

## Original Research Article

# DYNAMICS OF CROP DIVERSIFICATION IN MIDLANDS OF KERALA, INDIA

### ABSTRACT

**Aims:** This study presents the extent of crop diversification in three districts of Kerala state; Thiruvananthapuram, Kottayam and Kannur which falls in the midland region of Kerala over the period of 2005-06 to 2020-21.

**Methodology:** Secondary data on area under cultivation of various crops for the considered time period was subjected to analysis using Simpson Index, Modified Entropy Index and Markov chain analysis.

**Results:** Kannur was found to be highly diversified with high value of Simpson Index of around 0.79 followed by Thiruvananthapuram with SI of around 0.74. Transitional probability matrix of Thiruvananthapuram revealed that coconut, spices and condiments retained more area in the district followed by non-food crops with an area retention. Non-food crops retained highest area followed by coconut, spices and condiments in Kottayam. More area occupying crop in Kannur was found to be non-food crops followed by coconut, spices and condiments. However, overall scenario in midland region showed that more area was occupied by non-food crops followed by coconut, spices and condiments.

**Conclusion:** The period from 2005-06 to 2020-21 showed changing pattern of acreage distribution in the three selected districts of Kerala with a declining trend in total cropped area and shift from food crops to non-food crops.

*Keywords: Crop diversification, Midlands, Markov chain, Non-food crops, Simpson index*

### 1. INTRODUCTION

Looking from a narrow perspective, crop diversification means increasing the types of agricultural commodities produced at the farm level which can either be driven by market forces or biotic/abiotic stress conditions. From broader aspect, agricultural diversification involves the entire rural economy and leads to expanding the income sources of rural households (Goletti, 1999)<sup>[1]</sup>. Crop diversification aims to provide a wider range of options in the production of crops in a given area, to expand production related activities on various crops, reduce agricultural risks, ensure food and nutrition security, increase income and employment for a wider segment of society and has a substantial impact on the country's GDP.

Kerala is the most literate state, however, there is ample amount of cultivation of crops in the state. Nearly 30 per cent of the families in Kerala depend upon agriculture for their livelihood. Agricultural land of the state accounts for 55 per cent, while forest land covers 28 per cent and 11 per cent lands are put for non-agricultural use. Kerala has a rich agricultural heritage with a wide range of traditional and indigenous crops including rice, coconut, banana, pepper, cardamom, rubber, ginger, turmeric, yam, tapioca, and various types of vegetables. With the state government and agricultural agencies actively promoting high-value horticultural crops, such as fruits, vegetables, spices, and flowers, crops like pineapple, mango, jackfruit, passion fruit, cashew, nutmeg, clove, vanilla, and various leafy greens are being encouraged which diversify income sources and enhance nutritional security. Moreover the state encompasses different regions with varying

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altitudes, rainfall patterns and soil type which allows for the cultivation of different crops that thrive in specific microclimates contributing to overall crop diversification.

The formation and strengthening of Farmer Producer Organizations that provide collective marketing, technical assistance, and input procurement support to farmers, encouraging them to diversify crops based on market demands, have played a vital role in promoting crop diversification in Kerala. Agricultural research institutions and extension services in Kerala develop and disseminate improved crop varieties, provide training on sustainable farming practices, and offer technical guidance to farmers thus actively contributing to crop diversification.

One of the significant features of Kerala's agricultural scenario is the gradual shifting of areas from food crops like rice and tapioca to plantation crops like coconut, rubber and coffee (Karunakaran, 2013)<sup>[2]</sup>. Rice was considered the prominent food crop even though the agro climatic conditions of Kerala is favourable for spices and plantation crops. In recent years, perennial crops have taken over the agricultural lands of the state. In contrast to rest of the country where diversification occurred among annual crops, Kerala faced a shift from seasonal crops like paddy to perennial crops such as coconut and rubber (Kannan and Pushpangadan, 1988)<sup>[3]</sup>. The trend of crop diversification in Kerala started slowly in favour of non-food crops since the mid-1970's (Mahesh, 1999)<sup>[4]</sup>. The reduction in the area under food crops in Kerala from 40.43 percent in 1970-71 to 18.74 percent in 1992-93 and 16.52 percent in 2002-03 is a phenomenon that has happened very rarely in any state (Mani, 2009)<sup>[5]</sup>. Agriculture in Kerala became more vulnerable due to decline in cultivable area, fragmentation of land holdings and reduction in availability of agricultural labour (Sanitha and Singla, 2016)<sup>[6]</sup>. The state has high population density and limited availability of arable land which results in farmers having small and fragmented landholdings. The area under food crops in Kerala has been dwindling over the years, while the area under commercial crops like rubber, arecanut and banana has been rising (Geethu *et al.*, 2019)<sup>[7]</sup>. Also, Kerala has witnessed many environmental challenges like soil erosion, recurring floods, biodiversity loss and declining soil fertility in recent years. Hence this study focusses mainly on extend of crop diversification in the midlands of Kerala over the years.

## 2. METHODOLOGY

Kerala state has 14 districts, among which the midland area is spread over all the districts except Wayanad, which is predominated by the highlands. Among the midlands, three districts, i.e., Thiruvananthapuram from the southern side, Kottayam representing the central region and Kannur from the northern region were selected randomly. Published sources and reports like Agricultural statistics by Department of Economics and Statistics, Kerala and Natural Resource Data Bank by Kerala State Land Use Board were referred for statistical data<sup>[8]</sup>.

### 2.1. Compound Annual Growth Rate

Compound Annual Growth Rate is calculated by using following formula:

$$CAGR = [\text{antilog}(b) - 1] \times 100$$

Where, b= Regression Coefficient that shows the rate of change or growth rates in a series

The positive sign and magnitude in CAGR suggests accelerated growth rate while negative sign suggests deceleration.

### 2.2. Diversification index

Given the widespread applicability in research works, we employed Herfindahl index, Simpson index and Modified Entropy index to measure the degree of agricultural

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This should be under the study area. This will tell the readers the farming systems or crops that are cultivated in this area.

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diversification. Among all the indices, Simpson's and Entropy Index are widely used in the view of agricultural diversification (De and Chattopadhyay, 2010)<sup>[9]</sup>.

### 2.2.1. Modified Entropy Index (MEI)

Entropy Index (EI) measures crop diversification directly which has a logarithm character. The formula of Entropy index is,

$$EI = \sum_{i=1}^N P_i \times \ln\left(\frac{i}{P_i}\right)$$

Here,  $P_i = \frac{A_i}{\sum_{i=1}^N A_i}$

Where,  $P_i$ = percentage of area of the  $i^{\text{th}}$  crop in total cropped area

$A_i$ =actual area under  $i^{\text{th}}$  crop

$\sum A_i$  = total cropped area

$N$ = number of crops grown

When Entropy Index takes up the value 0, it indicates complete specialization whereas the upper limit of EI value indicates full diversification. The upper limit of Entropy Index is determined by the base of the logarithm and number of crops. The upper limit can exceed one, when the number of total crops are higher than the base of logarithm. In order to bound the Entropy Index within 1 and 0, logarithm to the base of total number of crops are considered. This is Modified Entropy Index (MEI) and is given as,

$$MEI = \sum_{i=1}^N P_i \times \log_N\left(\frac{i}{P_i}\right)$$

### 2.2.2. Simpson Index (SI)

Simpson index is the most practicable and widely used index for measuring horizontal crop diversification in any specific geographical area.

The formula of Simpson Index is,

$$SI = 1 - \sum_{i=1}^N P_i^2$$

The value of SI ranges between 0 and 1. The value almost zero denotes area is close to specialization whereas value near to one denotes that area is fully diversified.

### 2.3. Markov Chain Analysis

The First order Markov chain analysis was used to study the diversification towards shares of land use of different crops. The process of crop diversification can be described in the form of a matrix  $P$  of first order transition probabilities. The element  $P_{ij}$  of the matrix indicates the probability of a farmer to cultivate crop  $i$  in one period will move to crop  $j$  during the following period. The diagonal elements of the matrix measure the probability that the proportion  $i^{\text{th}}$  crop will be retained.

$$E_{jt} = \sum_{i=1}^r (E_{it-1} \times P_{ij} + e_{jt})$$

Where,  $E_{jt}$ = Area under  $j^{\text{th}}$  crop during period  $t$

$E_{it-1}$  = Area under  $i^{\text{th}}$  crop during the period  $t-1$

$P_{ij}$  = Probability that the share of area will shift from  $i^{\text{th}}$  crop to  $j^{\text{th}}$  crop

$e_{jt}$  = The error term which is statistically independent of  $E_{it-1}$

$t$  = Number of years considered for the analysis

### 3. RESULTS AND DISCUSSIONS

Table 1 depicts the changing pattern of acreage distribution among different crops in three chosen districts of Kerala during 2005-06 to 2020-21. Allocation share of acreage under paddy shows a declining trend in Thiruvananthapuram and Kannur, with subsequent rise in non-food crops. Unlike in other parts of country where shifts occurs within the annual crops, in Kerala shift has been from seasonal crops such as paddy to perennial crops like coconut and rubber (Kannan and Pushpangadan, 1988) [3]. Total cropped area shows a declining trend in all the three districts (CAGR of -0.16% for both districts Thiruvananthapuram and Kottayam and -0.14% for Kannur). Significant decline in pulses (-9.04 %), paddy (-5.28 %), spices and condiments (-6.90 %) is chiefly responsible for the downfall in total cropped area in Thiruvananthapuram whereas significant decline in pulses (-28.23 %) is responsible for the subsequent downfall of total cropped area in Kottayam district. Significant decline in acreage of paddy (-3.00 %), tapioca (-1.93 %), spices and condiments (-5.46 %) explains the decrease in total cropped area of Kannur district. Non-food crops shows a significant increase of 1.14% and 1.47% in Thiruvananthapuram and Kannur respectively, whereas Kottayam show a non-significant rise of 0.09 %. It is concluded from the table that the overall crop area of paddy, pulses, tapioca, coconut, spices and condiments have been shifted towards the total fruit crops and non-food crop area over a period of time.

Indices of diversification is carried out and Table 2 depicts the extent of Diversification Indices in study area during 2005-06 to 2020-21 period. A close perusal of Table 2 depicts extend of crop diversification in three districts, i.e., Thiruvananthapuram, Kottayam and Kannur during different points of time i.e., 2005-06, 2009-10, 2013-14, 2017-18 and 2020-21. All the three methods used showed similar pattern of results in crop diversification. The districts having cultivation of a number of crops ( $n > 25$ ) shows a very good range of crop diversification indices (similar to results of Mithiyaet al., 2018 [10], Basu and Barman, 2014 [11]). Though, small extend of changes in diversification has been observed in the districts over the years, SI remains around 0.74 in Thiruvananthapuram, 0.67 in Kottayam and 0.79 in Kannur. Among the three districts, Kannur was evidenced to be highly diversified with HI around 0.21 and SI around 0.79. Even though the district showed a downfall of SI from 0.82 during 2005-06 to 0.78 in a time span of 8 years, Kannur topped during all the time period in sense of crop diversification. Thiruvananthapuram stagnated at SI of 0.73 and 0.74 which is considered to be fairly diversified situation. Kottayam had SI of 0.70 during 2005-06 which slipped down to 0.64 over 7 years span. However, ranking of the district based on diversification indicated that the crop area was slightly shifting to the specialized farming like non-food crops and fruit crop farming.

Table 3 proves that Kannur district ranked first during all the time period. Both the indices (SI and MEI) shows similar results i.e. Kannur ranks first followed by Thiruvananthapuram and then Kottayam. From Table 3 it is clear that diversification indices is going down slightly over 15 years

**Comment [MOU7]:** Under this section, we should talk about results interpretation and discussions. So far, the results were interpreted but it was not discussed.

The results talked about declining and shift in crops in some part of the study areas. But what leads to the declining and shift of crops in these study areas?

**Comment [MOU8]:** The result is well interpreted but it did not discuss the reason(s) why it happens like that.

**Comment [MOU9]:** Why the shifting to specialized farming like non-food crops and fruit crop farming?

**Table 1. Growth of area coverage under major crops in the selected districts**

Crops	Thiruvananthapuram					Kottayam					Kannur				
	CAGR (%)	R <sup>2</sup>	P-Value	SE	t-value	CAGR (%)	R <sup>2</sup>	P-Value	SE	t-value	CAGR (%)	R <sup>2</sup>	P-Value	SE	t-value
<b>Paddy</b>	-5.28**	0.68	0.00	0.01	-5.43	3.46**	0.59	0.00	0.01	4.53	-3.00**	0.50	0.00	0.01	-3.72
<b>Pulses</b>	-9.04*	0.25	0.05	0.04	-2.19	-28.23**	0.56	0.00	0.08	-4.20	2.02 <sup>NS</sup>	0.07	0.32	0.02	1.03
<b>Spices &amp; Condiments</b>	-6.90**	0.93	0.00	0.01	-13.45	-4.85**	0.72	0.00	0.01	-6.03	-5.46**	0.80	0.00	0.01	-7.54
<b>Fruits</b>	1.79**	0.57	0.00	0.00	4.29	0.06 <sup>NS</sup>	0.00	0.90	0.00	0.13	-0.51 <sup>NS</sup>	0.07	0.33	0.01	-1.02
<b>Tapioca</b>	-2.41**	0.68	0.00	0.00	-5.44	0.30 <sup>NS</sup>	0.06	0.34	0.00	0.98	-1.93**	0.48	0.00	0.01	-3.63
<b>Vegetables</b>	1.34*	0.35	0.01	0.00	2.77	0.13 <sup>NS</sup>	0.00	0.84	0.01	0.21	0.82 <sup>NS</sup>	0.14	0.16	0.01	1.50
<b>Coconut</b>	-0.64**	0.39	0.01	0.00	-2.98	-2.71**	0.79	0.00	0.00	-7.20	0.13 <sup>NS</sup>	0.01	0.69	0.00	0.41
<b>Non-food crops</b>	1.14**	0.93	0.00	0.00	13.19	0.09 <sup>NS</sup>	0.20	0.08	0.00	1.87	1.47**	0.83	0.00	0.00	8.20
<b>Other crops</b>	-2.89**	0.52	0.00	0.01	-3.89	-5.35**	0.78	0.00	0.01	-7.07	-3.59**	0.66	0.00	0.01	-5.19

\*Significant at 5% level; \*\*Significant at 1% level

**Table 2. Dynamics of crop diversification in selected districts**

Year	Thiruvananthapuram			Kottayam			Kannur		
	SI	EI	MEI	SI	EI	MEI	SI	EI	MEI
2005-06	0.74	1.83	0.67	0.70	1.75	0.65	0.82	2.10	0.78
2009-10	0.73	1.78	0.66	0.67	1.67	0.62	0.80	2.04	0.75
2013-14	0.74	1.81	0.67	0.64	1.57	0.58	0.78	1.95	0.72
2017-18	0.75	1.81	0.67	0.67	1.49	0.55	0.78	1.95	0.72
2020-21	0.74	1.78	0.66	0.67	1.66	0.61	0.78	1.93	0.71

**Table 3. Ranking the districts based on diversification Indices in three districts over the year**

Districts	Simpson Index			Modified Entropy Index		
	2005-06	2013-14	2020-21	2005-06	2013-14	2020-21
Thiruvananthapuram	0.74 (II)	0.74 (II)	0.74 (II)	0.67 (II)	0.67 (II)	0.66 (II)
Kottayam	0.70 (III)	0.64 (III)	0.67 (III)	0.65 (III)	0.58 (III)	0.61 (III)
Kannur	0.82 (I)	0.78 (I)	0.78 (I)	0.78 (I)	0.72 (I)	0.71 (I)

*\*Figures in parentheses indicates the corresponding rank (R<sub>i</sub>) among the districts*

Transitional probability of area in Thiruvananthapuram, Kottayam and Kannur district has been presented in the Tables 4, Table 5 and Table 6 respectively which helps in determining the crop retention area and shift in crop area over a period of time in the district.

It is revealed from Table 4 that over a period of 15 years, Thiruvananthapuram district retained 39 per cent of area under paddy, 35 per cent of area under tapioca, 59 per cent of area under vegetables and pulses, 52 per cent area under fruits, 83 per cent of area under coconut, spices and condiments and 70 per cent of area under non-food crops and others. It is also indicated that 42 per cent of area was shifted towards tapioca from paddy whereas 41 per cent area shifted towards non-food crops and others from vegetables and pulses. However, no major shift was observed from coconut, spices and condiments and non-food crops and others.

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**Table 4. Transitional probability matrix of area in Thiruvananthapuram district**

Crops	Paddy	Tapioca	Vegetables & Pulses	Fruits	Coconut, Spices & Condiments	Non Food Crops & Others
Paddy	<b>0.39</b>	0.42	0.00	0.00	0.19	0.00
Tapioca	0.09	<b>0.35</b>	0.00	0.00	0.39	0.17
Vegetables & Pulses	0.00	0.00	<b>0.59</b>	0.00	0.00	0.41
Fruits	0.00	0.00	0.03	<b>0.52</b>	0.27	0.18
Coconut, Spices & Condiments	0.00	0.11	0.01	0.00	<b>0.83</b>	0.05
Non Food Crops & Others	0.00	0.00	0.00	0.30	0.00	<b>0.70</b>

It is depicted from Table 5 that Kottayam district over a period of time, retain 48 per cent of area under paddy, 15 per cent of area under tapioca, 37 per cent area under vegetables and pulses, 71 per cent area under fruits, 84 per cent of area under coconut, spices and condiments and 90 per cent area under non-food crops and others. However, it is indicated that 35 per cent area was shifted towards non-food crops from paddy and 43 per cent area shifted towards fruits from vegetables and pulses. There was no major shift observed from coconut, spices and condiments, fruit crops and non-food crops and others.

**Table 5. Transitional probability matrix of area in Kottayam district**

Crops	Paddy	Tapioca	Vegetables & Pulses	Fruits	Coconut, Spices & Condiments	Non Food Crops & Others
Paddy	<b>0.48</b>	0.02	0.00	0.15	0.00	0.35
Tapioca	0.85	<b>0.15</b>	0.00	0.00	0.00	0.00
Vegetables & Pulses	0.00	0.20	<b>0.37</b>	0.43	0.00	0.00
Fruits	0.00	0.16	0.04	<b>0.71</b>	0.00	0.09
Coconut, Spices & Condiments	0.00	0.00	0.00	0.00	<b>0.84</b>	0.16
Non Food Crops & Others	0.03	0.01	0.01	0.01	0.04	<b>0.90</b>

It is clear from Table 6 that over a period of time, Kannur district retained 53 per cent of area under paddy, 49 per cent of area under vegetables and pulses, 45 per cent area under fruits, 61 per cent of area under coconut, spices and condiments and 71 per cent of area under non-food crops and others. It is also revealed that 100 per cent area from tapioca, 47 per cent area from paddy, 51 per cent area from vegetables and pulses and 53 per cent area from fruits were shifted towards coconut, spices and condiments. There was no major shift observed from coconut, spices and condiments and non-food crops and others.

**Table 6. Transitional probability matrix of area in Kannur district**

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Crops	Paddy	Tapioca	Vegetables & Pulses	Fruits	Coconut, Spices & Condiments	Non Food Crops & Others
Paddy	<b>0.53</b>	0.00	0.00	0.00	0.47	0.00
Tapioca	0.00	<b>0.00</b>	0.00	0.00	1.00	0.00
Vegetables & Pulses	0.00	0.00	<b>0.49</b>	0.00	0.51	0.00
Fruits	0.00	0.00	0.02	<b>0.45</b>	0.53	0.00
Coconut, Spices & Condiments	0.03	0.02	0.00	0.16	<b>0.61</b>	0.19
Non Food Crops & Others	0.00	0.00	0.01	0.14	0.15	<b>0.71</b>

Overall scenario changing cropping pattern of midland area is depicted in Table 7 and it is clear that over a period of time, midlands retained only 17 per cent of area under paddy, 22 per cent of area under tapioca, 47 per cent area under vegetables and pulses, 48 per cent area under fruits, 84 per cent of area under coconut, spices and condiments and 75 per cent area under non-food crops and others. However, it is indicated that 52 per cent area was shifted towards fruits from paddy, 59 per cent area shifted towards non-food crops and others from tapioca and 53 per cent area shifted towards non-food crops and others from vegetables and pulses. There was no major shift observed from coconut, spices and condiments, fruit crops and non-food crops and others in the midland region of Kerala.

**Table 7. Transitional probability matrix of overall midland area**

Crops	Paddy	Tapioca	Vegetables & Pulses	Fruits	Coconut, Spices & Condiments	Non Food Crops & Others
Paddy	<b>0.17</b>	0.00	0.00	0.52	0.31	0.00
Tapioca	0.12	<b>0.22</b>	0.00	0.00	0.07	0.59
Vegetables & Pulses	0.00	0.00	<b>0.47</b>	0.00	0.00	0.53
Fruits	0.13	0.00	0.06	<b>0.48</b>	0.10	0.23
Coconut, Spices & Condiments	0.00	0.07	0.00	0.00	<b>0.84</b>	0.09
Non Food Crops & Others	0.03	0.01	0.00	0.14	0.07	<b>0.75</b>

#### 4. CONCLUSION

The period from 2005-06 to 2020-21 showed changing pattern of acreage distribution in the three selected districts of Kerala. Total cropped area showed a declining trend in all the three districts throughout the period. Significant decline was found in case of spices and condiments in all the three districts, whereas paddy showed declining trend in Thiruvananthapuram and Kannur. However as against the continuous decline in all other crops, an increasing trend was observed in case of non-food crops and fruits in all the three districts. Though, small extend of changes in diversification has been observed in the districts over the years, SI remains around 0.74 in Thiruvananthapuram, 0.67 in Kottayam and 0.79 in Kannur. Kannur was found to be highly diversified with high value of Simpson Index of around 0.79 followed by

Thiruvananthapuram with SI of around 0.74. Transitional probability matrix of Thiruvananthapuram revealed that coconut, spices and condiments retained more area in the district followed by non-food crops. Non-food crops retained highest area followed by coconut, spices and condiments in Kottayam. More area occupying crop in Kannur was found to be non-food crops followed by coconut, spices and condiments. However, overall scenario in midland region showed that more area was occupied by non-food crops followed by coconut, spices and condiments.

**Comment [MOU12]:** This is just the result again. The conclusion should be a summary of the whole research with the key finding about the research.

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