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Research Note

Crop Diversification in Gadag District of Karnataka§

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Abstract

The nature, extent and determinants of crop diversification have been analysed in the Gadag district of Karnataka over space and time. The area under vegetables, fruits and pulse crops has registered a higher (7-11%) growth compared to cereals, oilseeds, fibre and other crop groups (<1%). Over the years, the share of cereal crop groups has decreased significantly from 32.53 per cent to 28.81 per cent and that of fruits and vegetables has increased considerably from 0.10 per cent to 0.25 per cent for fruits and from 4.66 per cent to 7.80 per cent for vegetable crops. The transition probability matrix has indicated that over the years, horticultural crop groups have retained a higher share (92%) in terms of area under crops. The Northern Dry Zone (Gadag taluk) has been found to be more diversified with Entropy index of 0.99 and household crop richness of 3.20 compared to 0.55 and 1.90 in the Northern Transitional Zone (Shirahatti taluk), respectively. The major factors influencing crop diversification have been identified as size of landholding, gross irrigated area, and net return realised per farm.

Key words: Crop diversification, horticulture, entropy, crop richness, probability matrix, Karnataka

JEL Classification: Q16, R11

Introduction

In India, the agricultural sector contributes 13.7 per cent to the national gross domestic product (GDP). This sector also provides employment to 52 per cent of the total work force of the country. In dry land agriculture, diversification serves as a sole source of combating risk against climate and weather vagaries. Crop diversification in India is generally viewed as a shift from the traditionally grown less-remunerative crops to more remunerative crops. The crop diversification ensures security for food, nutrition, income and employment to a wider section of the society and hence, has a significant bearing on GDP of the nation. Gopalappa (1996), based on his study in Andhra Pradesh, reported that there was scope to increase income through crop diversification. Acharya *et al.* (2011) have reported that crop diversification contributes to increased cropping intensity, higher employment, commercialization of farming, reduction in migration of male members and involvement of women in income-generating activities. However, the study has analysed crop diversification at the state level and there is a need to have micro level evidences of crop diversification.

The present study has analysed the nature and extent of crop diversification at the micro level under two distinct agro-climatic conditions of the state. It has also identified the factors that influence crop diversification in this area. It was hypothesised that crop diversification is more in the northern dry zone (NDZ) than in the northern transitional zone (NTZ).

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Data and Methodology

To analyse the nature and extent of diversification, Gadag, which is one of the districts in Karnataka that are undergoing diversification, was selected. From the district, two taluks belonging to different zones were selected. The primary data were collected from 30 sample farmers from each of the selected taluks representing different zones such as northern dry zone (NDZ) and northern transitional zone (NTZ).

The district Gadag was formed (carving out of Dharwad district) in 1997 and the secondary data pertaining to area under important crop groups were obtained for the period from 1998-99 to 2011-12 from the Directorate of Economics and Statistics and Directorate of Horticulture, Government of Karnataka. The primary data on socio-economic characteristics, cropping pattern, factors influencing diversification, etc. were collected from the sample farmers of Gadag (NDZ) and Shirahatti (NTZ) taluks for the agricultural year 2012-13. The growth in area under different crop groups in Gadag and Shirahatti taluks of Gadag district were analysed through the standard compound growth function. Different indices, viz. Herfindahl index, Simpson Index, Margaleff Index and Entropy Index were used for assessing crop diversification.

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 Equation (1):

$$\text{Herfindahl Index (HI)} = \sum_{i=1}^{N} Pi^2 \qquad \ldots(1)$$

where, Pi represents acreage proportion of the i^{th} crop in total cropped area.

As diversification increases, the sum of square of the proportion of activities decreases and so also the indices (HI). The Herfindahl index takes the value of one when there is specialization and approaches zero when there is diversification. Since the index measures concentration; it is transformed by subtracting from one, i.e., 1 – HI. The transformed value of HI avoids confusion on comparing it with other indices.

Simpson Index — It is the most suitable index for measuring diversification of crops in a particular geographical region and is calculated by Equation (2):

$$\text{Simpson Index (SI)} = 1 - \Sigma P_i^2 \qquad \ldots(2)$$

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

Magalef Index (MI) — It is the number of crops normalized for area planted and has a lower limit of zero when only one variety is grown. The MI is constructed as per expression (3):

$$CD = S\text{-}1/\ln A \qquad \ldots(3)$$

where, CD is the crop diversity maintained by a farmer; A is the total area planted to all crops by a farmer; S is the total number of crops maintained by the farmer.

Entropy Index (EI) — It is a direct measure of diversification having a logarithmic character and is given by Equation (4):

$$\text{Entropy index (EI)} = \sum_{i=1}^{N} Pi * \log(1/P_i) \qquad \ldots(4)$$

where, P_i represents acreage proportion of the i^{th} crop in total cropped area.

The Entropy index increases with diversification. The Entropy index approaches zero when the farm is specialized and P_i equals one (perfect specialization) and takes a maximum value when there is perfect diversification. The upper limit of Entropy Index is determined by the base of logarithms and the number of crops. The upper value of the index can exceed one, when the number of crops is higher than the value of the logarithm's base, and it is less than one when the number of crops is lower than the base of logarithm.

Markov Chain Analysis — To assess the dynamism in direction of area under crops during 1998 to 2012, transitional probabilities were calculated based on linear programming (LP) approach using LINDO software. To know the shift in cropping pattern, different crop groups like cereals, pulses, sugar crops, oilseeds, fibre and horticulture crops were considered. Markov chain analysis develops a transitional probability matrix 'P', whose elements P_{ij} indicate the probability (share) of crop group switching from the i^{th} crop group to the j^{th} crop group over time. Its diagonal elements represent retention share of respective crop group in terms of area under crops. This can be algebraically expressed as Equation (5):

$$E_{jt} = \Sigma\, [E_{it}\text{-}1]\, P_{ij} + e_{jt} \qquad \ldots(5)$$

$i=1,\ldots,n$

where,

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

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

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

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

n = The number of crop groups.

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

$$\Sigma P_{ij} = 1 \text{ and } 0 \leq P_{ij} \leq 1$$

$$i=1,...,n$$

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

Min, OP* + I e

ST

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.

Garret Ranking Technique — In this study, Garret ranking technique was used to assess the benefits of practising crop diversification and constraints in crop diversification.

The respondents were asked to rank (in the order of severity) the factors- benefits and constraints and these ranks were converted to scores by referring to Garret table.

The order of merit given by the respondents was changed into ranks by using formula, (6):

$$\text{Per cent position} = \frac{100(R_{ij} - 0.50)}{N_j} \quad \ldots(6)$$

where,

R_{ij}= Rank given for the i^{th} item by the j^{th} individual, and

N_j=Number of items ranked by the j^{th} individual

The per cent position of each rank was converted to scores by referring to the tables given by Garret and Woodworth (1969). Then, for each factor, the scores of individual respondents were summed up and divided by the total number of respondents for whom scores were gathered. The mean scores for all the factors were ranked, following the decision criterion, that is higher the score, more important is the benefit and problem to farmers.

Multiple Linear Regression Analysis — It was used to examine the factors influencing crop diversification in the study area, through Equation (7):

$$Y=a_0+a_1X_1+a_2X_2+a_3X_3+u \quad \ldots(7)$$

where, Y is the crop diversification (Index or crop richness), X_1 is the size of holding (acre), X_2 is the income of family (₹), X_3 is the irrigated land (acre), u is the random error-term and a_0 is the constant term.

Results and Discussion

Growth in Area under Crop Groups in Gadag District

The growth in area under different crop groups over the period of 14 years from 1998-99 to 2011-12 was analyzed using the exponential growth function. The results (Table1) showed a positive growth in area — 0.43 per cent in cereals, 6.58 per cent in pulses, 22.84 per cent in sugar crops and 0.53 per cent for spice crops

Table 1. Growth in area of different crop groups in the Gadag district, 1998-99 to 2011-12

(in per cent)

Crop group	Gadag taluk	Shirahatti taluk	Gadag district
Cereals	-0.967	0.72	0.43
Pulses	5.63*	5.72*	6.58*
Sugar crops	10.09	21.37*	22.84*
Spices	-0.471	-3.911	0.53
Fruits	7.82*	5.17*	10.67*
Vegetables	4.00*	0.94	6.7*
Oilseeds	-1.01	-0.057	-0.91
Fibres	-1.72	0.58	-0.55
Medicinal and aromatic	25.57*	-17.96	-10.03
Flowers	-4.19	0.78	-1.18

Note: * denotes significance at 5 per cent level.

Table 2. Changes in share of crop groups in total cropped area in Gadag district, TE 2000-01 to 2011-12

(Per cent)

Period	Crop group									
	Cereals	Pulses	Sugar	Spices	Fruits	Vegetables	Oilseeds	Fibres	Medicinal and aromatic crops	Flowers
TE 2000-01	32.53	16.39	0.04	3.48	0.10	4.66	28.80	13.87	0.06	0.07
TE 2003-04	30.96	18.98	0.10	3.28	0.16	5.51	29.09	11.83	0.02	0.07
TE 2006-07	26.63	25.87	0.02	3.23	0.17	6.00	28.85	9.13	0.01	0.08
TE 2009-10	28.23	25.31	0.10	3.07	0.23	7.87	25.47	9.66	0.01	0.06
TE 2011-12	28.81	26.89	0.90	3.15	0.25	7.80	19.41	12.73	0.02	0.05

annually. The area under fruits and vegetables increased at the rate of 10.67 per cent and 6.7 per cent per annum, respectively. But, in the case of oilseeds, fibre crops, medicinal and aromatic and flower crops, the growth rate during 1998-99 to 2011-12 was negative with the values at level being -0.91 per cent, -0.55 per cent, -10.03 per cent and -1.18 per cent per annum, respectively.

At the taluk level also, the area under commercial crops like sugar cane and horticultural crops increased. Among the two taluks under study, the growth in area under fruits, vegetables and medicinal & aromatic crops was found to be more in Gadag taluk than in Shirahatti taluk.

Changes in Cropping Pattern in Gadag District

The changes in the cropping pattern for the period 1998-2012 were analysed for the Gadag district. The results (Table 2) indicated that the share in area of cereals, oilseeds and fibre crops had a decline in Gadag district. The area share of vegetables, pulses and fruits increased during the study period. Over the years, the area share of cereal crops group decreased significantly from 32.53 per cent in TE 2003-04 to 28.81 per cent in TE 2011-12. However, cereals still occupied the major share of the cropped area, indicating the farmers' awareness about their value in food security besides livelihood security. For the pulse crops, the area share increased from 16.39 to 26.89 per cent. It may be due to the awareness among the farmers about protein requirement (nutritional security) and its availability from pulses. It is a healthy sign as India relies heavily on the imports of pulses to meet its domestic requirements. It is also to be noted that in order to address the supply side constraints and to enhance the seed replacement rates, the Government of India has launched the National Food Security Mission–Pulses (NFSM -pulses) and Accelerated Pulses Production Program (A3P) in the major pulses-growing states of Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh and Karnataka (Rimal *et al.*, 2015). In Karnataka, both the programs have been in existence since 2007-08 and the accelerated pulses production program (A3P) was launched with a target of 38000 ha, under pulses in the districts of Gadag, Raichur, Bijapur, Bidar and Dharwad to increase the productivity of tur, gram, horsegram, blackgram, greengram, cowpea and avare (Anon, 2010). As a result, there has been an increase in production of pulses in these districts which also includes Gadag (Venkatesh, 2013). The positive impact of A3P on increased pulses productivity and production was also observed in other pulses- growing major states of Madhya Pradesh, Rajasthan, Maharashtra, Uttar Pradesh and Karnataka (Rimal *et al.*, 2015).

The area share of medicinal & aromatic crops, fibre crops, flower crops and spice crops was less in the total cropped area (except spices) and decreased over the years. In the case of fruits and vegetables, their share to the total cropped area increased significantly from 0.10 per cent and 4.66 per cent to 0.25 per cent and 7.80 per cent, respectively. This clearly reflects the role of high-value horticultural crops and the emphasis laid on this sector by way of promotion of this sector by the Horticulture Department through implementation of its schemes like Comprehensive Horticulture Development Programme (CHDP), National Horticulture Mission (NHM), etc.

Table 3. Transitional probability matrix for area under different crop groups in Gadag district, 1998-99 to 2011-12

Crop group	Cereals	Pulses	Oilseeds	Fibres	Horticulture
Cereals	0.48	0.00	0.32	0.19	0.00
Pulses	0.37	0.49	0.00	0.03	0.11
Oilseeds	0.00	0.10	0.46	0.00	0.44
Fibres	0.56	0.00	0.00	0.44	0.00
Horticulture	0.00	0.06	0.02	0.00	0.92

Transitional Probability Matrix for Area under Different Crop Groups in Gadag District

The change in the area under crops in the Gadag district was analysed using Markov chain, capturing the shift in the area under crops over a period of 14 years. Cereals, pulses, oilseeds, fibre and horticultural crop groups were considered for the analysis. In the horticultural crop group, vegetables, fruits, flowers, medicinal & aromatic and spice crops were included. The results (Table 3) revealed that among the five crop groups, horticulture group retained a higher share (92%) over the years and it gained even the meagre shares from fibre and oilseed groups, and this indicates that over the years, farmers are shifting towards horticultural crops group. The cereals and pulses groups retained a higher share compared with fibre and oilseeds crop groups, but lesser compared to horticultural crops. Fibre and oilseed groups retained only a meagre share over the years. The analysis indicates an overall shift towards horticultural crops at the cost of other crops.

Crop Diversification Index

Table 4 shows the average values of Simpson Index for different crop groups in Gadag district, Gadag taluk and Shirahatti taluk for 14 years (1998-2012). The calculated average values of Simpson Index for different crop groups were 0.77 for Gadag district, 0.80 for Gadag taluk and 0.75 for Shirahatti taluk. Bhattacharya (2008) has indicated that Simpson Diversity Index moved up from 0.52 in 1997-98 to 0.59 in 2004-05 implying a gradual shift in cropping pattern towards high-value crops like flowers, fruits and vegetables in West Bengal.

Table 4. Indices for area under different crop groups of Gadag district, 1998-99 to 2011-12

Indices	Gadag taluk	Shirahatti taluk	Gadag district
Simpson Index	0.80*	0.75	0.77
Entropy Index	1.71*	1.56	1.59
Herfindahl Index	0.20*	0.25	0.23

Note: * denotes significance at 5 per cent level.

Entropy Index for Area under Different Crop Groups of Gadag District

The Entropy Index increases with increase in diversification and vice versa. The results have clearly shown that Gadag district, Gadag taluk and Shirahatti taluk are diversifying over the years and among the two study taluks, Gadag taluk has diversified more than Shirahatti taluk. The results are in line with the findings of Kalankar (2003), who studied agricultural output growth and diversification in Maharashtra and reported the decline in Herfindhal Index by 12.16 per cent and increase in Entropy Index by 5.27 per cent over the period 1961-64 to 1995-98.

Herfindahl Index for Area under Different Crop Groups of Gadag District

The Herfindahl Index would decrease with increase in diversification. The results (Table 4) indicated that values of Herfindahl Index was less for both the taluks as well as the Gadag district, thereby implying diversification. Among the two taluks, Gadag taluk having lower index value (0.20) is more diversified than Shirahatti taluk (0.25).

Farm Level Crop Diversification in Gadag and Shirahatti Taluks

An attempt was made to analyse crop diversification at the farm level based on the crops grown in the selected taluks, viz. Gadag and Shirahatti. The crops wheat, maize, green gram, cotton, groundnut, chilli, onion, sunflower, mango, sapota, banana,

Table 5. Crop diversification indices for different crops at farm level

Indices	Gadag talik	Shirahatti taluk
Simpson Index (HH)	0.58*	0.31*
Simpson Index (Community)	0.89*	0.83*
Margalef Index	1.18*	0.44*
Entropy Index	0.99*	0.55*
Crop richness (community)	15	10
Household richness	3.20	1.90

Note: * denotes significance at 5 per cent level.

sorghum, brinjal, tomato and bengalgram were considered for analysis using Simpson, Entropy and Margalef indices. The results are presented in Table 5. All the indices have indicated significantly higher values in both the taluks and among the taluks, Gadag (NDZ) has been observed to be more diversified than Shirahatti taluk (NTZ).

The sample farmers in the Gadag taluk cultivated 15 crops, but Shirahatti farmers cultivated only 10 crops. On an average, each household of Gadag taluk maintained about 3 crops, whereas in Shirahatti taluk, the average number of crops per household was only 2. This reveals that Gadag (NDZ) is more diversified even at the farm level. Thus, analysis of both secondary and primary data indicated that NDZ is more diversified than NTZ.

Crop Diversification and Size of Landholding

There existed a strong association (r = 0.67 and 0.78) between size of landholding and crop diversification. The size of holding appeared to be the major driving force for crop diversification towards commercial crops like Bt-cotton and horticultural crops like onion, chilli, brinjal, tomato, sapota, mango and banana (Table 6). The relationship between crop diversification and different farm sizes (marginal, small and large) was analysed for both Gadag and Shirahatti taluks. The results (Table 7) reveal that, in both the taluks, crop diversification increased with increase in landholding-size and this was because farmers with large holdings can grow more number of crops, whereas small size of landholding was the constraint for growing a larger number of crops. Kiru *et al.* (2014) have also reported that an increase in the size of landholding will better enable a farmer to diversify. The results also reveal that among the two taluks, Gadag (3 crops) experienced more crop diversification compared to Shirahatti taluk (2 crops).

Crop Diversification and Irrigation in Gadag Taluk

As Gadag taluk showed a higher diversification, an attempt was made to study the impact of factors like extent of irrigation. It was observed that the number of crops grown by irrigated farmers was more (15) than by non-irrigated farmers (11). This was also true in the case of household crop richness. Further, the average

Table 6. Correlation between crop richness and size of holding

Particulars	Gadag taluk		Shirahatti taluk	
	Crop richness	Size of holding	Crop richness	Size of holding
Crop richness	1.00		1.00	
Size of holding	0.78	1.00	0.67	1.00

Table 7. Crop diversification and size of holding in Gadag district

Farmer's category	Gadag taluk		Shirahatti taluk	
	Average landholding (acres)	Crop richness of household	Average landholding (acres)	Crop richness of household
Marginal	1.57	2.14	1.93	1.14
Small	4.00	2.57	4.13	1.63
Large	13.81	3.94	17.67	2.40
All	8.67	3.20	10.38	1.90

Table 8. A comparison between irrigated and non-irrigated farms in Gadag taluk

Particulars	Irrigated farmer	Non-irrigated farmer
Size of landholding (acre)	12.80 (27.1*)	5.50
Crop richness (HH)	3.76	2.76
No. of crops grown	15	11
Gross return (₹ /acre)	28785	24391
Cost of cultivation (₹/acre)	14563	11844
Net returns (₹/acre)	14222	12547

Note: * denotes percentage of irrigated land

size of holding was larger for irrigated farmers (12.8 acres). The larger size of holding, irrigation facilities and the associated number of high-value crops resulted in high returns (₹ 28785/acre) for irrigated farmers. This result is in line with Birthal *et al*. (2006), who have indicated that the extent of irrigation is the significant factor responsible for crop diversification.

Factors Influencing Crop Diversification in Gadag Taluk

The factors influencing crop diversification in Gadag taluk were identified using regression analysis wherein household richness was regressed on factors like size of holding, farm income and gross area irrigated (as a linear measure for extent of irrigation). The size of holding, family income and area under irrigation were found to have positive effect on crop diversification. The average landholding in Gadag taluk was 8.67 acres and the average farm income was ₹ 122352/acre (Table 9). The area under irrigated land was found to influence crop diversification positively and this result was in contrast with Joshi *et al*. (2004) who reported a negative regression coefficient between irrigation and crop diversification while studying the pattern of agricultural diversification in South Asia.

At farm level, the major constraints in crop diversification in Gadag district were captured using Garret ranking technique. The price of crop was regarded as the major factor influencing diversification because farmers expect high income from crop enterprise. The availability of irrigation water was the second most important factor responsible for crop diversification. In Gadag taluk, sample farmers could grow 15 crops because of water availability. Further,

Table 9. Factors determining crop diversification in Gadag taluk

Variable	Coefficient	t-stat
Intercept	1.826771***	7.96
Gross irrigated area	0.034202*	1.44
Income of family	0.000005**	2.20
Size of holding	0.080910***	2.80
F value	24.05	
Adj. R^2	0.71	

Note: *, ** and *** denote significance at 10 per cent, 5 per cent and 1 per cent levels, respectively.

Table 10. Constraints for crop diversification in Gadag district

Constraint	Garret score	Ranking
Price of crop	68.57	I
Water availability	56.10	II
Risk –yield and price of crop	50.80	III
Market availability	49.87	IV
Cost of cultivation	46.27	V
Productivity	45.80	VI
Input availability	44.20	VII
Income of family	40.00	VIII

the irrigated farmers could grow crops like transplanted chilli, brinjal, banana, mango, sapota, cotton (Bt), onion and tomato.

The market availability is an important factor for diversification. The Gadag district has well organised marketing infrastructure with 21 sub-markets. In particular, 7 markets are present in Gadag taluk itself. Costlier inputs resulting in high cost of cultivation were regarded as another important factor influencing crop diversification (Table 10). Input availability and economic status of family also influence crop diversification. The hypothesis that economic variables like size of holding, irrigated area, household income, access to market, etc. are the causes behind crop diversification is proved valid with our results.

Conclusions and Policy Implications

The study has revealed a higher growth rate in the area under horticultural crops and pulses than in cereals, oilseeds, fibre and other crop groups. Over the years, though share of cereal crop groups has decreased

significantly, it still occupies the major share of the cropped area reflecting farmers' concern for food security. The share of fruits and vegetables in the total cropped area has increased significantly. This result is amply supported by the transitional probability matrix, indicating that among five crop groups, horticultural crop group has retained the highest share of 92 per cent, reflecting its stability. Simpson Index and Entropy Index for different crop groups from 1998 to 2012 have been found relatively higher for the Gadag taluk compared to Shirahatti taluk, indicating thereby that NDZ is more diversified than NTZ.

The size of holding is the major determinant of crop diversification. However, investment on infrastructure like irrigation by the government would help even the small farmers enabling them to be a part of the diversification process. Labour – both human and bullock – is becoming scarce, costly and also not available at the right time. Hence, mechanization in the form of tractor and associated machineries/ implements is required by the farmers as its non-availability is reflected as one of the major constraints hindering diversification, especially for small farmers. Efforts may be made to develop custom hiring centre for tractors and other machineries required as the small farmers cannot afford to invest in costly equipments.

Crop diversification ensures livelihood security to the farmers and as market development has direct bearing on crop diversification, there is a need to develop more markets in the study area. At present, support mechanism is not operating for horticultural crops and as stable price acts as an incentive for growing a number of crops, this may be ensured by market intervention or price support even for horticultural crops. The program A3P has increased the production of pulses and the farmers need to be made aware about this program. Crop diversification should address food security, nutritional security as well as livelihood security and this calls for enabling the farmers to grow cereals and pulses in some area instead of totally diversifying in favour of high-value crops like cotton (Bt) and horticultural crops. Conducting awareness generation campaigns, intensifying the role of extension service providers, promoting research-based recommendations and technologies on the farm would strengthen the crop diversification process in the study area.

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