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# Consequences of Agricultural Labour Scarcity on Cropping Pattern Dynamics in Tamil Nadu, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author RG, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author KRK designed and guided of the study. Authors AV and GaD authors read and approved the final manuscript Consent. All authors read and approved the final manuscript.*

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## ABSTRACT

Cropping Pattern is a complicated process that is influenced by a variety of socioeconomic, agro-climatic, and ecological factors. Even though India has the second-largest manpower in the world, all sectors of the economy have been affected by the scarcity of labour, the impact being felt more in the agricultural sector. The acute scarcity of agricultural labourers in the India has resulted in crop establishment delays, poor crop growth, no or late weeding, inappropriate fertilizer use, insufficient irrigation water, and other factors that have pushed Indian farmers to switching from farming to non-farm occupations. The present study was undertaken to analyze the dynamics of cropping patterns in the state, Tamil Nadu. Tiruchirappalli and Pudukkottai districts were selected purposively to represent the high and low crop diversity cropping system respectively. The study was based on both primary and secondary data for the period of 10 years from 2010-11 to 2019-20 to analyze the decadal change. Tabular Analysis, Compound Growth Rate and Markov chain

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analysis were used to analyze the data. The study results revealed that there are marginal changes in cropping pattern, increases towards the commercial crops such as sugarcane, tapioca, cotton and banana. The total fallow land share has increased continuously leaving a lesser area for cropping. The reported dynamics change the agricultural productivity and increased mechanization, which might be due to growth in the labour scarcity. The results showed that farmers were shifting from high labour intensive crops such as paddy, sugarcane, cotton to low labor-intensive crops such as groundnut, black gram over the years. Due to the higher requirement of laborers for cultivating crops, crop retention probability was lesser which means the crops have become less and less stable. It is therefore recommended that the district, state, and country's agricultural extension systems must be geared up to curbing the shifting farmers away from traditional farming practices and educate them on the use of available labor-saving equipment and technology.

*Keywords: Cropping pattern; agricultural labour scarcity; human labour; mechanization; productivity; markov chain analysis.*

## 1. INTRODUCTION

Indian economy is largely dependent on agriculture and even after 70 years of independence, the livelihood of the Indian farmer depends on the grace of the monsoon patterns. Seventy percent of the population is directly or indirectly engaged in agricultural activities in India while around 58 percent of the total employment in the country is through the agriculture sector. In India, the agricultural and allied sector contributes around 20 percent of the Gross Domestic Product (Ministry of Finance, Government of India, April, 2021). Moreover, the labour requirement for crops varies from one to one, and its changes throughout the year are based on the season and climatic factors. For example, the paddy needs more labour during sowing than other crops. Labour scarcity at any point of the crop stage may lead to a reduction in crop yield, reduction in cropping intensity, and changes in traditional cropping patterns. Labourers constitute a vital input to agricultural production, but they are migrating from one place to another, implementation of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) program during peak agricultural season [1] and urbanization are the two major problems that leads to a shortage of agricultural laborers [2]. Farm labour shortages are a major problem for farmers, who may not hesitate to abandon farming. The acute scarcity of agricultural labourers in the state has resulted in crop establishment delays, poor crop growth, no or late weeding, inappropriate fertilizer use, insufficient crop irrigation, and other factors that have pushed Indian farmers to transfer from farming to non-farm occupations. The scope of agricultural labour usage and the wage rate is theoretically linked to agricultural land and labour productivity. The returns to labour would increase in physical terms with the introduction of the labor-saving technology and increase in productivity, while the increase in labour productivity in economic terms would be dependent on the price of the output as well.

### 1.1 Agricultural Labour Scarcity in India

Agricultural labourers are those persons who work on the land of others on wages for the major part of the year and earn a major portion of their income as a payment in the form of wages for works performed on the agricultural farms owned by others. They are the most exploited unorganized class of the rural population of the country. Even though India has the second-largest manpower in the world, all sectors of the economy have been affected by the scarcity of labour, the impact being felt more in the agricultural sector. According to this, the following impacts have been predominantly noticed in agriculture in recent years; reduction in crop yield, reduction in cropping intensity, and changes in traditional cropping patterns. Though agricultural research has evolved many crop-specific such as, labour-saving implements and technologies and the problem has not been addressed fully. The proportion of agricultural workers to the total workforce has been declining over the year, while the corresponding ratio in the secondary and tertiary sector is on the increasing trend. While population density and rainfall have a favorable impact of reducing the extent of fallow lands, urbanization and land put to non-agricultural uses - both indicating a shift in land and labour from agriculture to non-agriculture - tend to increase the extent of total fallow lands. Labour scarcity is reported to be one of the major reason for fallowing of lands or resorting to less-labour intensive crops. Non-agricultural income of the farm households, size

of the holdings, labour availability, credit availability, and extent of irrigated area in the farm were found to be statistically significant in explaining the changes in the area under fallow lands across farms [3].

## 1.2 Consequences of Labour Scarcity

The Impact can be seen in terms of changing cropping pattern, reduction in crop yield and cropping intensity, higher wages and higher cost of cultivation which is reflected in higher output prices thereby causing food inflation. Concerning the impact of labour scarcity in agriculture, it is evident that there are changes in cropping pattern, increases in fallow land, change in agricultural productivity and measures like improved mechanization and labour-saving techniques were adopted to overcome prevailing conditions. Owing to the labour scarcity in agriculture, the cropping pattern has shifted to less labour intensive crops. The small farmers are found to be involved in the cultivation of labour-intensive crops (short duration) over the large farmers who prefer less labour-intensive crops owing to the lack of family labour. It has been emphasized that non–availability of labourers in the peak time has also resulted in the delay in carrying out the various operations and the reduction in agricultural productivity.

In Tamil Nadu, the nature of labour scarcity and its impact on agricultural labour productivity has not gotten the attention it deserves. Despite the increased demand for land, there is a propensity to leave land inactive owing to reasons such as labour scarcity, indicating that land management is not working. In this context we attempt to study how the cropping pattern has been changed over time due to labour scarcity and its consequence on crop productivity and other input use pattern besides suggesting policy options to sustain the crop production system.

## 2. MATERIALS AND METHODS

The present study is based on an analysis of primary and secondary data on cropped areas at the selected districts and in the state. The time-series data on crop area in districts of Tamil Nadu were obtained from various issues of Season and Crops Reports of Tamil Nadu published by the Government of Tamil Nadu, for the last decade (2010-11 to 2019-20). The inputs use and cost and return related data used in this paper are drawn from various Reports of The Commission for Agricultural Costs and Prices, for the Crops Sown During Various Years, Department of Agriculture and Co-operation, Ministry of Agriculture. The labour (man-days) requirement for each crop was calculated using Cost of Cultivation of Principal Crops where the labour hours were converted into man days per hectare. Based on the nature and extent of the data, Markov chain analysis was used to accomplish the study's dynamic changes in cropping pattern in high and low diversified cropping pattern for the state.

The Primary data comprises data collected from agricultural households in Tiruchirappalli and Pudukkottai districts (Fig. 1) during the year 2020-21, selected by applying multistage random sampling procedure. One taluk from each district and two villages from each taluk were selected for the study. The sample size was restricted to 80 farm sample and 40 agricultural labourers at the rate of 20 farmers and 10 agricultural labourers from each village. Based on the investigation with the farmers in the sample districts, about 65 per cent of the farmers were reporting prevalence of labour scarcity and dominance in influencing cropping pattern and crop productivity.

The different principal crops grown in the area were categorized into different groups based on their agronomical characters. The crop groups considered based on the agronomical characters were Cereals, Pulses, Spices & Condiments, Sugar Crops, Oilseeds, Fruits, Vegetables, Fiber crops, and other crops. The prevailing acute labour scarcity might have impacts on the cropping pattern of the state in the long run. It is therefore imperative to probe into the type of labour transition that has taken place or would take place in the future.

## 2.1 Tools of Analysis

### 2.1.1 Tabular analysis

In order to meet out the objective of the study, ratios, averages, Percentage, etc. for different parameters related to crops were extensively used.

### 2.1.2 Compound growth rate

The Compound Growth Rate (CGR) was used to measure the annual rate of growth of major crops grown in the study area is presented as $Y_t=ab_t$ . The Logarithmic form of the above equation is Ln Y=ln a + t ln b. The percent CGR is derived using the following formula.

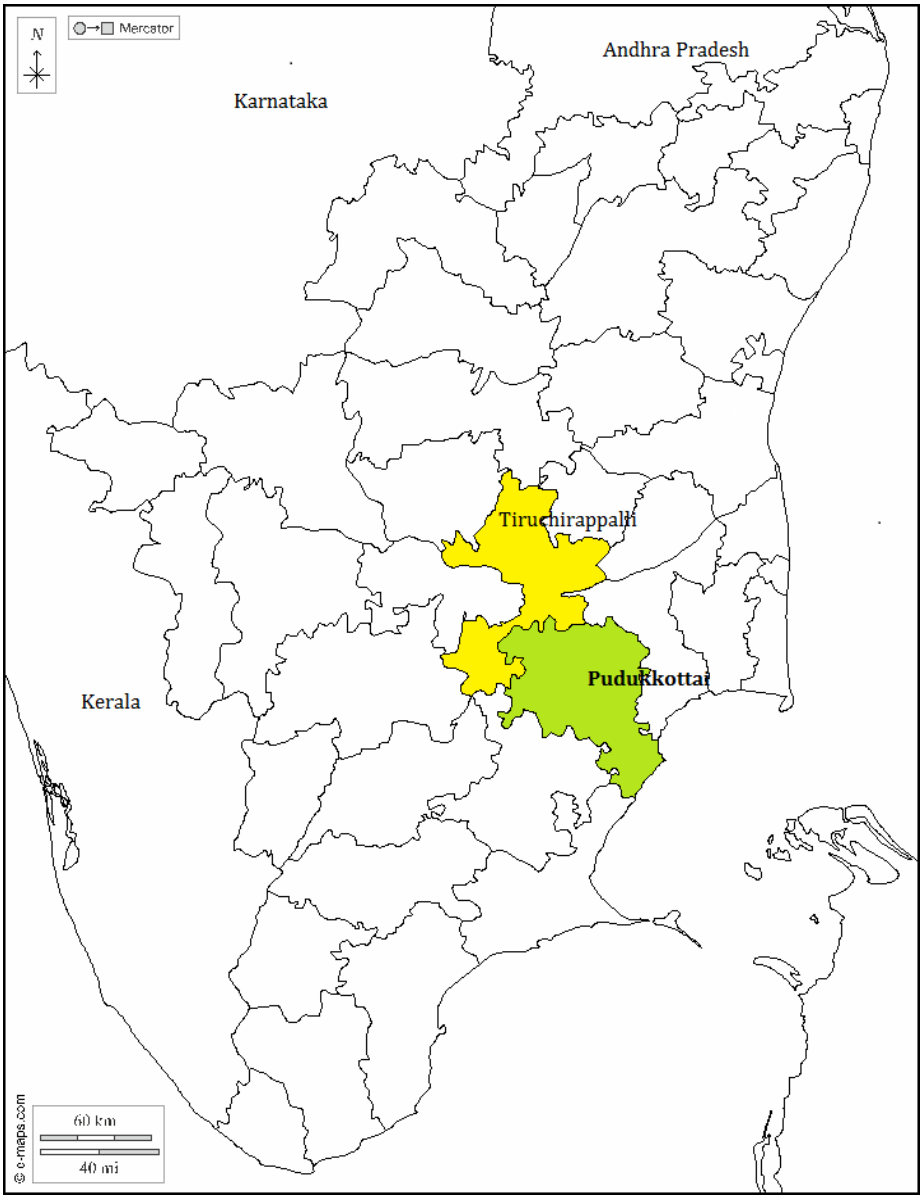


**Fig. 1. Map showing selected districts in Tamil Nadu**

**CGR(r) = [Antilog (b)-1] *100**

Whereas, $Y_t$ =Area under each crop; a = Intercept; b = Regression coefficient of t; t = Time variable; r = Compound Growth Rate.

### 2.1.3 The markov probability model

The Markov chain analysis is a dynamic programming technique used to solve a stochastic decision process with a finite number of states. A Markov Chain may be simply defined as a sequence of random values whose probability value at time t hinge on the value of a value of number in the time interval t-1. Central to this approach is to estimate the transitional probability matrix. A transition probability matrix is defined as a square array of non-negative numbers such that the rows total to unity. The element P of this matrix indicates the probability that cropped area will switch from crop i to crop j with the passage of time [4,5]. The Markov process was used to investigate shifts in crop share and acquire a better understanding of the dynamics of the changes. The statistics for the study are the percentages of areas cultivated

under various crops. It is anticipated that the proportions shift from year to year due to fluctuations in the proportion of labour supply. A stochastic process analyzes a set of trials or experiments probabilistically. For stochastic process, if N assumed that the movements (transitions) of objects from one division (possible outcome) to another are governed by a probability mechanism or system. A finite Markov process is a stochastic process whereby the outcome of a given trial t (1=1,2,.. T) depends only on the outcome of the preceding trial (t-1) and this dependence is the same at all stages in the sequence of trials. Consistence with this definition, let

S; represent the r district or possible outcomes; i 1,2….r.

Wit represents the probability that crop Si occurs on trial t or the proportion observed in trial t in alternative outcome crop i.e. of a multinomial population based on a sample of size n, i.e. Pr ($S_{it}$).

$P_{it}$ represents the transitional probability that denotes the probability that if for any time t the process is in state Si it moves on the next trial to division $S_j$ i.e. Pro ($S_{jt}$ + 1/$S_{jt}$) = $P_{ij.}$

P = ($P_{ij}$) represents the transitional probability matrix which denotes the transitional probability for every pair of the crop (i, j = 1,2 .... r) and has the following properties.

$$0 < P_{ij} < 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

and

$$\sum P = 1, \text{ for } i = 1,2....r \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Given this set of notations and definitions for a first-order Markov chain the probability of a particular sequence $S_i$ on trial t and $S_t$ on trial t+1 may be represented by Pr ($S_{it}$t $S_{it}$ + 1) = Pr

$$(S_{it})\ Pr\ (S_{it}\ t+1 / S_{it}) = W_{it}\ P_{jt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

and the probability of being in division j at trial t+1 may be represented by

$$Pr\ (S_j.\ t + 1) = \sum W_{it}\ P_{it} \text{ or } i$$
$$W_t\ t + 1 = \sum W_{it} P_{tj} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The data for the study are the proportions of the area under the crops. The proportion changes from year to year as a result of the factors like weather, technology, price, labour scarcity and institutional changes. It is reasonable to assume that the combined influence of these individually systematic forces approximates a stochastic process and the propensity of farmers to move from one crop state to another differs according to the crop state involved. If these assumptions are acceptable, then the process of cropping pattern change may be described in the form of a matrix 'P' of first-order transition probabilities. The element of '$P_{ij}$' of the matrix indicates the probability of a farmer in crop state 'i' in one period will move to crop state 'j' during the following period. The diagonal element '$P_{ij}$' measures the probability that the proportional share of $j^{th}$ category of the crop will be maintained.

## 3. RESULTS AND DISCUSSION

### 3.1 Level of Labour Scarcity

Among the total 80 sample farmers, 86 per cent of the large farmers reported the case of severe labour scarcity where it directly influences the decision of cropping pattern at farm level, whereas the 83 per cent of small farmers reported High level of labour scarcity (Table 1). Large farmers involved in the production of High Labour Intensive Crops (HLI) felt the labour shortage more, especially during the peak crop season. Small farmers who favored the production of Less Labour Intensive (LLI) and Medium Labour Intensive (MLI) crops were able to manage the labour demand using family labour. The small farmers, who were involved in the cultivation of HLI crops, also reported the problem of labour scarcity.

**Table 1. Level of labour scarcity among farmers in Pudukkottai and Tiruchirappalli districts**

| S. No. | Category | Severe (< 80%) | High (60-80%) | Moderate (40-60 %) | Low (> 40 %) |
|---|---|---|---|---|---|
| 1. | Marginal Farmers | - | - | 24 (80) | 6 (20) |
| 2. | Small Farmers | - | 30 (83) | 6(17) | - |
| 3. | Large Farmers | 12 (86) | 2 (14) | - | - |
| | Total Farmers | 12 (15) | 32 (40) | 30 (37.50) | 6 (7.50) |

The major reasons as opined by the sample farmers for the labour scarcity existing in the study area were as follows, Existence of MGNREGA, shift to a regular/ permanent job since agricultural job is seasonal, Migration to nearby cities for higher wages and Migration due to improvement in educational status. Due to labour scarcity, farmers were pushed to carry out the delayed agricultural operations thus results in reduction in yield and net returns.

### 3.2 Changes in Area under Fallows

The implications of labour scarcity are left unattended may discourage farmers who leave their land fallow [6,7] and shift to non-agricultural avenues for livelihood. In Tamil Nadu, the Gross Cropped Area (GCA) dropped down to the lowest levels in 2016-17 coupled with the highest ever stand in total fallows reason being attributed to the influence of Disastrous Drought, Cauvery River Issue and Lesser Rainfall ever in 140 years (Fig. 2), Fallow lands other than current fallow exhibit gradually increasing trend while current fallows revealed instability due to labour scarcity, unpredictable natural factors manifested highly unstable trend in the gross cropped area poses a serious threat to food security in Tamil Nadu.

In Pudukkottai district, the inverse relationship between total fallow land and the gross cropped area is mainly attributed to less diversified crops and increasing labour scarcity. The total fallow land discloses a comparatively stable but decreasing pattern of GCA in Tiruchirappalli district (Figs. 3 & 4), and over time, the former demonstrates comparatively elevated levels of fallow lands other than current fallow that too with a declining trend in GCA pose a serious threat to the state agriculture in general and the food security in particular.

### 3.3 Level of Farm Mechanization

Mechanization is a cost-cutting technology besides to overcome the increasing labour scarcity particularly for agriculture. [8]. Mechanization (major operations like primary and secondary tillage) and shifting towards alternative crops having less labour-requirement were opined as major strategies adopted by the farmer to mitigate labour scarcity [9]. There are different kinds of implications associated with agricultural labour scarcity such as delay in crop establishment, no or untimely weeding, irrational use of fertilizers, insufficient irrigation to crops, poor crop growth etc. Non-timely operation of activities in the farm led by labour scarcity during important stages of the crop resulting in inefficiency at field level as expressed by most of the farmers. An acute labour-scarcity in agricultural works, might affecting consequently the productivity levels of almost all the crops grown in the state. The combined efforts of the State research system and state agricultural extension system have enhanced the crop productivity in most of the crops except marginally decrease in crop such as cotton and coconut (Table 2).

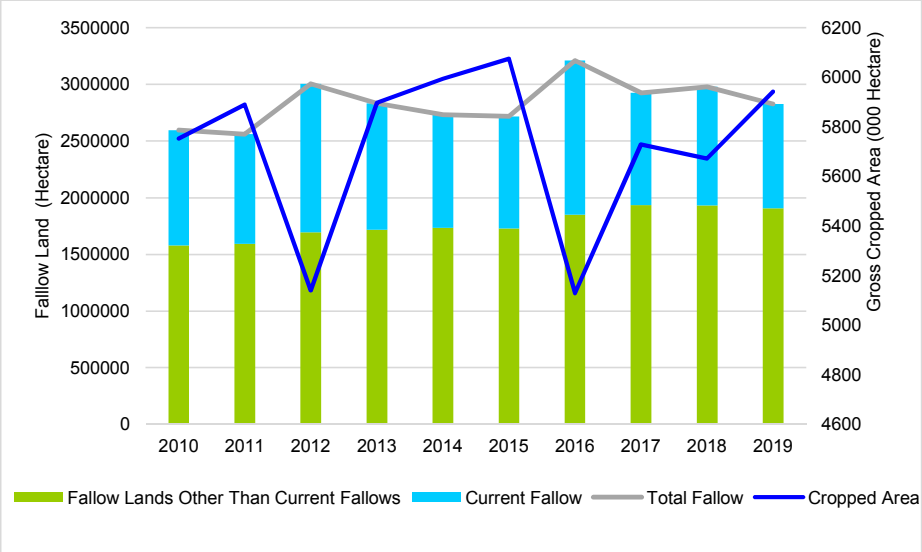


**Fig. 2. Trend of fallow land in Tamil Nadu during 2010 to 2019**

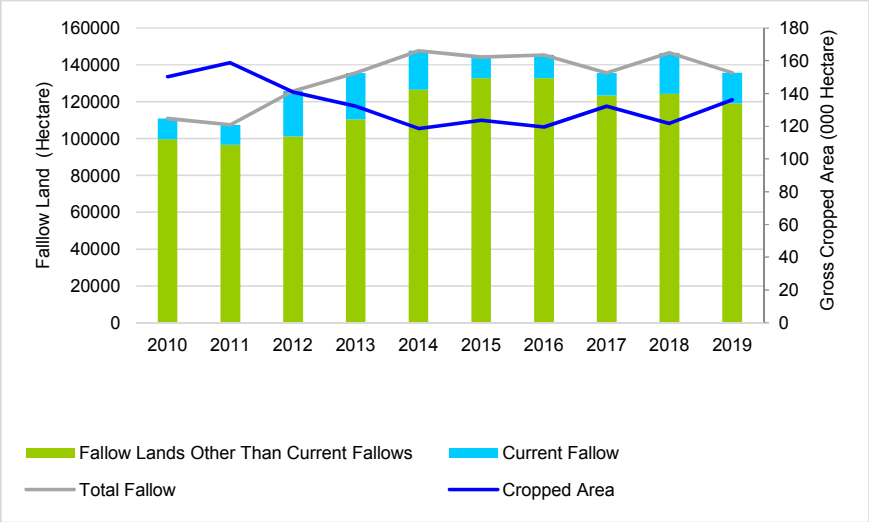


**Fig. 3. Trend of fallow land in Pudukkottai during 2010 to 2019**

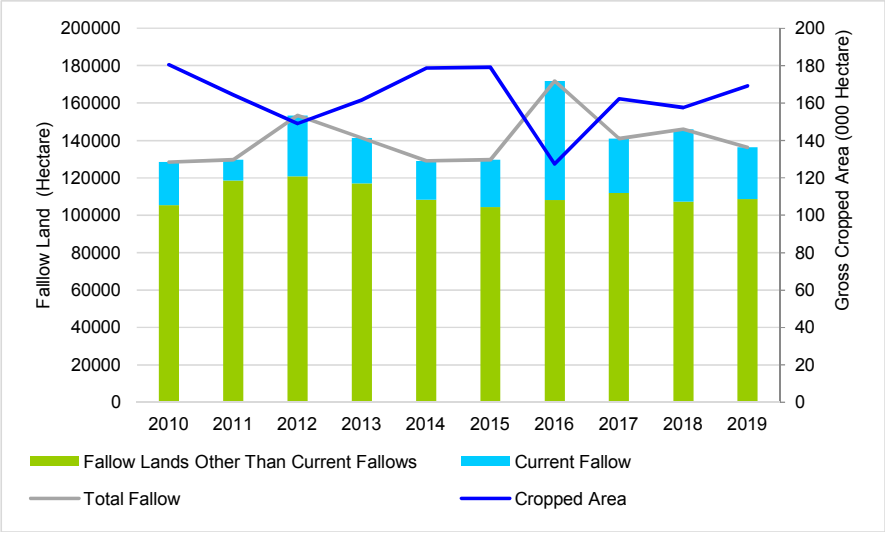


**Fig. 4. Trend of fallow land in Tiruchirappalli during 2010 to 2019**

**Table 2. Productivity of major crops during 2009 & 2017**

| S. No. | Crop | Productivity (Kg/Ha.) | | % Change in productivity |
|---|---|---|---|---|
| | | 2009 | 2017 | |
| 1. | Paddy | 3070 | 3630 | 18.24 |
| 2. | Maize | 4661 | 7986 | 71.34 |
| 3. | Jowar | 931 | 1117 | 19.98 |
| 4. | Black Gram | 380 | 410 | 7.89 |
| 5. | Cotton | 368 | 312 | -15.22 |
| 6. | Sugarcane* | 101 | 100 | -0.99 |
| 7. | Groundnut | 2169 | 3078 | 41.91 |
| 8. | Sesame | 463 | 555 | 19.87 |
| 9. | Coconut # | 14796 | 13637 | -7.83 |

** tonnes/Hectare; #Nuts/Hectare*

*Source: Various issues of Season and crop report, DES, Chennai*

The consistent prevalence of labour scarcity led to substitution of mechanization of many crops. The plot level cost of cultivation data from Directorate of Economics and Statistics, were used to analyze the farm power usage *viz.,* Animal labour, Machine labour and Human labour usage in major crops. The results are presented in Fig. 5. The level of mechanization have been higher in case of Paddy, maize, cotton, coconut and Sugarcane, where the Human labour hours share is declined over years particularly in paddy, Sugarcane, cotton which may be due to substituting with machine power. As most of the agricultural operations like tillage, inter-culture, harvesting were done through machinery in Tamil Nadu.[10]. Jowar and sesame were less mechanized where the human labour hours are almost the same as in past years.

### 3.4 Changes in Cropping Pattern

The cropping pattern in Tamil Nadu has undergone a significant shift from seasonal food crops to commercial crops during the last decade. Changes in cropping patterns, from seasonal farm crops to commercial crops, have significant consequences for labour demand. The seasonal agricultural crops create peak labour demand during sowing/planting and harvesting seasons. In the intervening period also labour is required for crop maintenance of the crops. The demand for labour was thus high but seasonal. Commercial crops, on the other hand, only create a demand for labour during the first few years. Under the new commercial crop production pattern, the labour displaced by the reduction in the area of seasonal crops may not be properly used. As Paddy is the most leading crop in Tamil Nadu, but the proportion of area has dropped to 32 % in 2019-20 from 34 % in 2010-11 (Figs. 6 & 7). Paddy holds the major share in Pudukkottai district i.e. 61 % in 2010 and 65 % per cent in 2019 and it can be classified under monocropping system. In Tiruchirappalli district, the paddy has been replaced by other major cereals like Jowar and Maize (Figs. 10 & 11).

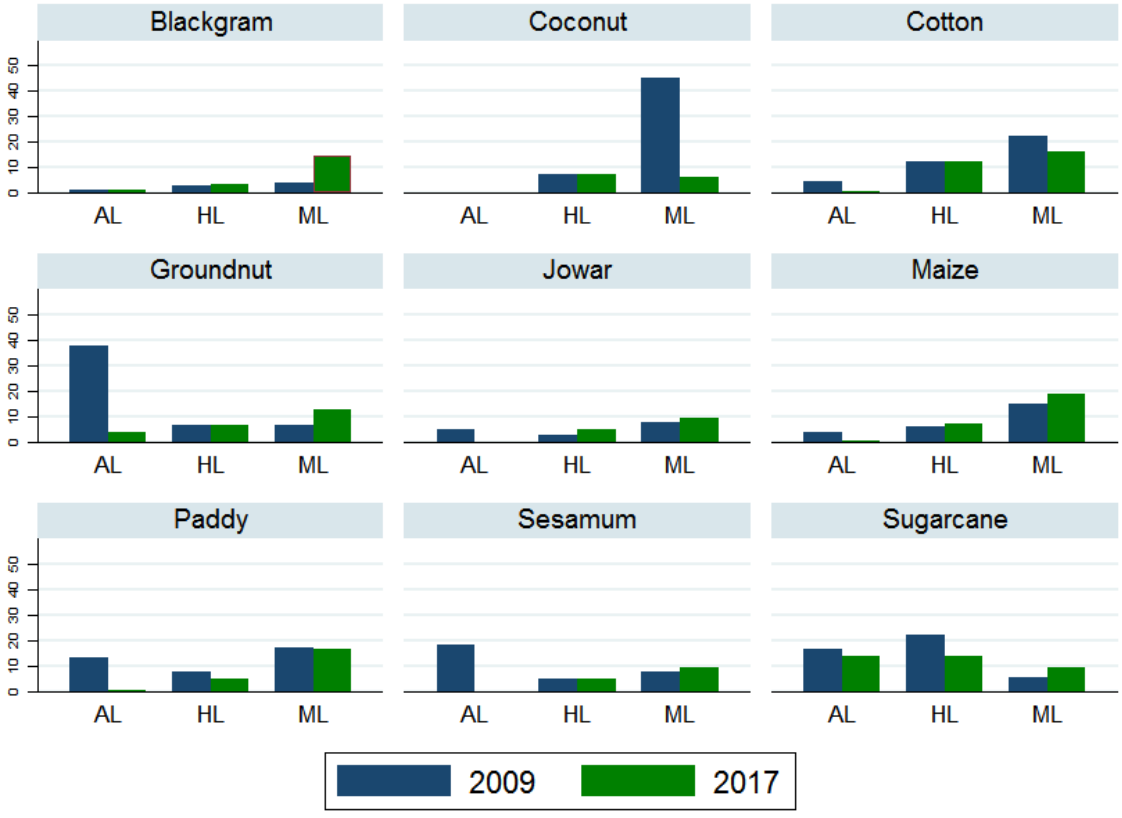


**Fig. 5. Decadal changes in farm power usage in major crops of Tamil Nadu during 2009 & 2017**
*(AL-Animal Labour & ML – Machine Labour (Hrs/ha); HL-Human Labour('00 Hrs))*

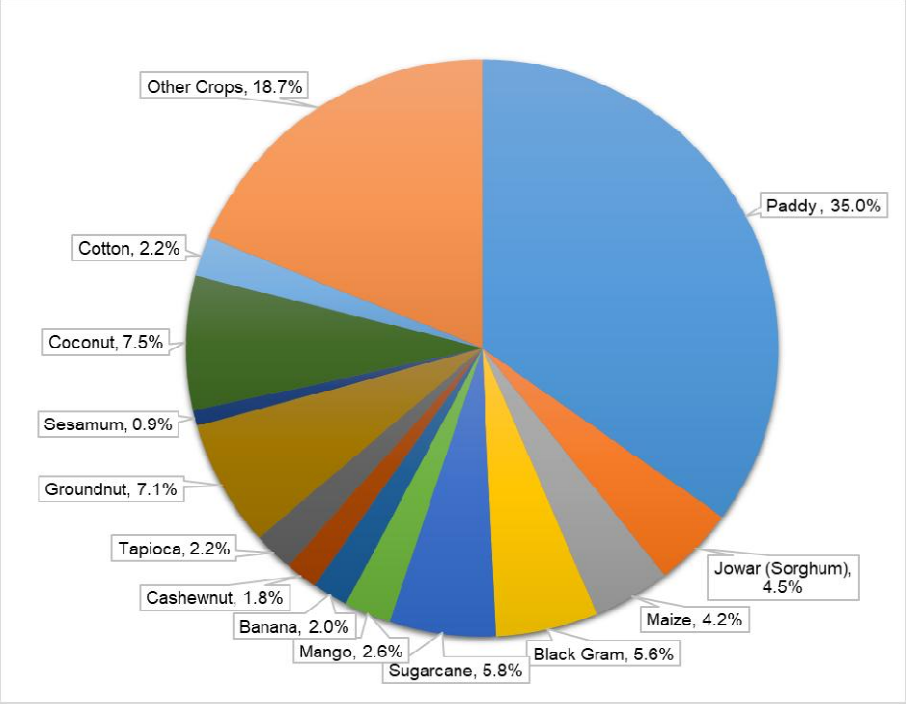


**Fig. 6. Share of major crop area in Tamil Nadu during 2010**

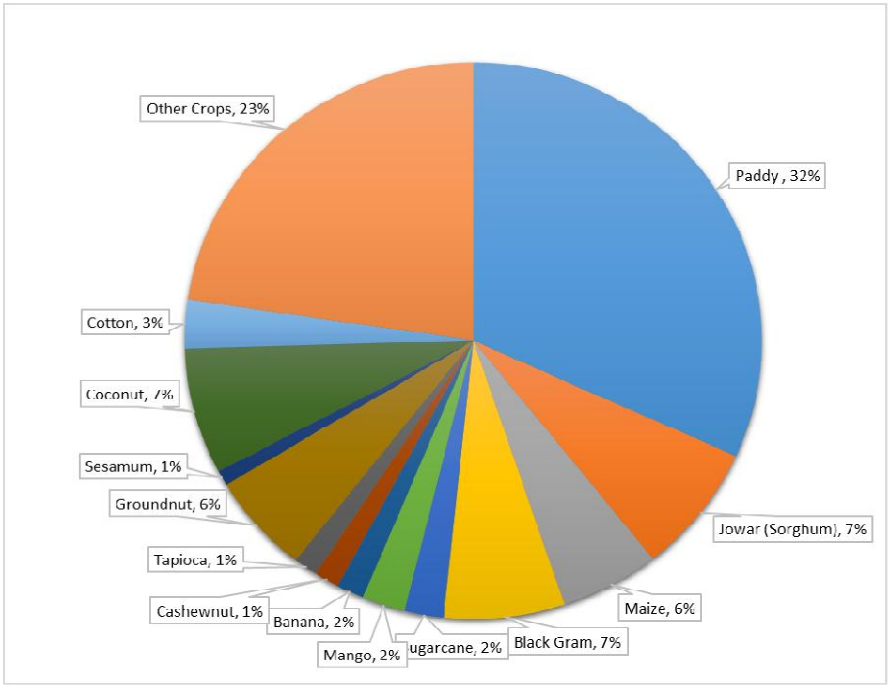


**Fig. 7. Share of major crop area in Tamil Nadu during 2019**

For example, taking monocropping system of paddy, one of the labour-intensive crops, the prevailing labour shortage urges farmers to use of machineries. By making use of machinery, the cost of cultivation is getting increased, which tends the farmers to leave the land as fallow.

This will considerably reduce the Gross Cropped Area. The Monocropping system has negative impact on gross cropped area, where Pudukkottai district is having higher negative growth, while Tiruchirappalli district has lesser impact due to higher crop diversity followed in the district. The Multi-cropping system has a positive influence in increasing the crop area (Fig. 12).

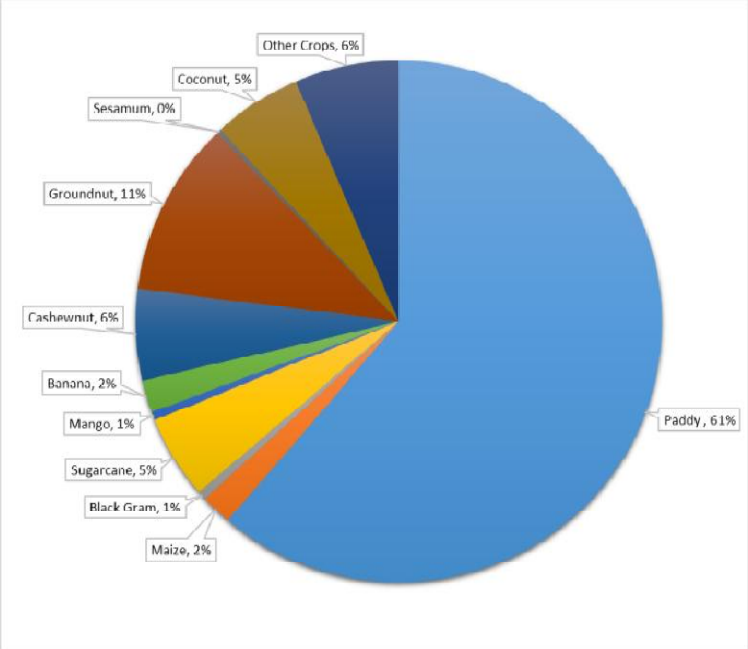


**Fig. 8. Share of major crop Area in Pudukkottai during 2010**

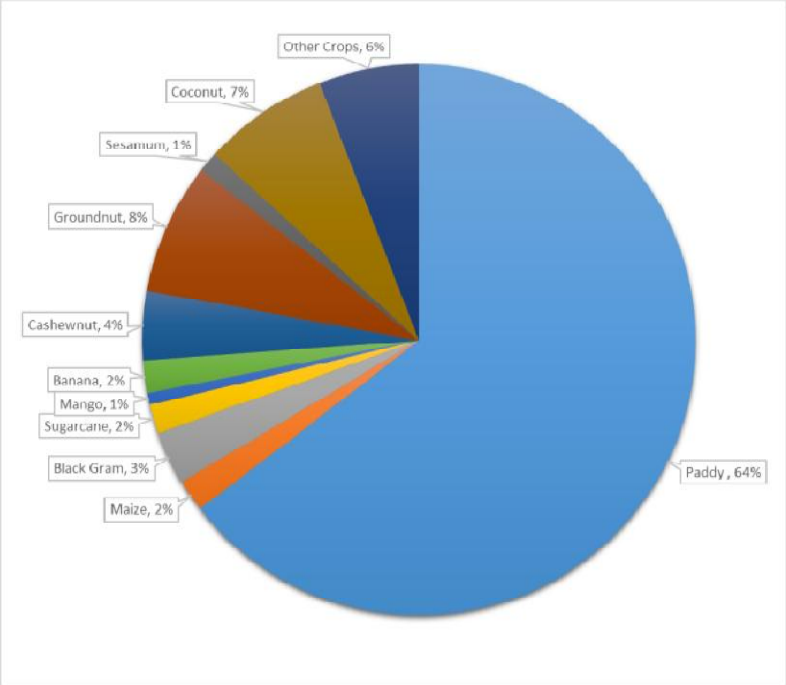


**Fig. 9. Share of major crop area in Pudukkottai during 2019**

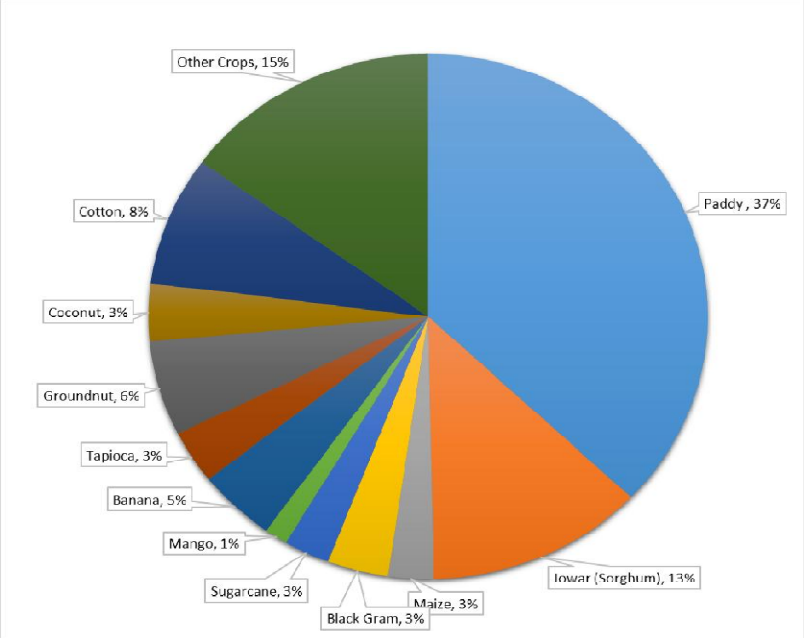


**Fig. 10. Share of major crop area in Tiruchirappalli during 2010**

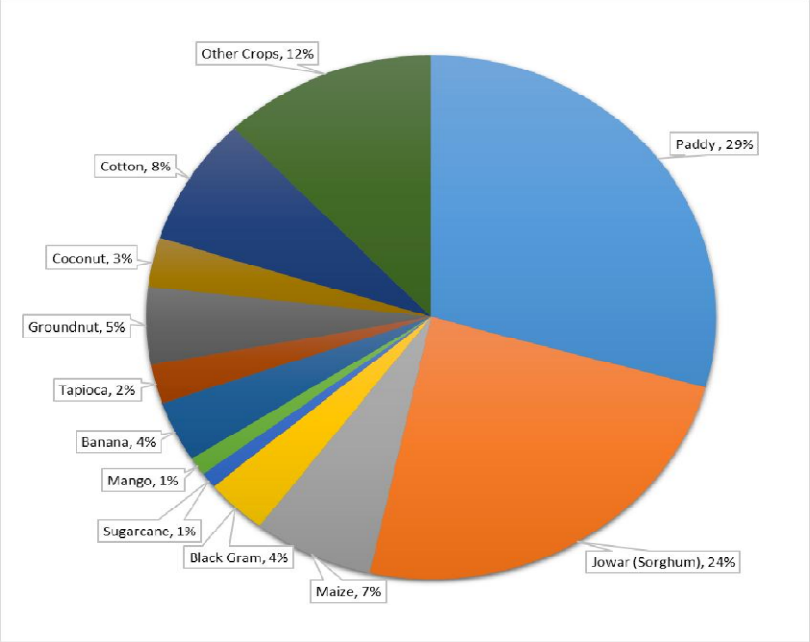


**Fig. 11. Share of major crop area in Tiruchirappalli during 2019**

### 3.5 Transition of Area under Major Crop

The change in cropping pattern was studied by estimating the transitional probability matrix using the Markov chain framework. Transitional probabilities are presented in Table 3, which depicts a broader idea of change in the cropping pattern over 10 years from 2010-11 to 2019-20. As the diagonal elements approach zero, the crops become less and less stable and as they approach one, they become more and more stable over some time. There were eight major crop groups based on agronomical categorization. The diagonal elements in a

transitional probability matrix provide the information on the probability of retention of the area under crop, while the row elements indicate the probability of loss in the area of a particular crop on account of competing crops. The column elements indicate the probability of gain in the area from another competing crop group. It is evident from the table that sugar crops have been the most stable crop among the major crop groups as reflected by the higher probability of retention of 0.88 i.e., the probability with which pulses had retained their area share is 88 percent over the study period. Thus, the sugar crop was the most reliable and loyal crop group in Tamil Nadu, as the state ranks top in productivity. Cereals have shown probability retention of 0.27 which has retained its share of 27 percent. Pulses have shown the retention probability of 0.17 which has retained 17 percent of its share in the area.

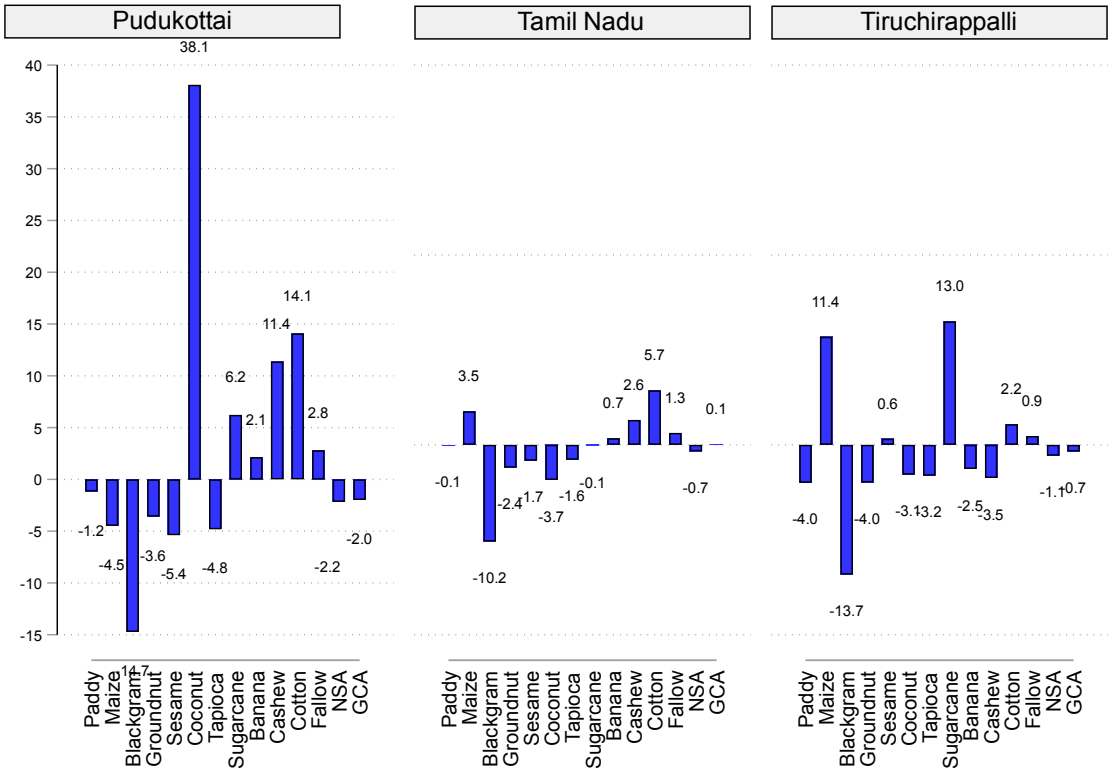


**Fig. 12. Compound growth rate for Pudukkottai, Tamil Nadu and Tiruchirappalli**
*(NSA – Net Sown Area; Fallow – Total Fallow Land; GCA: Gross cropped area)*

**Table 3. Transition probability matrix of major crop groups in Tamil Nadu during the period of 2010-11 to 2019-20**

| Crop | Cereals | Pulses | Spices & Condiments | Sugar Crops | Fruits | Vegetables | Fiber crops | Oil Seeds | Other Crops |
|---|---|---|---|---|---|---|---|---|---|
| Cereals | **0.279** | 0.226 | 0.019 | 0.006 | 0.098 | 0.071 | 0.050 | 0.228 | 0.023 |
| Pulses | 0.830 | **0.170** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Spices & Condiments | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | 0.000 |
| Sugar Crops | 0.000 | 0.019 | 0.015 | **0.887** | 0.000 | 0.000 | 0.005 | 0.073 | 0.000 |
| Fruits | 0.942 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 | 0.058 | 0.000 | 0.000 |
| Vegetables | 0.000 | 0.000 | 0.132 | 0.000 | 0.299 | **0.116** | 0.000 | 0.453 | 0.000 |
| Fibre | 0.434 | 0.566 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 |
| Oil Seeds | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 |
| Other Crops | 0.000 | 0.000 | 0.096 | 0.000 | 0.134 | 0.000 | 0.000 | 0.000 | **0.769** |

**Table 4. Transition probability matrix of major crops in Pudukkottai district during the Period of 2010-11 to 2019-20**

| Crop | Paddy | Maize | Black Gram | Sugarcane | Banana | Cashewnut | Groundnut | Sesamum | Coconut | Other Crops |
|---|---|---|---|---|---|---|---|---|---|---|
| Paddy | **0.744** | 0.000 | 0.000 | 0.000 | 0.031 | 0.059 | 0.084 | 0.012 | 0.057 | 0.013 |
| Maize | 0.000 | **0.211** | 0.140 | 0.000 | 0.000 | 0.003 | 0.000 | 0.000 | 0.266 | 0.380 |
| Black Gram | 0.170 | 0.000 | **0.055** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.357 | 0.418 |
| Sugarcane | 0.000 | 0.000 | 0.000 | **0.391** | 0.000 | 0.272 | 0.000 | 0.000 | 0.000 | 0.337 |
| Banana | 1.000 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Cashewnut | 0.000 | 0.282 | 0.000 | 0.185 | 0.000 | **0.038** | 0.000 | 0.000 | 0.000 | 0.495 |
| Groundnut | 0.462 | 0.000 | 0.000 | 0.191 | 0.000 | 0.000 | **0.347** | 0.000 | 0.000 | 0.000 |
| Sesame | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 |
| Coconut | 0.372 | 0.000 | 0.360 | 0.000 | 0.000 | 0.000 | 0.000 | 0.030 | **0.238** | 0.000 |
| Other Crops | 0.877 | 0.123 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** |

**Table 5 Transition probability matrix of major crops in Tiruchirappalli district during the Period of 2010-11 to 2019-20**

| Crop | Paddy | Jowar | Maize | Black Gram | Banana | Tapioca | Groundnut | Coconut | Cotton | Other Crops |
|---|---|---|---|---|---|---|---|---|---|---|
| Paddy | **0.411** | 0.000 | 0.000 | 0.000 | 0.095 | 0.013 | 0.000 | 0.044 | 0.070 | 0.367 |
| Jowar | 0.166 | **0.518** | 0.184 | 0.115 | 0.000 | 0.000 | 0.017 | 0.000 | 0.000 | 0.000 |
| Maize | 0.000 | 0.980 | **0.020** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Black Gram | 0.759 | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.241 |
| Banana | 0.627 | 0.000 | 0.000 | 0.000 | **0.058** | 0.000 | 0.000 | 0.085 | 0.230 | 0.000 |
| Tapioca | 0.734 | 0.266 | 0.000 | 0.000 | 0.000 | **0.000** | 0.000 | 0.000 | 0.000 | 0.000 |
| Groundnut | 0.000 | 0.319 | 0.212 | 0.000 | 0.180 | 0.164 | **0.000** | 0.124 | 0.000 | 0.000 |
| Coconut | 0.000 | 0.106 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | **0.000** | 0.894 | 0.000 |
| Cotton | 0.000 | 0.019 | 0.271 | 0.158 | 0.014 | 0.024 | 0.000 | 0.071 | **0.241** | 0.201 |
| Other Crops | 0.417 | 0.000 | 0.000 | 0.000 | 0.000 | 0.085 | 0.288 | 0.036 | 0.000 | **0.174** |

It can be further seen from the table that pulses have lost 83 percent of their area to cereals, whereas it has gained 22 percent area from the cereals. Further to analyze the shift in the area of crops concerning the labour scarcity the shift in the area of the major crops categorized into different groups was analyzed using Markov chain analysis.

In Pudukkottai district, Paddy has retained 74 percent of its previous year's share of the area and it gained around 3 percent and 8 percent from Banana, Groundnut respectively (Table 4). Paddy holds the highest retention share among the major crop area in Pudukkottai district, as the mechanization impact has been higher in case of paddy where the labour days have been decreased over the years (Fig. 5). Sugarcane has retained about only 39 percent of its area as its High-Labour Intensive crop and lost its area by 27 and 33 percent to Cashewnut and Other crops.

The transitional and retention probability of cropped area for Tiruchirappalli in Table 5, the paddy has retained around 41 percent of its previous share of the area and it gained about 75 percent, 62 percent, and 73 percent of the area from Black Gram, Banana, and Tapioca respectively. Jowar has gained 98 percent area from maize and retained 51 percent of its previous year area. Cotton has reserved only about 24 percent and lost 89 percent of its area to Coconut where cotton is having more labour day requirements.

## 4. CONCLUSION

The study has revealed that labour scarcity has been enhancing the mechanization in paddy, sugarcane, maize and black gram which further improves productivity by making efficient use of resources particularly in multi-cropping system. It is also note that in low cropping diversity region. The caution has to be taken to retain the food production system, where an increasing trend in perennial crops like cashew and coconut is reported in less crop diversified region. If this trend continues, the cropping pattern of the districts may even get a shift towards tree crops like cashew and coconut, which are comparatively less labour-intensive. While increase in the area under commercial crops like coconut helped to increase farm income, changes in cropping-pattern in favor of perennial crops have an immediate and direct impact on the employment pattern in the rural area. That leads to the shrinkage of paddy cultivation and other seasonal crops has displaced agricultural labour from farm sector. The issue of increasing agricultural labour scarcity in crop production is mainly due to rapidly growing economy and blooming construction sector. The study suggests to address the issue by the district, state, and country's agricultural extension systems must be geared up to shifting farmers away from traditional farming practices and educate them on the use of available labour-saving equipment and technologies, particularly by using labor-saving technology/implements using a community-based strategy.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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