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Research Paper

Agricultural Diversification in Tamil Nadu – An Economic analysis

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ABSTRACT

In comparison to other Indian states, Tamil Nadu has unique agro-climatic and cropping patterns, which have caused a lot of concern, both environmentally and in terms of food security. From 2001 to 2020, the study examines changes in land use and cropping patterns in Tamil Nadu. Secondary data on area under major crops was gathered from various sources. To assess the expansion of area under major crops over time, the compound growth rate was calculated (2001-2020). In cropping pattern, direction of changes was investigated using Markov chain analysis and for each year, crop diversification index was calculated. The results indicated that land classified as land put to non-agricultural uses and fallow land recorded positive expansion in area. The area under paddy, bajra, sugarcane, groundnut, and gingelly are growing at a negative rate, but maize, pulses, fruits, vegetables, coconut, and cotton are growing at a positive rate. It can be stated that net sown area in Tamil Nadu is declining, with shift in food crops being hurt worse than non-food crops. Based on Crop Diversification Index score, crop intensification has increased in the state over time, helping to reduce failure of crop and income loss while also creating jobs for rural people.

HIGHLIGHTS

- Area under land put to non-agricultural use and fallow land has increased but net sown area decreased.
- Estimates of various crop diversification indices revealed increasing crop diversity of the state.

Keywords: Crop diversification index, cropping pattern, growth rate, land use, transitional probability

The Indian economy is based on agriculture, which promotes economic growth and development, provides raw materials to businesses, maintains food security and nutrition, generates foreign capital, raises farmer income level, expands employment possibilities, boosts national income, and reduces poverty. Agriculture is a significant sector in Tamil Nadu, accounting for 13% of the state's revenue. It has a net cultivated area of 4.74 million hectares, with various irrigation sources irrigating almost 57% of the land (TN seasonal crop report, 2020). It is divided into seven agroclimatic zones, which are suitable for a variety of crops. Agricultural intensification seems to be the only way to ensure further agricultural production in a society with limited natural resources and ever-growth in food intake and food security as a result of population growth (Devi and Prasher, 2018). Crop diversity and cropping patterns changes are two ways to promote agricultural intensification. It is without a doubt an important component of the overall smallholding development plan. Agricultural diversity in India began in the early 1980s and has gained steam in subsequent years, with farmers always ready to diversify into higher-value crops when market possibilities arose (Palanisami *et al.* 2009).

Crop diversification provides numerous advantages, including increased earnings, reducing poverty, food security, job creation, effective usage of land

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and water resources, sustainable agricultural production and environment protection. Crop diversity emerges as a fundamental method for improving revenue, providing gainful work, and stabilising the income flow (Velavan and Balaji, 2012).To maintain or enhance the value of natural resources, such as land and water, cropping systems have been changed or new cropping systems have been introduced in a number of scenarios. Diversification also said to help farmers maintain a greater level of farm income. This occurs when the diversification pattern is such that it accommodates a growing number of profitable crops. This seems to be particularly important for small growers who are trying to generate a profit from their operations. (Kalaiselvi, 2012 and Krishnan, 2017).

Tamil Nadu is an important agrarian state in India., has experienced rapid agricultural growth. It is a leading producer of major crops such as paddy, sugarcane, etc. Intensive farming has increased the production of numerous crops despite the limited gross area sown. However, since the 1990s, the state's agricultural growth has slowed as a result of key obstacles such as increasing water shortage, urbanisation, soil degradation, shrinking farm land, rising labour costs, and the switch from traditional crops to commercial crops (Amirthalingam and Devi, 2018). Keeping this in view, the purpose of the study was conducted to examine the dynamic changes in cropping patterns and the levels of crop diversification in Tamil Nadu state.

Data and Methodology

The study depended mainly on secondary data. The primary crops included for the analysis were paddy, maize, jowar, bajra, ragi, pulses, sugarcane, spices, fruits, vegetables, groundnut, gingelly, coconut and cotton for Tamil Nadu. The secondary data in relation to area under major crops from 2000-01 to 2019-20 were collected from Tami Nadu season and crop reports. The entire data were divided into three periods (period I, period II and overall period) which was done to find out the variation between those periods. Period I consists of 2000-2010, period II as 2010-2020 and the overall period was from 2000-2020.

Growth Rate Analysis

To capture changes in the cropping pattern, compound growth rates of area under major crops were estimated, as well as changes in land use pattern in terms of increase or reduction in area under different land use categories. It is computed by applying formula:

$$Yt = ab^t$$

In the log form, it is written as:

$$Log\ Y_t = Log\ a + t\ log\ b$$

Where,

Y_t = Area in the year 't'

t = Time element, which takes the value 1, 2, 3, ……. n

a = Intercept

b = Regression coefficient.

The value of b is computed by using OLS method (Narmadha and Kandeepan, 2017). Further the value of CGR was calculatedas follows:

$$CGR\ (r) = (antilog\ b - 1) \times 100$$

Markov Chain Analysis

Transitional probabilities were evaluated based on a linear programming (LP) approach using LINGO software to analyse the dynamism in the direction of area under crops from 2010 to 2020. To know the shift in cropping pattern, major crops such as paddy, maize, jowar, pulses, sugarcane, fruits, vegetables, groundnut, coconut, cotton and other crops were considered. The elements P_{ij} of the transitional probability matrix 'P' developed by Markov chain analysis represent the likelihood (share) of crops moving from i^{th} to j^{th} crop over time. Its diagonal parts show the crop's retention share in terms of area under cultivation (Gayathri *et al*. 2021).

This can be algebraically represented as:

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

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

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

n = number of crop groups

Crop diversification Index:

(a) Herfindahl Index (HI)

The Herfindahl index was used to determine the state's level of diversification. The Herfindahl index is calculated as follows:

$$HI = \sum_{i=1}^{i=N} p_i^2$$

P_i = Proportion of area under i^{th} crop

$P_i = A_i / \sum A_i$

In which A_i = Area under i^{th} crop and $\sum^n_{i=1} A_i$ = Total cropped area

The *HI* index is a measure that ranges from zero to one. In the event of perfect specialisation, it is one, while in the case of perfect diversity, it is zero.

(b) Simpson Index (SI): *It is defined by;*

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

It ranges between 0 to 1. *SI* assumes the value 1 at full diversification and 0 at full concentration.

(c) Entropy Index (EI)

The Entropy Index, unlike the Herfindahl Index, increases as diversification increases. Its definition is as follows:

$$EI = -\sum_{i=1}^{N} p_i \ln\left(p_i\right)$$

When $p_i = 1/N$ (i = 1,2.3..N), maximum diversification occurs, $log(N)$ reaches its maximum value. When there is just one crop, specialisation occurs, and it achieves a minimal value of 0.

(d) Modified Entropy Index (MEI)

There is a limitation to the EI. EI can't be used to compare the degree of diversification in different places where different numbers of crops are cultivated because its upper limit is $log(N)$ (which is dependent on N). A Modified Entropy Index is used to get around this limitation. This index is described as follows:

$$MEI = -\sum_{i=1}^{i=N} p_i \log_N p_i$$

MEI is the same as *EI*, except that the logarithm's base is N. It can be seen that this index has a value of 1 at maximum diversification and a value of 0 at maximum specialisation. The MEI is used as a norm to assess and rank the level of spatial diversification since it provides a uniform and stable scale. As a result, in the present study, this index was employed to rank the various indices. Table 2 summarises the three different diversity measures and their features.

RESULTS AND DISCUSSION

The findings are summarised below from 2010 to 2020, land use patterns changes represented in total area under various land use categories, whereas cropping patterns are depicted in terms of growth under the area of major crops cultivated in Tamil Nadu. Table 1 demonstrates that land classified as non-agricultural use (1.76%) and total fallow (1.39%), which includes current fallow, recorded a positive growth, whereas net sown area shows negative growth rate (0.68%). This reflects a wider trend in which cultivable areas are being used for other purposes, and farmers are gradually reducing the area under cultivation and looking for alternative employment (Rejula and Singh, 2015).

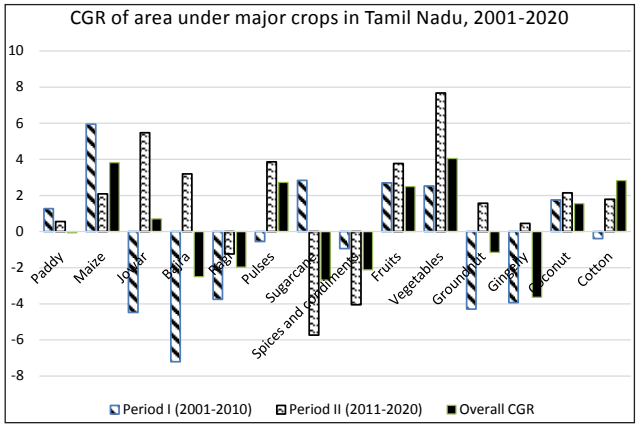
Table 1: Growth rate of land use pattern in Tamil Nadu (2010-2020)

Sl. No.	Land use pattern (Area in Ha)	Growth rate (%)
1	Forest	0.19
2	Land put to non-agricultural use	1.70
3	Barren & uncultivable land	-0.91
4	Permanent pastures and grazing lands	-0.25
5	Land under misc. tree crops and groves	-1.46
6	Cultivable waste	-0.26
7	Total fallows	1.39
8	Net area sown	-0.68
9	Gross cropped area	0.19

Source: Author's calculation based on data from TN Seasonal and Crop Report (2010-2020).

Growth rate of major crops in Tamil Nadu

The area under selected crops in Tamil Nadu was assessed from 2001-02 to 2019-20, and the compound growth rate of such crops was determined. The outcomes are depicted in Fig. 1.



Source: *Author's calculation based on data from TN Seasonal and Crop Report (2001-2020).*

Fig. 1: Compound growth rate of area under major crops in Tamil Nadu, 2001-2020

The results show that, with the exception of maize and jowar, the annual area growth rate of other cereals (paddy, bajra, and ragi) has decreased throughout the state. In period I and II, maize grew by 5.94 percent and 2.08 percent, respectively. Maize has grown at a rate of 3.81 percent over the study period. Over the last decade, the rate of growth in the pulses has been steadily increasing. Area under sugarcane growth has become negative in the period II (5.73 %) and overall growth rate (2.68 %). Fruits growth has increased from 2.70 per cent in period I to 3.77 per cent in period II. Similarly,in period I, II and overall period, the area under vegetable has grown by 2.52 percent, 7.67 per cent and 4.05 percent, respectively. In opposition, in the overall period, the area under spices, groundnut, and gingelly has decreased by 2.12, 1.15, and 3.63 per cent, respectively. Over the years, the area under coconut has improved positively, increasing by 1.55 percent. However, during period I, the area under cotton dropped, and in recent years, the area has increased by 1.79 percent.

According to the state's crop area growth rates, crops such as paddy, bajra, sugarcane, groundnut, and gingelly have increased negatively. Maize, pulses, fruits, vegetables, coconut, and cotton, which have the smallest share, had good growth over time. This provides a clearer understanding of the state's agricultural crop diversification.

Dynamic changes of major crops in Tamil Nadu

Markov chain analysis was employed to examine the direction of cropping pattern changes by estimating the 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 rival crop gaining ground in the area. As the diagonal elements approach zero, the crops become less and

Table 2: Transitional probability matrix of dynamic changes in major crops in Tamil Nadu, 2010-11 to 2019-20

Crops	Paddy	Maize	Jowar	Pulses	Sugarcane	Fruits	Vegetables	Groundnut	Coconut	Cotton	Others
Paddy	**0.11**	0.04	0.00	0.11	0.04	0.16	0.01	0.22	0.21	0.00	0.10
Maize	0.00	**0.35**	0.07	0.00	0.00	0.07	0.51	0.00	0.00	0.00	0.00
Jowar	0.24	0.00	**0.33**	0.17	0.00	0.00	0.26	0.00	0.00	0.00	0.00
Pulses	0.07	0.00	0.03	**0.57**	0.00	0.00	0.13	0.07	0.10	0.03	0.00
Sugarcane	0.10	0.00	0.00	0.00	**0.53**	0.00	0.00	0.02	0.26	0.09	0.00
Fruits	0.46	0.00	0.00	0.00	0.00	**0.31**	0.00	0.00	0.10	0.00	0.13
Vegetables	0.01	0.06	0.00	0.07	0.00	0.00	**0.29**	0.15	0.08	0.02	0.32
Groundnut	0.44	0.00	0.12	0.12	0.00	0.03	0.09	**0.13**	0.06	0.00	0.00
Coconut	0.14	0.04	0.00	0.07	0.00	0.10	0.00	0.07	**0.48**	0.07	0.03
Cotton	0.00	0.22	0.00	0.68	0.00	0.00	0.01	0.00	0.00	**0.00**	0.09
Others	0.39	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	**0.12**

Source: *Author's calculation based on data from TN Seasonal and Crop Report (2010-2020).*

less stable, and as they approach one, they grow more and more stable over time. The statistics on cultivated area from 2010-11 to 2019-20 was used to analyse the transitional probability matrix for cropping pattern changes in Tamil Nadu. Table 2 summarises the results of the Markov chain model.

The table 2 shows that pulse crops have been the most stable crop among the major crop groups, as evidenced by the greater chance of retention of 0.57., i.e., the chance of pulses maintaining their area share over the study period was 57 percent. Sugarcane has a probability retention of 0.53, which means it has kept 53 percent of area share, followed by coconut, which has kept 48 percent of area share. It can be further seen from the table that fruits and groundnut have lost 46 and 44 percent of their area to paddy, respectively, whereas it has gained 16 and 22 percent area from paddy. The study also found that shifting land from maize to vegetables was 51 per cent, sugarcane to coconut was 26 per cent, cotton to pulses was 68 per cent, and area of other crops shifted to coconut was 41 per cent. This illustrates that the percentage of food crops to total cropped area has been decreasing year after year, while the area of non-food crops has been increasing.

Crop Diversification

Crop diversification study is extremely important for land use planning and agricultural development in the future. Crop diversification is determined by soil conditions, rainfall characteristics, irrigation facilities, and the availability of arable land (Acharya *et al.* 2011). Table 3 summarises the results of crop diversification. Different types of indexes have been used to measure the extent of specialisation or diversification. It's worth noting that the diversity index here tracks the spread and concentration of crops across time. The diversification index indicates whether there have been any differences in general concentration or spread in the cropping pattern in the area of study. Higher concentration is projected to increase income variance, which could be damaging to the region's progress. The average of Herfindahl index, Simpson index, Entropy index, and Modified Entropy index values for the period 2001-2020 were 0.15, 0.85, 2.28, and 0.98, respectively. This clearly shows that agricultural diversification has occurred in the state over time.

Table 3: Crop Diversification Index

Year	HI	SI	EI	MEI
2001-02	0.16	0.84	2.26	0.98
2002-03	0.14	0.86	2.32	1.01
2003-04	0.12	0.88	2.38	1.04
2004-05	0.15	0.85	2.29	0.99
2005-06	0.16	0.84	2.25	0.98
2006-07	0.15	0.85	2.27	0.99
2007-08	0.14	0.86	2.30	1.00
2008-09	0.15	0.85	2.27	0.99
2009-10	0.15	0.85	2.27	0.98
2010-11	0.15	0.85	2.25	0.98
2011-12	0.15	0.85	2.27	0.98
2012-13	0.14	0.86	2.26	0.98
2013-14	0.14	0.86	2.32	1.01
2014-15	0.14	0.86	2.30	1.00
2015-16	0.16	0.84	2.24	0.97
2016-17	0.14	0.86	2.30	1.00
2017-18	0.15	0.85	2.26	0.98
2018-19	0.15	0.85	2.27	0.98
2019-20	0.15	0.85	2.26	0.98
Average	0.15	0.85	2.28	0.99

Note: *HI = Herfindahl Index, SI = Simpson Index, EI = Entropy Index, MEI = Modified Entropy Index.*

Source: *Author's calculation based on data from TN Seasonal and Crop Report (2010-2020).*

CONCLUSION

Non-agricultural land and fallow land have a positive trend, whereas net sown area has a negative trend, according to the report. Because of the current situation, cultivable land is being exploited for various uses. Major crops such as paddy, bajra, sugarcane, groundnut, and gingelly have grown at a negative rate over the years, whereas minor crops such as maize, pulses, fruits, vegetables, coconut, and cotton have grown positively. The percentage of food crops to total cropped land has been falling year after year, while the amount of non-food crops has been growing, according to the transitional probability matrices.

The transitional probability matrices revealed that percentage of food crops to total cropped land has been falling year after year, while the amount of non-food crops has been increasing. The agricultural diversification index value indicates that crop

intensification has increased in the state over time. In this juncture the diversification index has remained stable throughout the years, which will aid in reducing crop failure and income loss, as well as providing employment for rural people.Hence, the study recommends that appropriate steps be adopted, such as assuring a reasonable profit from the farm and providing special consideration to farmers who grow horticultural crops, which also give various ecosystem benefits to the societyby government.

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