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Dynamics of cropping pattern in Koppal district of Karnataka with special reference to Gangavathi taluk

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Abstract
The evaluation of changes in cropping patterns in various places is critical for gaining a better understanding of the agricultural development method. The goal of this study was to look into the dynamics of cropping patterns in the Koppal region of Karnataka, particularly in the Gangavathi taluk from 2005-06 to 2015-16 and the data was collected from the Government of Karnataka's Directorate of Economics and Statistics. The study's main findings revealed that the district has shown crop diversification and that Gangavathi taluk is heading toward specialisation. During the study period, the taluk's transitional probability score revealed that the probability of transitioning from fruits to cereals and minor millets was highest (0.75). Cereals and minor millets have a probability of area of 0.48, while oilseeds have a probability of 0.75. As a fact, the majority of cereals and minor millets grown in the Gangavathi are paddy, and the retention probability of cereals and minor millets is highest in the taluk, as most farmers continue to cultivate paddy throughout the year. Furthermore, the study assessed the instability index of key crops to determine which crop had the most stable area throughout the previous decade, and it was clear that the paddy crop had the least unstable index when compared to other crops in the area. There is more flexibility in crop selection to elevate agriculture to the forefront of property development, which must be included in research and extension programmes.

Keywords: crop diversification, crop specialization, simpson index, paddy farmers, Gangavathi taluk

1. Introduction
Agriculture is the principal source of income for most rural Karnataka citizens. According to the 2001 census, agriculture and allied activities employ about 56% of the workforce in Karnataka. A total of 12.31 million hectares (m ha) of land is cultivated, accounting for 64.60 percent of the state's total area. Paddy, sorghum, ragi, maize, pearl millet, and wheat are the most important cereals grown in the state; red gramme, green gramme, and chickpea are the most important pulses; groundnut, sunflower, and safflower are the most important oilseed crops; and cotton, sugarcane, and tobacco are the most important commercial crops. Farmers were able to cultivate a variety of food crops, particularly paddy, owing to the availability of major irrigation infrastructure. In 2014–2015, the total area under rice in Karnataka was 1.29 million hectares, with an annual production of 3.6 million tonnes and a productivity of 2,630 kg/ha.

The major irrigation project Tungabhadra area is referred to as the “Rice Bowl of Karnataka”, as nearly 65.00% of the total (3.63 lakh ha) area of paddy in Karnataka including the Tungabhadra Project (TBP) command area (Ballari, Koppal and Raichur districts). The Tungabhadra river sub-basin, the main area lies within the Krishna River Basin and largely within Karnataka. (Shanbhoga, 2020) [6]. The crop pattern along the Tungabhadra Left Bank Canal (TLBC) that irrigates around 6 lakh acres in Koppal and Raichur districts has changed over the last decade. Earlier, the whole chunk of the irrigated belt grew paddy. Owing to growing scarcity of water, farmers at the tail-end sections such as parts of Manvi and Raichur taluks have now switched to alternative crops such as red gram, cotton and chilli that require less water. On the other hand, the area under paddy cultivation has expanded in Karatagi, Munirabad, and Gangavati areas in Koppal district, and Sindhanur taluk in Raichur district.

Around 1.75 lakh acres of rain-fed land have been transformed to irrigated grounds along these areas by "illegally" using TLBC water to cultivate paddy. “Illegal water drawing in the upper reaches of the TLBC, particularly in Gangavati taluk, for irrigating unauthorised lands has deprived farmers in the lower reaches of the TLBC, particularly in Manvi and Raichur taluks in Raichur district, of their legitimate share of water for their authorised lands,” says a report. Farmers in Gangavthi taluk must grow 25% cane and paddy, 6% horticulture crops, and 69%

low irrigation crops, according to a Bachawat Aayog decision. Farmers, on the other hand, tend to cultivate more paddy when profit is the driving force.
This is also one of the reasons for the scarcity of water in this area." The talukas of Koppal district include Koppal, Kushtagi, Yelaburga, and Gangavathi. According to the time series graph of cropping intensities provided by Neelakantha (2012) [4] study, Gangavathi taluk has the maximum cropping intensity. Cropping intensity increased from 112 percent in 1981-82 to 145 percent in 2010-11. Koppal has a cropping intensity of 117 percent, but dry taluks of Kushtagi and Yelburga have just 108 percent (J.K. Neelakanth, 2012) [4]. Indeed, it is self-evident that the greater the number of crops combined, the greater the degree of diversification. Crop specialization and crop diversity are the two most important aspects of agricultural geography because they allow you to understand a region's cropping pattern in great detail. As a result, knowledge of a region's concentration and diversity can be quite beneficial in agricultural land use planning. The authors aimed to look at cropping patterns in the Gangavathi taluk over a decade, given the context of irrigation water availability and other considerations. The goal of this study was to investigate how cropping patterns changed over time from 2005-06 to 2015-16.

2. Study area

The current study was conducted in Karnataka's Gangavathi taluk, which is part of the Tungabhadra Command Area in Koppal district (Northern Dry Zone). Northern Dry Zone is the largest of Karnataka's ten agro-climatic zones, with 4.78 million hectares distributed across 35 taluks in nine districts. Vijayapur, Bagalkote, Bellary, Dharwad, Koppal, Gadag, Haveri, Belagavi, and parts of Raichur districts are included in this area. This zone is characterised by unpredictable rainfall distribution and an average rainfall of less than 600 mm, hence the name "less rainfall districts." In most regions, the soils are black clay, ranging from shallow to deep.
Gangavathi taluk was chosen because it has the most area under irrigation in Koppal district and is one of the primary paddy commercial hubs in the entire Hyderabad Karnataka region. It is also the largest city in terms of area and population among the cities in Koppal district. It is known as Karnataka's "Rice Bowl" because it is home to hundreds of rice mills that hull and process lakhs of tonnes of rice each year and export rice to every corner of the state and country. In comparison to other taluks in the district, Gangavathi taluk has a larger area under paddy crop and produces more paddy. Paddy from Telangana and Andhra Pradesh is also brought in and processed here, in addition to paddy cultivated in these areas. The Tungabhadra reservoir-irrigated region is noted for high-quality Sona Masoori rice, which is popular not just in Karnataka but also in Andhra Pradesh, Telangana, Tamil Nadu, Maharashtra, and Kerala, and is also exported.**3.**

3. Material and Methods

3.1 Secondary Data: The district and taluk wise time series data for the period from 2005-06 to 2016-17 pertaining to the area occupied by different crops were collected from Directorate of Economics and Statistics (DES), Government of Karnataka, Bengaluru. The details about the command area, water inflows, outflows and utilization of water from different canal systems of Tungabhadra command area were collected from Command Area Development Authority, Tungabhadra Project, Munirabad.

3.2 Analytical techniques

Crop diversity is the absolute opposite of crop specialisation in terms of concept. In an agricultural year, it refers to the planting of multiple crops in the holdings. Crop diversification is mostly determined by a region's geoclimatic/socioeconomic conditions and technical advancement. Crop diversification can be measured in a variety of ways. Bhatia's Crop Diversification Index, Herfindahl's Index, Simpson's Diversification Index (a modified form of Harfindahl's Index), Ogive Index, Entropy Index, Berry's Index, and others are among the most important. The Herfindahl Index and the Simpson Diversity Index were employed to determine the level of agricultural diversity, which was the study's goal. The following diversification indices were used to investigate the extents of crop diversification. The analytical tools and procedures used to evaluate the study's objectives are briefly explained below.

3.2.1 Crop diversification indices

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:

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

Where, $P_i = A_i / \Sigma A_i$ represents acreage proportion of the i^{th} crop in total cropped area. A_i represents proportion of acreage under i^{th} to the total cropped area. The Herfindahl index takes the value of one when there is specialization and approaches zero when there is diversification. It is appropriate for measuring diversification for a farm.
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:

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

Where, $P_i = A_i / \Sigma A_i$ is the proportion of the i^{th} activity in acreage. A_i represents proportion of acreage under i^{th} to the total cropped area. 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.

3.2.2 Markov chain analysis

To assess the shift in cropping pattern of area under crops during 2005-06 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 and crop groups 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:

$$E_{jt} = \Sigma [E_{it} -_1] P_{ij} + e_{jt} \quad \text{---------- (3)}$$
$$i=1... n$$

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 $0 \leq P_{ij} \leq 1$
i=1,...,n

The transitional probability matrix (T) based on LP framework is estimated using Minimization of Mean Absolute Deviation (MAD).
Min, OP* + Ie
Subjected toX P* + V = Y
GP* = 1
P* > 0

Where,
P* = Vector in which probabilities P_{ij} are arranged
O = Vector of Zero's
I = The appropriately dimensional vector of areas
e = Vector of absolute errors
Y= Vector of area shift to each crop
X= Block diagonal matrix of logged values of Y
V= Vector of errors
G= Grouping matrix to add the row elements of P, arranged in P' to unity
Using the estimated transitional probabilities, the share of different crops were calculated for the period 2005-06 o 2015-2016.

4. Results and Discussions

4.1 Crop diversification in Koppal district and Gangavathi Taluk

The average values of Herfindahl Index and Simpson Index for different crop groups in Koppal district and Gangavathi taluk over the years (2001-02 to 2015-16) are presented in Table 1. The Herfindahl Index decreases with increase in diversification. The results indicated that value of Herfindahl Index was less for Koppal district (0.22) implying a gradual shift in cropping pattern towards greater diversification. While, it was more in Gangavathi taluk (0.45), thereby implying specialization.
The Simpson Index increases with increase in diversification and vice versa. The calculated average values of Simpson Index for different crop groups were 0.78 for Koppal district and 0.55 for Gangavathi taluk indicated that diversification in district and specialization in the taluk, respectively. Both indices revealed that the district as a whole showing diversification but taluk was showing specialization. Similar results were reported by Singha *et al.* (2014) [7] in their study. Owing to climatic variations, unpredictable rainfall, market prices the farmers of the district have switched to alternative crops and went for diversification. The factors which are responsible for the crop diversification that most of the farmers were moved towards low value crop to high value crop for sustaining the economic prosperity and generate alternate source of income (Sandipan Ganguly; Palash Patra, 2015) [2]. Specialization in the taluk can be seen as almost all the area is growing paddy for all the seasons and in all years because availability of irrigation water, profit motive of the farmers as the market prices of paddy does not fluctuate much to the market fluctuations.

Table 1: Crop diversification in Koppal district and Gangavathi taluk (2005-06 to 2015-16)

Index	Koppal district	Gangavathi Taluk
Herfindahl Index (HI)	0.22	0.45
Simpson Index (SI)	0.78	0.55

4.2 Shift in cropping pattern (Markov chain analysis)

The change in the area under principal crops in Koppal district and Gangavathi Talukof Karnataka was analyzed using Markov chain, capturing the shift in area under crops over a period from 2005-06 to 2015-16.

4.2.1 Transition probability matrix of changes in cropping pattern for Koppal district of Karnataka (2005-06 to 2015-16)

The transition probability matrix of changes in cropping pattern for Koppal district (Table 2) indicates that cereals and minor millets, pulses, oilseeds, cotton and sugarcane had a probability of retention of 0.60, 0.74, 0.05, 0.00 and 0.03, respectively. Highest probability of retention was seen in pulses followed by cereals and minor millets in the district. The pulses retention was highest because of increased market value of pulses and more demand for pulses in the market. Due to assured price of paddy, cereals and minor millets have also higher probability of retention.
The probability of transition from cotton to cereals and minor millets was highest (1.0) during the study period because of higher level of pest infestation to the cotton crop in addition to longer crop duration. Cereals and minor millets had gained a probability of area of 0.14 from pulses and 0.66 from oilseeds.

Table 2: Transition probability matrix of changes in cropping pattern in Koppal district of Karnataka (2005-06 to 2015-16)

Crops #	Cereals and minor millets	Pulses	Oilseeds	Cotton	Sugarcane
Cereals and minor millets	0.60	0.00	0.40	0.00	0.00
Pulses	0.14	0.74	0.00	0.10	0.03
Oilseeds	0.66	0.22	0.05	0.07	0.00
Cotton	1.00	0.00	0.00	0.00	0.00
Sugarcane	0.00	0.97	0.00	0.00	0.03

Note: # Crops considered are given in Appendix I

4.2.2 Transition probability matrix of changes in cropping pattern for Gangavathi taluk of Koppal district (2005-06 to 2015-16)

The transition probability matrix for the major crops grown in Gangavathi taluk for the period 2005-06 to 2015-16 is presented in Table 3.The results indicated that cereals and minor millets, pulses, commercial crops, oilseeds, fruits and vegetables had a probability of retention of 0.90, 0.89, 0.08, 0.26, 0.26 and 0.45, respectively. Highest probability of retention was seen in cereals and minor millets followed by pulses in the taluk. The retention of cereals and minor millets was highest in the taluk because paddy is the major crop among cereals and minor millets and its retention is highest among all other crop groups due to availability of water

through Tungabhadra command area project for two seasons in a year, assured price of paddy and assured demand by the consumers. Paddy is also called as the lazy man's crop as it doesn't need much care and protection as it is needed in commercial crops. And also most of the farmers in Gangavathi region only know cultivation practices of paddy and they seem lazy to adopt new crops or new methodologies. Even though constant denial from the Government for growing only paddy in the area, farmers keep on growing paddy as they think paddy can only give them better prices in the market and also one more reason is that the productivity of paddy in Gangavathi region is more compared to any other region in the state.

The probability of transition from fruits to cereals and minor millets was highest (0.75) during the study period. Cereals and minor millets had gained a probability of area of 0.48 from oilseeds and 0.75 from fruits. Pulses had gained probability of area of 0.59 from commercial crops and 0.35 from vegetables. The probability of transition from cereals and millets to oilseeds and commercial crops was only 0.09 and 0.01, respectively in the taluk which indicated that the transition from cereals and minor millets to other crop groups was very less compared to any other crop group. The results are in line with the findings of Sathishkumar, 2017 [5].

Table 3: Transition probability matrix of changes in cropping pattern in Gangavathi taluk of Koppal district (2005-06 to 2015-16)

Crops #	Cereals & minor millets	Pulses	Commercial crops	Oilseeds	Fruits	Vegetables
Cereals and millets	0.90	0.00	0.01	0.09	0.00	0.00
Pulses	0.00	0.89	0.02	0.08	0.00	0.02
Commercial crops	0.00	0.59	0.08	0.19	0.00	0.14
Oilseeds	0.49	0.00	0.00	0.26	0.14	0.12
Fruits	0.75	0.00	0.00	0.00	0.26	0.00
Vegetables	0.00	0.35	0.13	0.00	0.07	0.45

Note: # Crops considered are given in Appendix II

4.3 Growth and instability in the area of major crops in Gangavathi Taluk (2005-06to 2015-16)

Growth rate and instability in area of major crops in Gangavathi taluk are presented in Table 4. The area under the majority of crops had shown a positive trend over the years from the period 2005-06 to 2015-16 except for the paddy and sugarcane. The area under red gram has grown significantly at the rate of 135.83 per cent per annum in the taluk. Similarly, the area under bengal gram (133.98%), bajra (58.56%), cotton (32.67%) and jowar (28.83%) has shown a significant positive trend over the years.

The area under paddy crop had a significant negative growth rate with the value 1.49 per cent per annum, which was mainly due to the irregular release of irrigation water from the Tungabhadra Command Area in the taluk. Due to which, many paddy growing farmers in the taluk started growing pulse crop like bengal gram and light irrigated crops like jowar and maize. Similarly, the area under sugarcane had a very low growth rate (0.001%) per annum in the taluk, because of shut down of sugar factory which was located at Marali village of Gangavathi taluk. The sugarcane growing farmers near Marali village and other villages nearby shifted towards other crops after the shutdown of the sugar factory.

Instability index of paddy crop was the lowest among all other major crops in Gangavathi taluk with the instability index of 11.53 per cent (Table 4). Whereas, area under cotton (78.45%) and maize (80.43%) had highest instability index in Gangavathi taluk for the period from 2005-06 to 2015-16. It can be noticed that, the mean area under paddy crop (64370 ha) in the taluk was extremely high when compared to other crops (Table 4).

The mean area under all other crops was very less in comparison with area under paddy which clearly indicates that paddy was the major crop grown in the taluk. The less instability in paddy area in the taluk was mainly due to the assured market price for paddy, especially which was grown in that command area. The Sona masoori variety which was grown in Gangavathi taluk with high quality has demand from all over the world.

The study revealed that, the cropping pattern has changed over the years in the study area. Hence, the hypothesis that, the cropping pattern has changed over the years is accepted. Table 4 showed that, area under major crop like paddy is decreasing significantly over the years with a value 1.49 per cent per annum.

Table 4: Growth and instability in the area of major crops in Gangavathi Taluk (2005-06to 2015-16)

Crops	Mean area (000'ha)	CGR (%)	Instability Index (%)
Paddy	64.37	-1.49*	11.53
Jowar	2.33	28.83**	42.70
Bajra	4.55	58.56**	78.22
Maize	2.26	15.74	80.43
Bengal gram	4.39	133.98**	69.81
Red gram	0.78	135.83**	40.71
Cotton	0.79	32.67**	78.45
Sugarcane	0.42	0.001	50.87

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

5. Conclusion

The values of Simpson Index for different crop groups in Koppal district and Gangavathi taluk were 0.78 and 0.55 respectively implying a gradual shift in cropping pattern towards diversification in the district and specialization in the Taluk. Both indices revealed that the district as a whole showing diversification but taluk is showing specialization. The specialization in the taluk is mainly due to growing of paddy by almost all the farmers in the region. We can say that in the study period that is from 2005-06 to 2015-16 (over a decade) there has been more diversification in the district as major part of the district is rain fed area except Gangavathi region where farmers are shifting towards growing of less water requirement crops such as bajra, sorghum and minor millets. Further, the values of instability index of major crops in the Gangavathi taluk also indicated that paddy crop has the minimum variation in area among all other major crops over the decade. The less instability in the area of paddy crop in the taluk was mainly due the assured price and yield of the paddy crop.

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Appendix

Appendix I: Area under different crops in Koppal district for the year 2015-2016

Sl. No.	Crops	Area (ha)	% to total cropped area
1	Paddy	50753	11.24
2	Jowar	26275	5.82
3	Bajra	44190	9.78
4	Maize	45210	10.01
5	Ragi	0	0.00
6	Wheat	2757	0.61
7	Minor millets	7395	1.64
8	Tur	11637	2.58
9	Horse gram	15725	3.48
10	Black gram	1077	0.24
11	Greeen gram	18779	4.16
12	Avare	336	0.07
13	Cowpea	2926	0.65
14	Bengal gram	89794	19.88
15	Ground nut	22273	4.93
16	Sunflower	49051	10.86
17	Safflower	1083	0.24
18	Castor	928	0.21
19	Sesamum	8322	1.84
20	Niger seed	542	0.12
21	Soyabean	0	0.00
22	Linseed	582	0.13
23	Cotton	27765	6.15
24	Sugarcane	2094	0.46
25	Fruits	5248	1.16
26	Vegetables	16888	3.74
	Total	451630	100.00

Appendix II: Area under different crops in Gangavathi Taluk for the year 2015-2016

Sl. No.	Crops	Area (ha)	% to total cropped area
1	Paddy	42904	45.30
2	Jowar	3255	3.44
3	Bajra	7938	8.38
4	Maize	2650	2.80
5	Ragi	0	0.00
6	Wheat	44	0.05
7	Minor millets	3459	3.65
8	Tur	1421	1.50
9	Horse gram	1349	1.42
10	Black gram	999	1.05
11	Greeen gram	479	0.51
12	Avare	10	0.01
13	Cowpea	471	0.50
14	Bengal gram	12306	12.99
15	Ground nut	2145	2.26
16	Sunflower	6495	6.86
17	Safflower	10	0.01
18	Castor	151	0.16
19	Sesamum	867	0.92
20	Niger seed	8	0.01
21	Soyabean	0	0.00
22	Linseed	0	0.00
23	Cotton	1286	1.36
24	Sugarcane	203	0.21
25	Fruits	2227	2.35
26	Vegetables	4041	4.27
	Total	94718	100.00