

Original Research Article

Land Use Changes and Extent of Crop Diversification in North Western Zone of Tamil Nadu

ABSTRACT

Tamil Nadu, one of the important agrarian states in India has experienced remarkable growth in the agricultural sector. Among the seven agro-climatic zones of Tamil Nadu, north western zone is known for intensive agrarian economy of which, the economy of Salem district is predominantly agrarian having 2.20 lakh hectares of net cultivated area (42.31 per cent of total geographical area). The district has distinctive cropping patterns and the major crops grown in the district include Paddy, Tapioca, Maize, Sorghum and Vegetables. Given the importance of changing scenarios in cropping patterns, this study was undertaken to analyze the land use and cropping pattern changes and to examine the extent of crop diversification in Salem District over the year using the time series data for 20 years, i.e., from 2000-01 to 2019-20. Direction of changes in land use and cropping pattern was investigated using Markov chain analysis and for each year, crop diversification index was calculated. It was concluded from the study that the compound annual growth rate of area under crops like cereals and millets, pulses, spices and condiments, fruits, fibres, drugs, narcotics & plantation crops and other non-food crops were positive whereas it was negative for sugar crops, oilseeds, vegetables, fodder and green manure. Based on the crop diversification index value, it is evident that Salem district is moving towards crop diversification rather than specialization however the process as analysed on a time series basis is stagnant.

Keywords: CAGR, Crop diversification, Cropping pattern, Land use pattern, Salem district

INTRODUCTION

Crop diversification is a concept which is opposite to crop specialization. In India, crop diversification is typically viewed as a shift from the traditionally grown less-remunerative crops to more remunerative crops. Crop diversification ensures greater security for food, nutrition, income, and employment to a wider section of society; as a result, it significantly affects the GDP of the country (Amirthalingam and Devi, 2018). According to Acharya *et al.*, 2011, crop diversification contributes to increased cropping intensity, higher employment, commercialization of farming, a decrease in male member migration, and participation of women in income-generating activities. Crop diversification as an effective strategy for sustainable agriculture development has the sound capacity for achieving the goal of nutritional security, stabilize farm income, food security, employment generation, reduce poverty, and conserve natural resources (Von Braun, 1995; Pingali and Rosegrant, 1995; Ryan and Spencer, 2001; Birthalet *et al.*, 2005; Amirthalingam and Devi, 2018). In a developing country like India where the man-land ratio is high, the concept of crop diversification is very

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much significant as it is an important way to enhance agricultural output. (Nagpureet *al.*, 2017).

Tamil Nadu, a Southern States of Indian union with overall geographical area covers 130,058 sq.km which is about 3.96 per cent of country's total geographical area. The share of agriculture and allied activities declined from the level of 24.57 per cent of the state GDP in the 1980s to 21.85 per cent in 1990s before declining to the current level of 13 per cent (Government of Tamil Nadu, 2021). The economy of the state is predominantly agrarian in nature with almost 70 per cent of the state's population is engaged in agricultural activity. It is an agrarian state, the share of net sown area to total geographical area has been continuously declining from 45 per cent in 1960-61 to around 36 per cent in 2020-21 with the continuous changes in its land use pattern and cropping pattern. Also, the gross cropped area had declined from 79.47 lakh ha in 1960-61 to 59.42 lakh ha in 2020-21, nearly 26 per cent of the area has been reduced over six decades (Government of Tamil Nadu, 2021). Among the major crops, the area under rice has also registered a declining share to the gross cropped area in the state, as the crop occupies more than 30 per cent of total cropped area. It is assumed that both climatic and technological factors are crucial in determining land use pattern as well as cropping pattern. Cropping pattern changes occurred in many regions of Tamil Nadu in recent decades where in it was at higher rate in North Western Zone of Tamil Nadu. Specifically in Salem district, it was noticed that the major crops viz., paddy, groundnut and sugarcane was rapidly varied at 15 per cent to 6 per cent in paddy, 13 per cent to 6 per cent in groundnut and 4 per cent 2 per cent in sugarcane over the two decades. But the share of area under horticultural crop-tapioca, the perennial crop-mango and cereal crop-maize are increasing steadily, indicating that there was a definite shift in the area allocation from paddy, ground nut and sugarcane to tapioca and mango in the district. This continuous shift increases in the area under tapioca and mango which will lead to specialization in these crops and the cost of other food and commercial crops (Kumar *et al.*, 2018).

Given the importance of this changing scenarios in cropping patterns of Salem district, to analyse the dynamic changes in land use and cropping pattern of major crop groups and to examine the extent of crop diversification over the years. This study was undertaken by hypothesized that crop diversification is varied over the years in the district.

DATA SOURCE AND METHODOLOGY

Salem district has been randomly selected from the North Western Zone of Tamil Nadu for the analysis of land use and cropping pattern changes from 2000-02 to 2019-20. The

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study was based on the secondary data. The time series data on land use classification and area under different crop groups for the period of 20 years from 2000-01 to 2019-20 was collected using secondary sources like Season and Crop Report and District Statistical Handbook, Salem district and analysed to assess the land use changes and cropping pattern changes in the Salem district of Tamil Nadu. The major crop groups selected for the study are cereals and millets, pulses, sugar crops, spices and condiments, fruits, vegetables, oilseeds, fibre crops, Drugs, Narcotics and plantation crops, fodder crops, green manure and other non-food crops.

To ascertain the changes in different categories of land and cropping pattern changes, the three-year average was calculated for two time periods viz., Period I (TE 2009-10) and Period II (TE 2019-20). The study also attempted to analyse the growth rate and extend of crop diversification for 20 years (2000-01 to 2019-20) using the statistical tools such as Compound Annual Growth Rate (CAGR) and Crop Diversification indices, respectively. Markov chain analysis was used to measure the direction of changes in land use category and area under major crop groups in Salem district.

Compound Annual Growth Rate

The exponential type functional form was used to compute the compound annual growth rate of land use classification and cropping pattern of major crop groups in the Salem district.

$$Y = ab^t e_t$$

where,

Y= dependent variables such as land use classification and area under major crop groups,

a = Intercept,

b = Regression co-efficient,

t = Time variable and

e = Error term

The above equation was transformed into a log form and is estimated by applying the Ordinary Least Square (OLS) method. The t-test was applied to test the significance of 'b'.

$$\ln Y = \ln a + t \ln b + \ln e_t$$

Then, the compound annual growth rate (per cent per annum) was calculated by using the following relationship

$$\text{CAGR} = \{ \text{antilog of } b-1 \} \times 100$$

The standard error of the growth rate was estimated and tested for its significance with "t" statistic which is defined as,

$$t = \frac{b}{se(b)}$$

Where, b= regression coefficient and se(b)= standard error of the regression coefficient.

Markov Chain Analysis

The Markov Chain Analysis is the application of dynamic program to the solution of a stochastic decision process that can be described by a finite number of states. The Markov process was used to study the shift in the shares of land use categories and cropping pattern there by gain in understanding about the dynamics of the its changes.

Transitional probabilities were evaluated based on a linear programming (LP) approach using LINGO software to analyse the dynamics of land use and cropping pattern from 2010 to 2020. The elements P_{ij} of the transitional probability matrix 'P' developed by Markov chain analysis represent the likelihood (share) of land area and crops moving from i^{th} to j^{th} category over time. Its diagonal parts show the retention share in terms of land and cropping area.

This can be algebraically represented as:

$$E_{jt} = \sum_{i=1}^n [E_{it} - 1] P_{ij} + e_{jt}$$

Where

E_{jt} = area under land use/ crop group to the j^{th} category in year 't'

$E_{it} - 1$ = area under land use/ crop group of i^{th} categories during the year 't - 1'

P_{ij} = probability of shift in area under land use/ crop group from i^{th} to j^{th} category

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

n = number of land use category/crop groups

The transition probabilities of P_{ij} , which can be arranged in a (c×n) matrix, are as follows:

$$\sum_{i=1}^n P_{ij} = 1 \text{ for all } "i" 0 \leq P_{ij} \leq 1$$

Thus, the expected area share under each category during the period t were calculated by multiplying the preceding period's area (t-1) by the transitional probability matrix "P". A method known as minimization of Mean Absolute Deviation (MAD) was used to estimate the transitional probability matrix in the linear programming (LP) framework. The LP formula is as follows:

$$\begin{aligned} & \text{Min } O * P + I e \\ & \text{Subject to, } X P^* + v = y \quad G P^* = 1 \end{aligned}$$

$$P^* \geq 0$$

Where, P^* is a vector of the probabilities P_{ij} , 0 is a vector of zero, I is an appropriately demonstrated identity matrix, e is the vector of absolute error, y is the vector of share in land use/ crop group to each category, X is a block diagonal matrix of lagged values of y and v is the vector of errors and G is a grouping matrix to add the row elements of P arranged in P^* to unity.

Crop Diversification Indices

There are few methods, which explain either concentration/ specialization or diversification of commodities or activities. Table 1 provides a summary of different measures of diversification and their properties:

Table 1: Characteristic features of different measures of diversification

Index	Formula	Measure of	Perfect Diversification	Perfect Concentration
Ogive index	$OI = N \sum_{i=1}^N \left\{ P_i - \left(\frac{1}{N} \right) \right\}^2$	Diversification	1	0
Entropy index	$EI = \sum_{i=1}^N P_i * \log \left(\frac{1}{P_i} \right)$	Diversification	$\ln(N)$	0
Modified Entropy index	$MEI = \sum_{i=1}^N P_i * \log_N \left(\frac{1}{P_i} \right)$	Diversification	1	0
Composite Entropy Index	$CEI = - \sum_{i=1}^N (P_i \log_N P_i) \times \{1 - (1/N)\}$	Concentration	1	0
Herfindahl index	$HI = \sum_{i=1}^N P_i^2$	Concentration	0	1
Simpson Index	$SI = 1 - \sum_{i=1}^N P_i^2$	Diversification	1	0

Each method has some limitation and/or superiority over the other. Entropy index (EI) and modified entropy index (MEI) are widely used by agricultural economists for analysing diversification of agriculture (Singh *et al*, 1985; Shiyani and Pandya, 1998). Whereas Ogive Index was first used to measure the industrial diversity. However, the Simpson's index takes into account both richness (the number of crop species present in a particular area) and evenness (the relative abundance of different crop species) of crops

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present in a particular area. As crop richness and evenness increase, diversity increases. Thus, the Simpson's index provides a clear dispersion of crops in a particular area. The most widely used method for measuring diversity in recent times is Simpson's index, which is the modified version of Herfindahl Index (SI= 1-HI). It is easy to compute and interpret (Joshi et al., 2004). Considering the study objective of assessing the extent of diversity in crops, Herfindahl and the Simpson's index has been used.

RESULTS AND DISCUSSION

Land use pattern of Salem district:

The rapid pace of economic development along with population growth, urbanization and industrialization exert tremendous pressure on the limited natural resource base of a district or a region. Land, being one of the most basic natural resources has always been the subject matter of debate regarding its effective use. A study on land use patterns would be more useful in planning for expanding the forest area, reclamation of fallow lands and other classifications to make them suitable for the provision of environmental services, farming and so on. The overall geographical area of Salem district was 5.20 lakh hectares as shown in table 2.

The changes in the proportion of different categories of land in the Salem district are presented in Table 2. The area under each category of land was assessed for two period viz., Period I (2009- 10) and Period II (2019-20) in order to ascertain the dynamic changes. During the Period II (2019-20), it was assessed as Net area sown as 38.29 per cent of the total geographical area, while the gross cropped area accounted for 53.23 per cent. The forest area covered on an average 24.15 per cent of the total geographical area. Land put to non-agricultural use accounted for 12.42 per cent of the total geographical area, whereas the barren and uncultivable wasteland accounted for 7.34 per cent of the total geographical area. Fallow land other than current fallow and the current fallows account for 15.26 per cent whereas cultivable waste land accounts for only 1.19 per cent of geographical area, implied the scope for improving the utilization of these lands for agriculture. Over the past twenty years, there has been an increasing trend in the land under current and other fallows with the declining area under net area sown in Period II compared to Period I which is a major concern for policy makers.

The result in table 2 also revealed that during 2000-01 to 2019-20, there had been increases in the land put to non-agricultural uses, cultivable waste land, total fallow land and area sown more than once whereas decreases in the net area sown, total cropped area.

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However, barren and uncultivable land, permanent pastures and grazing land and land under miscellaneous trees, groves,*etc.*, also exhibited negative growth.

Table2: Land use pattern of Salem district

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Particulars	Period I(2009-10) (Area in ha)	Period II(2019-20) (Area in ha)	CAGR (%)
Geographical Area	5,20,530.00	5,20,530.00	0
Forest	1,25,682.00(24.15)	1,25,682.00(24.15)	0
Land put to non-agricultural uses	59,775.00(11.48)	64,670.67(12.42)	1.28***
Barren and Unculturable Land	38,894.00(7.47)	38,198.00(7.34)	-0.41***
Permanent Pastures and other Grazing Land	4,200.00(0.81)	4,200.00(0.81)	-1.33***
Land under Misc.trees,groves, etc.,(not included in net sown area)	3,104.00(0.60)	2,855.33(0.55)	-1.14***
CulturableWasteland	5,040.00(0.97)	6,187.67(1.19)	0.71*
Fallow Land other than current fallow	20,741.33(3.98)	21,143.67(4.06)	0.36
Current Fallow	55,497.67 (10.66)	58,275.67(11.20)	3.33**
Net Area sown	2,07,596.00(39.88)	1,99,317.33(38.29)	-0.67**
Gross Cropped Area	2,42,336.33(46.56)	2,77,062.00(53.23)	-0.15
Area sown more than once	34,740.33(6.67)	81,282.33(15.62)	2.69
Cropping Intensity	116.65	140.78	0.57

Source: Author's calculation based on data from District Statistical HandBook (different columns), Assistant Director of Economics and Statistics, Salem.

Note: Figures in parentheses indicate the percentage of total geographical area

Changes in barren and unculturable land (-0.41 per cent), permanent pastures and other grazing land (-1.33 per cent) and land under miscellaneous trees, groves,*etc.* (-1.14 per cent) was observed as negative growth with a one per cent significance level. On the other hand, land put to non-agricultural uses and culturablewasteland has a positive growth rate of 1.28 per cent and 0.71 per cent per annum with a one per cent and 10 per cent significance level, respectively which implied that in selected study district, the change in land use pattern might be due to industrialization (total number of registered units around 2258 during Period I to 8906 during Period II) and urbanization (4.07 per cent of the total geographical area was

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urban during Period I to 12.88 per cent during Period II) . However, the fallow land other than the current fallow and current fallow land exhibited a positive growth rate of 0.36 and 3.33 per cent per annum which was at five per cent significant level might be due to low receipt of rainfall (1069.37 mm in Period I to 801.32 mm in Period II)and non- availability of agricultural labour.

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The decrease in net area sown and the total cropped area is due to more area occupied under current fallow land. A similar result to Mohanty (2007), there was a decline in the net area sown, which was mostly attributed to increasing agricultural land area for non-agricultural purposes. Over the last 20 years, cropping intensity had slightly improved with a positive growth rate of 0.57 per cent per annum.

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Dynamic changes of Land use category in Salem District

Markov chain analysis helped us to analyse the dynamic changes in land use category in common. This analysis was carried out and the results are presented in Table 3. The Markov chain analysis was carried out for the period from 2010-11 to 2019-20 to analyse the shift in land use pattern in Salem district. The stability/ retention of the area shares of the different land use categories and the direction and the volume of changes over time is captured by transitional probability matrix and the results are presented in Table 3.

It can be inferred from the table 3 that land use categories have shown stability. But the highest stability was acquired by forest land, Barren and Unculturable Land and Permanent Pasture and Other Grazing Land as reflected in high probability of retention at 1.00 i.e., the probability of these land area retains its share from one period to another period is 100 per cent. Similar interpretation could be made for net area sown, area under non-agricultural uses, fallow lands other than current fallows, culturablewaste land and current fallow with probability of retention of 0.87, 0.85, 0.84, 0.75 and 0.39 respectively. Current fallow land could be retained its major share and it is likely to contribute its 0.47 share to net area sown and 0.07 share to area under non-agricultural uses. Implemented development programmes by the Government motivates the farmers to utilize their land productivity. On the contrary, land under misc. tree crops and groves not included in net area sown was having the probability of zero retention indicating that its share of land is unstable which means it could not retain its share during the period.

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Table 3: Transitional Probability matrix of dynamic changes of land use category (2009-10 to 2019-20)

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Particulars	Forests	Area Under Non-Agricultural Uses	Barren and Unculturable Land	Permanent Pasture and Other Grazing Land	Land Under Misc. Tree Crops and Groves not Included in Net Area Sown	Culturable Waste Land	Fallow Lands Other Than Current Fallows	Current Fallow	Net Area Sown
Forests	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Area Under Non-Agricultural Uses	0.00	0.85	0.00	0.00	0.00	0.02	0.00	0.13	0.00
Barren and Unculturable Land	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Permanent Pasture and Other Grazing Land	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Land Under Misc. Tree Crops and Groves not Included in Net Area Sown	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00
Culturable Waste Land	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.25	0.00
Fallow Lands Other Than Current Fallows	0.00	0.00	0.00	0.00	0.01	0.00	0.84	0.15	0.00
Current Fallow	0.00	0.07	0.00	0.00	0.01	0.00	0.06	0.39	0.47
Net Area Sown	0.00	0.03	0.00	0.00	0.01	0.00	0.00	0.09	0.87

Source: Author's calculation based on data from District Statistical HandBook (different columns), Assistant Director of Economics and Statistics, Salem.

Cropping pattern in Salem District

An analysis of cropping patterns would reveal information on farmers' decision-making behaviour on the crop – mix prevalent in the region. The growth in the area under different crop groups over the last 20 years from 2000-01 to 2019-20 was analysed and presented in table 4.

The results showed a positive growth rate in the area offruits with 3.87 per cent per annum, followed by 2.91 per cent per annum for other non-food crops, 2.37 per cent per annum for cereals and millets and 0.93 per cent per annum for Drugs, Narcotics and Plantation crops annually with one per cent, 10 per cent, 5 per cent and 10 per cent significance level, respectively. The area under pulses, spices and condiments and fibres increased at the rate of 2.24 per cent, 1.01 per cent and 1.09 per cent per annum, respectively. But, in the case of fodder crops, oilseeds and vegetables, the growth rate during 2000-01 to 2019-20 were negative at the rate -10.88 per cent and -3.02 per cent per annum with a one per

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cent significance level for fodders and oilseeds and -1.84 per cent per annum for vegetables with 5 per cent significance level, respectively.

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Table 4: Cropping pattern in Salem (area in ha)

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Crop groups	Period I (2009-10) (Area in ha)	Period II (2019-20) (Area in ha)	CAGR (%)
Cereals and Millets	75,206.33(31.03)	1,15,369.67(41.64)	2.37**
Pulses	16,465.00(6.79)	52,311.00(18.88)	2.24
Sugar crops	11,511.33(4.75)	5,242.33(1.89)	-0.51
Spices and Condiments	10,329.00(4.26)	7,584.67(2.74)	1.01
Fruits	7,493.33(3.09)	9,305.67(3.36)	3.87***
Vegetables	31,690.67(13.08)	22,666.00(8.18)	-1.84**
Oilseeds	41,893.33(17.29)	34,637.00(12.50)	-3.02***
Fiber crops	14,252.33(5.88)	13,510.33(4.88)	1.09
Drugs, Narcotics and Plantation crops	7,270.33(3.00)	8,234.00(2.97)	0.93*
Fodder crops	23,406.00(9.66)	3,302.00(1.19)	-10.88***
Green manure	289.67(0.12)	114.33(0.04)	-14.50
Other non-food crops	2523.67(1.04)	4776.00(1.72)	2.91*
Gross cropped area	2,42,336.33(100)	2,77,062.00(100)	-0.15

Source: Author's calculation based on data from District Statistical HandBook (different columns), Assistant Director of Economics and Statistics, Salem.

Note: Figures in parentheses indicate the percentage of the gross cropped area.

The changes in the cropping pattern for the period from Period I to Period II were analysed for the Salem district. The results in table 4 indicated that the share of the area of cereals and millets, pulses, fruits, and other non-food crops has increased during the period. The share in the area of sugar crops, vegetables, oilseeds, fodder and green manure crops had declined over the years. The share in the area of cereals and millets increased from 31.03 per cent during Period I to 41.64 per cent during Period II. Thus, cereals crops occupied the major share of the total cropped area, indicating that the farmers in the region have aware of the value of food security. For the pulse crop, the area share increased from 6.79 per cent during Period I to 18.88 per cent during Period II, which indicates the farmers' awareness of nutritional requirements. The area share of sugar crops was less in the total cropped area

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and decreased over the years. The area share of oilseed crops has also lessened from 17.29 per cent during Period I to 12.50 per cent during Period II. In the case of fruits crops, their share of the total cropped area increased from 3.09 per cent during Period I to 3.36 per cent during Period II, whereas the vegetable crops declined from 13.08 per cent during Period I to 8.18 per cent during Period II.

Dynamic changes of major crop groups in Salem district

Markov chain analysis was employed to examine the direction of cropping pattern changes by estimating transitional probability matrices. The diagonal and off-diagonal components of the transitional matrix were used to identify the probability of keeping a certain crop (gain or loss), while the row elements indicated the probability of crop loss owing to competing crops. The column elements represent the probability of another crop gaining ground in the area. As the diagonal elements approach zero, the crops become less and less stable, and as they approach one, they grow more and more stable over time. The data on cultivated area of various crop groups from 2010-11 to 2019-20 was used to analyse the transitional probability matrix for cropping pattern changes in Salem district of Tamil Nadu. Table 5 summarize the results of the Markov chain model. The table 5 showed that fodder crops have been the most stable crop among other crop groups, as evidenced by the greater chance of retention of 0.63, i.e., the chance of fodder crops maintaining their area share over the study period was 63 per cent. Cereals and millets has a probability retention of 0.59, which means it has kept 59 per cent of area share, followed by oilseeds, which has kept 34 per cent of area share. It can be further seen from the table that the probability of shift in area from cereals and millets to pulses was 33 per cent and oilseeds was 6.4 per cent whereas to other crop groups was only in meagre. The sugar crops, fruits and oilseeds have lost 52, 83 and 56 per cent of their area to paddy, respectively. The study also found that shifting in area from sugar crops and fiber crops to pulses was 40 and 93 per cent respectively, whereas it has gained 8 per cent and 9 per cent from pulses respectively. The study also revealed that shifting in area from spices and condiments to oilseed was 57 per cent, vegetables to fiber crops

Table 5: Transitional Probability matrix of dynamic changes in major crop groups (2010-11 to 2019-20)

Crops	Cereals & millets	Pulses	Sugar crops	Condiments and Spices	Fruits	Vegetables	Oilseeds	Fibres	Fodder crops	Others
Cereals & millets	0.59	0.34	0.00	0.00	0.01	0.00	0.06	0.00	0.00	0.00
Pulses	0.000	0.00	0.08	0.13	0.05	0.27	0.26	0.09	0.01	0.11
Sugar crops	0.53	0.40	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00

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Condiments and Spices	0.00	0.00	0.12	0.00	0.03	0.05	0.58	0.00	0.00	0.22
Fruits	0.83	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
Vegetables	0.02	0.00	0.00	0.08	0.14	0.24	0.00	0.36	0.00	0.16
Oilseeds	0.56	0.00	0.00	0.00	0.00	0.09	0.35	0.00	0.00	0.00
Fibres	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06
Fodder crops	0.00	0.00	0.16	0.07	0.00	0.04	0.00	0.05	0.63	0.05
Others	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Author's calculation based on data from District Statistical HandBook (different columns), Assistant Director of Economics and Statistics, Salem.

Crop Diversification Index

For measuring the extent of crop diversification and changes over the period from 2000-01 to 2019-20, the Herfindahl index (HI) and Simpson index (SI) were examined and presented in table 6. Both these indices were computed based on the proportion of gross cropped area under different crop groups (cereals and millets, pulses, sugar crops, spices and condiments, fruits, vegetables, oilseeds, fibre crops, Drugs, Narcotics and plantation crops, fodder crops, green manure and other non-food crops) cultivated in Salem district.

The calculated average value of the Herfindahl index for different crop groups was 0.182 (i.e., less than 0.5), which means that diversification took place. The value of the Herfindahl index in the Salem District was found to be low i.e., the value moved up from 0.138 during 2012-13 to 0.254 during 2019-20. The result of the Simpson index has a high crop diversification value, which lies between 0.746 and 0.862 during 2019-20 and 2012-13, respectively. The factors which are responsible for crop diversification are that most of the farmers were moved from low-value crops to high-value crops for sustaining economic prosperity and to generate alternate sources of income (Sandipanand Palash, 2015).

Table 6: Indices of Crop Diversification in Salem district from 2000-01 to 2019-20

Year	Herfindahl index	Simpson index	Year	Herfindahl index	Simpson index
2001	0.172	0.828	2011	0.166	0.834
2002	0.167	0.833	2012	0.151	0.849
2003	0.165	0.835	2013	0.138	0.862
2004	0.179	0.821	2014	0.177	0.823
2005	0.176	0.824	2015	0.211	0.789
2006	0.184	0.816	2016	0.219	0.781
2007	0.162	0.838	2017	0.165	0.835
2008	0.154	0.846	2018	0.231	0.769
2009	0.182	0.818	2019	0.227	0.773
2010	0.166	0.834	2020	0.254	0.746

Source: Author's calculation based on data from District Statistical HandBook (different columns), Assistant Director of Economics and Statistics, Salem.

The results clearly show that farmers in the Salem district were progressive towards diversification rather than specialization. Thus, the diversification from subsistence crops to more commercial crops was taking place in the district. Therefore, the result of the analysis has proved the hypothesis that crop diversification took place in the Salem district over a period of time.

CONCLUSIONS

The study concluded that there was positive growth in the land put to non-agricultural uses, culturable waste land, total fallow land and area sown more than once. However, the increase in area under non-Agricultural uses was due to a sharp increase in the population of the district. Further, it was observed that there has been negative growth in barren and unculturable land, permanent pastures and other grazing land and land under misc. trees, groves in Salem district during 2000-01 to 2019-20. The cropping intensity has been slightly increasing over the period in the Salem district.

Comment [AM184]: need arrangements

Agricultural diversification is an important mechanism for economic growth. The Salem district showed a high level of diversification as measured by these Indices but the process as analysed on a time series basis is somewhat stagnant. It is concluded from the study that the share of crops like cereals and millets, pulses, spices and condiments, fruits, fibre and non-food crops has increased over the years with a positive compound annual growth rate in the area of each crop group in the district. However, the share of sugar crops, vegetables, oilseeds, fodder crops and green manure decreased over the years with a negative compound annual growth rate of the area of crops in the area of each crop group. This shows that the district is moving towards crop diversification rather than specialization.

POLICY IMPLICATIONS

Presently, diversification in agriculture is leading to agribusiness, and the focus on vertical integration between farmer and retailer is increasingly becoming common therefore public and private investments, especially in the areas of research and development, extension services delivery and technology development need to be enhanced. More high-value crops should be incorporated into the cropping system which would expect to increase both the farm income and cropping intensity.

REFERENCES

- Acharya, S.P., Basavaraja, H., Kunnal, L.B., Mahajanashetti, S.B. and Bhat, A.R.S. (2011) Crop diversification in Karnataka: An economic analysis. *Agricultural Economics Research Review*. 24 (1): 351-357.
- Amirthalingam, N and Devi, K.S. (2018). An economic analysis of crop diversification and dynamics of changes in the cropping pattern in Villupuram district of Tamil Nadu. *International Journal of Research and Analytical Reviews*. 5(4): 243 to 248
- Birthal, P.S., Joshi, P.K. and Gulati, A. (2005). *Vertical Coordination in High-Value Commodities: Implications for Smallholders*. MTID Discussion Paper No. 85. International Food Policy Research Institute, Washington, D.C.
- Chand, R., Raju, S.S. and Pandey, L.M. (2008). Progress and Potential of Horticulture in India. *Ind. J. Agric. Econ.* 63:3.
- Ganguly, S., Patra, P. (2015). Crop concentration and crop diversification analysis of Maldah district, West Bengal, India. *International Journal of Multidisciplinary Research*. 5(5): 56-65.
- Government of Tamil Nadu, Season and Crop Report of Tamil Nadu (2001-2020), Directorate of Economics and Statistics, Chennai.
- Government of Tamil Nadu. District Statistical Handbook, Assistant Director of Economics and Statistics. Salem District.
- Joshi, P.K., Ashok, G., Bertha, P.S. and Tiwari, L. (2004). Agricultural Diversification in South Asia: Patterns Determinants and Policy Implication. *Econ. Polit. Wkly*. 39:24.
- Kalaiselvi. V (2012). An Economic Analysis of Crop Diversification in Tamil Nadu. *International Journal of Current Research and Review*. 4(8):147-153.
- Kumar, P.N., Rajasekar, D.D. and Felix, T.K. (2018). Study on crop diversification of major crops in Salem district. *Trends in Biosciences*. 11(30): 1-3.
- Mohanty, S. (2007). Population Growth and Changes in Land Use in India. Mumbai: IIPS Mumbai, ENVIS Centre.
- Nagpure, S.C., Deshmukh, R.G., Sharma, P.K. and Ingole, D.N. (2017). Pattern of crop concentration and crop diversification- An economic analysis. *Maharashtra J. of Agril. Econ.* 20(2): 128-132.
- Pingali, P.L. and Rosegrant, M.W. (1995). Agricultural commercialization and diversification: Processes and kalaipolicies. *Food Policy*. 20(3): 644-651.

Comment [AM185]: (2008)

Comment [AM186]: and

Comment [AM187]: (2004)

Comment [AM188]: (2018)

Comment [AM189]: (2017)

Ryan, J.G. and Spencer, D.C. (2001). *Future Challenges and Opportunities for Agricultural R&D in the Semi-Arid Tropics*. International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Telangana.

Sandipan, G. and Palash, P. [2015]. Crop concentration and crop diversification analysis of Maldah district, West Bengal, India. *Int. J. of Multidisciplinary Res.* 5(5): 56-65.

Shiyani, R.L. and Pandya, H.R. [1998]. Diversification of Agriculture in Gujrat: A Spatial-Temporal Analysis. *Indian J. Agric. Econ.* 53(4):627-639.

Singh, A.J., Jain, K.K. and Sain, I. [1985]. Diversification of Punjab Agriculture: An Econometric Analysis. *Ind. J. Agric. Econ.* 40(3):298-303.

Von Braun, J. [1995]. Agricultural commercialization: Impacts on income and nutrition and implications for policy. *Food Policy.* 20(3): 187-202.

Comment [AM190]: (2015)

Comment [AM191]: (1998)

Comment [AM192]: (1985)

Comment [AM193]: (1995)

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