × n) matrix have the following properties:

$\Sigma P_{ij} = 1$ and 0 dH P_{ij} dH 1

$i=1,...,n$

The transitional probability matrix (T) based on LP framework is estimated using Minimization of Mean Absolute Deviation (MAD).

Min, OP* + Ie

Subjected to

X P* + V = Y

GP* = 1

P* > 0

Where, P* is the transitional probability matrix, '0' is the zero vector, 'I' is an appropriately dimensional vector of areas, and 'e' is the vector of absolute errors.

Results and Discussion

Growth and instability in area of major crop groups in Southern Dry Zone of Karnataka

The results from Table I indicate that though there was a negative growth rate in area under cereals and minor millets, pulses and oilseeds at district level, the growth rates were statistically non-significant. The area under commercial crops, vegetables and spices and, fruits and nuts had shown significant positive growth rate of 2.35, 8.31 and 2.36 per cent at district level, respectively. The results of instability index indicate that the variation in area under major crop groups was minimum.

At taluk level, the area under vegetables and spices and fruits and nuts had shown significant growth rate of 7.39 and 9.88 per cent, respectively. Whereas, the area under pulses had shown significant negative growth rate of 4.47 per cent. The instability index indicates that the area under oilseeds and fruits and nuts was more unstable when compared to other crop groups (Table I).

Growth and instability in area of major crops in Southern Dry Zone of Karnataka

At district level, the results from Table II revealed that the area under sugarcane and coconut had shown significant positive growth rate of 2.38 and 3.11 per cent, respectively. While, the area under remaining crops had shown non-significant growth rates. The area under sugarcane had shown significant positive growth rate (9.51 %) and area under horsegram had shown significant negative growth rate (5.36 %) at taluk level. The findings of Ashwini (2014) has aptly supported the findings of this study.

TABLE I

Growth and instability in area of major crop groups in southern dry zone of Karnataka (2001-02 to 2015-16)

Crop Group	Mandya district			Mandya taluk		
	Mean area (000, ha)	CGR (%)	Instability Index (%)	Mean area (000, ha)	CGR (%)	Instability Index (%)
Cereals and minor millets	136.11	-0.63	18.95	21.18	1.31	23.51
Pulses	41.15	-1.61	24.89	05.55	-4.47 *	32.62
Oilseeds	09.66	-3.41	38.93	00.57	3.15	78.69
Commercial crops	37.41	2.35 *	15.53	10.81	1.55	23.03
Vegetables and Spices	06.70	8.31 **	14.75	00.67	7.39 **	28.32
Fruits and Nuts	27.17	2.36 **	08.71	02.56	9.88 **	62.81

Note : * Significance at 5 %, ** Significance at 1 %

TABLE II

Growth and instability in area of major crops in southern dry zone of Karnataka (2001-02 to 2015-16)

Crop Group	Mandya district			Mandya taluk		
	Mean area (000, ha)	CGR (%)	Instability Index (%)	Mean area (000, ha)	CGR (%)	Instability Index (%)
Cereals and minor millets	136.11	-0.63	18.95	21.18	1.31	23.51
Paddy	71.15	0.16	20.75	14.27	1.86	23.23
Ragi	60.15	-1.13	24.84	6.76	0.31	40.12
Horse gram	29.95	-2.68	38.34	4.71	-5.36 *	35.96
Cowpea	5.99	-2.68	37.58	0.38	5.85	55.44
Sesamum	4.84	1.86	58.14	0.32	11.52	119.99
Sugarcane	36.78	2.38 *	9.35	10.74	1.54	23.13
Coconut	21.44	3.11 **	10.49	2.09	9.51 *	66.42

Note : * Significance at 5 %, ** Significance at 1 %

The instability index had shown that the area under sesamum was more unstable at both district and taluk levels. The area under coconut at district level had shown more instability when compared to that at taluk level. Similarly, the fluctuation in area under other major crops also had shown more fluctuation at district level compared to that at taluk level except in horsegram (Table II).

TABLE III

Crop diversification in southern dry zone of Karnataka (2001-02 to 2015-16)

Index	Mandya district	Mandya taluk
Herfindahl Index (HI)	0.32	0.35
Simpson Index (SI)	0.68	0.65

TABLE IV

Transition probability matrix of changes in cropping pattern for Mandya district of Karnataka (2001-02 to 2015-16)

	Paddy	Ragi	Other cereals	Horsegram	Cowpea	Other pulses	Sesamum	Other oilseeds	Sugarcane	Coconut	Horticulture	Other Crops
Paddy	0.5547	0.1314	0.0000	0.0000	0.0000	0.0218	0.0000	0.0000	0.2916	0.0005	0.0000	0.0000
Ragi	0.0501	0.3690	0.0479	0.1426	0.0312	0.0000	0.0044	0.0170	0.0963	0.1108	0.0406	0.0901
Other cereals	0.0000	0.0000	0.0000	0.0000	0.0000	0.1131	0.0000	0.0000	0.6539	0.2330	0.0000	0.0000
Horsegram	0.3117	0.3585	0.0000	0.1322	0.0002	0.0046	0.0337	0.0343	0.0000	0.0000	0.0000	0.1248
Cowpea	0.3429	0.0000	0.0775	0.0000	0.1627	0.0000	0.2190	0.0000	0.0000	0.0000	0.1979	0.0000
Other pulses	0.8814	0.0000	0.0000	0.0000	0.0000	0.0000	0.1186	0.0000	0.0000	0.0000	0.0000	0.0000
Sesamum	0.0000	0.6073	0.0000	0.0000	0.0000	0.0000	0.2761	0.1166	0.0000	0.0000	0.0000	0.0000
Other oilseeds	0.0000	0.5462	0.0000	0.2899	0.0000	0.0458	0.0189	0.0992	0.0000	0.0000	0.0000	0.0000
Sugarcane	0.1851	0.3538	0.0000	0.0000	0.0204	0.0575	0.0000	0.0000	0.2801	0.1031	0.0000	0.0000
Coconut	0.0000	0.0000	0.0344	0.4296	0.0808	0.0000	0.0000	0.0000	0.0000	0.4511	0.0041	0.0000
Horticulture	0.0000	0.0000	0.0284	0.1762	0.0000	0.0000	0.0000	0.0000	0.0000	0.0664	0.7290	0.0000
Others	0.7548	0.0000	0.0000	0.0000	0.0000	0.0646	0.0000	0.0934	0.0000	0.0000	0.0000	0.0872

TABLE V

Transition *probability matrix of changes in cropping pattern for Mandya taluk of Mandya district (2001-02 to 2015-16)*

	Paddy	Ragi	Other cereals	Horsegram	Cowpea	Other pulses	Sesamum	Other oilseeds	Sugarcane	Coconut	Horticulture	Other Crops
Paddy	0.5456	0.0622	0.0000	0.0517	0.0000	0.0084	0.0000	0.0178	0.2174	0.0081	0.0000	0.0888
Ragi	0.0000	0.2350	0.0000	0.0042	0.0000	0.0157	0.0000	0.0000	0.6379	0.0859	0.0213	0.0000
Other cereals	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Horsegram	0.0000	0.5819	0.0000	0.3930	0.0000	0.0251	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cowpea	0.0000	0.9253	0.0000	0.0000	0.0000	0.0000	0.0747	0.0000	0.0000	0.0000	0.0000	0.0000
Other pulses	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sesamum	0.0000	0.0000	0.0000	0.3208	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6792	0.0000
Other oilseeds	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
Sugarcane	0.5784	0.0000	0.0000	0.1771	0.0120	0.0000	0.0000	0.0000	0.2325	0.0000	0.0000	0.0000
Coconut	0.0000	0.1559	0.0000	0.0000	0.0586	0.0000	0.1341	0.0000	0.0701	0.5813	0.0000	0.0000
Horticulture	0.0193	0.0000	0.0566	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.8134	0.1101
Others crops	0.0284	0.3685	0.0070	0.0000	0.0795	0.0000	0.0034	0.0000	0.4209	0.0000	0.0853	0.0070

Crop diversification in Southern Dry Zone of Karnataka

The average value of Herfindahl index for different crop groups was 0.32 for Mandya district and 0.35 for Mandya taluk, indicating crop diversification at both the district and taluk levels. Similarly, the average value of Simpson index also indicated diversification at district and taluk levels (Table III). Birthal *et al.* (2008) reported that the marginal and small farmers optimize their cropping pattern in a way that enables them to obtain higher income without adversely affecting their food security.

Transition probability matrix of changes in cropping pattern for Mandya district of Karnataka (2001-02 to 2015-16)

It is evident from Table IV that the horticulture crops and paddy were the major crops of the district as reflected by the probability of retention of 0.7290 and 0.5547, respectively, followed by coconut (0.4511), ragi (0.3690) and sugarcane (0.2801). While other cereals and other pulses have shown instability in the retention of area with the probability value of zero. Horsegram, cowpea, sesamum, other oilseeds and other crops were least stable crops with probability retention of area of 0.1322, 0.1627, 0.2761, 0.0992 and 0.0872 of the total cultivatable area of the district, respectively. Similar results were reported by Harish (2006) in his study.

When the leading crops of the district is consider, sugarcane gained major proportion of area from paddy, ragi and other cereals, while it has lost its major share to ragi (0.3538) and paddy (0.1851). The probability of transition of paddy had shown a shift towards ragi, other pulses, sugarcane and cotton. The gained area over the year can be attributed from ragi, sugarcane, other crops and pulse crops. Ragi had gained a larger proportion of area from sesamum, other oilseeds, horsegram and sugarcane (Table IV).

Transition probability matrix of changes in cropping pattern for Mandya taluk of Mandya district (2001-02 to 2015-16)

The results from Table V revealed that the probability of retaining of paddy and ragi, the principal food crops of the taluk was 0.5456 and 0.2350, respectively. The probability of retention was higher for horticulture crops (0.8134), followed by coconut (0.5813). The other cereals, cowpea, other pulses, sesamum and other oilseeds had shown instability in the retention of area with probability value of zero. Among pulses, the horsegram was the major crop which had probability of retention of 0.3930. The probability of retention of sugarcane was 0.2325 over the previous years' share and the other crops had retained meager area of its previous years' share.

The paddy, sugarcane and ragi were the major crops of the taluk. The paddy gained a larger proportion of its share from sugarcane (0.5784). However, the probability of transition from paddy had shown loss of area to ragi, horsegram, other pulses, other oilseeds, sugarcane, coconut and other crops (Table V). Sugarcane had lost its major proportion to paddy (0.5784) and horsegram (0.1771). While it has gained larger area from other cereals (1.00) and ragi (0.6379). Ragi is the major staple food crop of the area, which has gained larger proportion from other pulses, cowpea and horsegram, but lost its major proportion of area to sugarcane (0.5784).

The study revealed that the area under commercial crops, vegetables and spices and fruits and nuts had shown significant positive growth rates at both district and taluk level. The area under sugarcane and coconut had shown significant positive growth rate at district. Whereas, the area under sugarcane had shown significant positive growth rate and area under horsegram had shown significant negative growth rate at taluk level. The average value of Herfindahl and Simpson indices indicated the diversification at district and taluk level. The transition probability matrix had indicated that the horticultural crops and coconut have retained a higher share in terms of area under crops. Whereas, other cereals and other pulses have shown instability at district level and other cereals, cowpea, other pulses, sesamum and other oilseeds had shown instability at taluk level in the retention of area with probability value of zero. The water scarcity has made the farmers to diversify their cropping pattern. Crop diversification ensures livelihood security to the farmers. Therefore, in addition to crop diversification, the farmers should be educated regarding the research based recommendations and technologies on the farm which would strengthen the crop diversification process in the study area.

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