CHAPTER IV

OBJECTIVES AND METHODOLOGY

Instability in food production has remained subject of intense debate in the agricultural economics literature in India. Instability in production raises the risk involved in farm production and affects farmers’ income and decisions to adopt high paying technologies and make investments in farming. It not only affects farmers, it also affects price stability and the consumers, and it increases vulnerability of low income households to market. In this context the present study assumes growth and instability of foodgrain production in Tamil Nadu. This study also exhibits the inter-district analysis of the foodgrains production in Tamil Nadu.

The previous chapter provides the review of past studies related to growth, instability and decomposition analysis related to agriculture production. Based on the review, objectives were formulated and suitable methodologies were selected and are presented in this chapter.

4.1 Objectives

The main objectives of this study are as follows:

1. To estimate the rate of growth in foodgrains production, area and yield in Tamil Nadu,

2. To examine the instability in foodgrains production, area and yield in Tamil Nadu,

3. To know the sources of instability in production of foodgrains in Tamil Nadu,

4. To measure the relative contribution of area, yield and their interaction to production of foodgrains in Tamil Nadu; and

5. To suggest some policy measures to overcome the problems faced in the agriculture sector.

4.2 Methodology

The methodology used in the study is discussed in the following sections of this chapter. It includes period of study, sources of data and analytical techniques used in this study.
4.2.1 Period of Study

The study utilizes time series data with respect to area, production and yield of major foodgrains cultivated in the state of Tamil Nadu viz., Paddy, Cholam, Cumbu, Ragi and Maize from the year 1979-80 to 2010-11. The entire study period is divided into two periods. Period I is Pre-reform period related to 1979-80 to 1990-91. Period II is Post-reform period related to 1991-92 to 2010-11.

4.2.2 Sources of Data

The present analysis was based on secondary source data relating to the area, production and yield of major foodgrains cultivated in Tamil Nadu. The data was obtained from various Season and Crop Reports published by the Department of Economics and Statistics, Chennai.

District wise data were used to study the growth, instability and sources of instability in foodgrains production in Tamil Nadu. According to the Season and Crop Report - 1979-80, there were 15 districts in Tamil Nadu. Presently the state is demarcated into 32 districts including so many new born districts. Comparable data were not available for the period of all the 32 years particularly for newly formed districts as these were created in different years during the study period. To make the comparison feasible, the new born districts were merged with the parent districts to form 15 original districts. The details of these districts are given in Appendix I.

The secondary data compiled from the various season and crop reports were formatted by using electronic spreadsheets (MS-Excel 2007). SPSS-15 (Statistical Package for Social Sciences) software was used for the data analysis.

4.2.3 Analytical Techniques

Simple statistics like mean and percentage were calculated and presented in the next chapter. Apart from these the collected data were systematically analyzed through the following techniques.
4.2.4 Compound Growth Rate

To study the growth pattern of area, production and yield of major foodgrains in Tamil Nadu for the period 1979-80 to 2010-11, the following semi log transformation model was used:

\[ y = \beta_0 (1 + g)^t e^u \]  

... (4.1)

Where,

\( y \) = Area (or) Production (or) Yield of foodgrains in Tamil Nadu,
\( t \) = Time period (years)
\( \beta_0 \) = a parameter,
\( g \) = a parameter that is the compound rate of the growth of \( y \)
\( u \) = the disturbance term

If we now take the logs of both sides of (4.1), we have

\[ \log y = \log \beta_0 + t \log (1+g) + u \]

If we let

\( y^* = \log y \)
\( \beta_0^* = \log \beta_0 \)
\( \beta_1^* = \log (1+g) \)

we obtain

\[ y^* = \beta_0^* + \beta_1^* t + u_t \]

This tells us that a compound rate of growth implies a linear relationship, not between \( y \) and \( t \), but rather between \( \log y \) and \( t \).

\[ \text{CGR} = [\text{Antilog } \beta_1^* - 1] \times 100 \]

4.2.5 Instability

To measure the instability in area, yield and production of foodgrains in Tamil Nadu, the coefficient of variations (CV) was worked out.

\[ \text{CV which is defined as } CV = \frac{SD}{AM} \times 100 \]

\( SD \) = Standard Deviation
\( AM \) = Arithmetic Mean
4.2.6 Decomposition Model

Foodgrains production in Tamil Nadu witnessed commendable changes in terms production, area and yield. In order to find out the sources of growth and variability in foodgrains production in Tamil Nadu, Hazell’s decomposition model was employed. A fairly long period of 32 years was taken to measure the sources of change in the variance of foodgrains production. Here an attempt is made to break down the growth of foodgrains production during 1991-92 to 2010-11 over the period of 1979-80 to 1990-91.

The procedure followed to compute the extent of variability and its decomposition into different components has been described below. Hazell (1982) suggested the linearly detrended data for his entire decomposition analysis. Because the long-term trend in each variable needs to be remove in order to separate it from the short-term stochastic variation. The area and yield data for major foodgrains in Tamil Nadu were detrended using linear relations of the form

\[ Z_t = a + b_t + e_t \] \hspace{1cm} \ldots (4.2)

Where \( Z_t \) denotes the dependent variable (area or yield), \( t \) is time and \( e_t \) is a random residual with zero mean and variance \( \sigma^2 \). Separate regressions are run for each of the two time periods to ensure that \( \sum_t e_t = 0 \) for each period. Linear relations are used here because they do not assume a deterministic part to any relation between the variance of \( Z \) and time \( t \).

After detrending the residuals are centered on the mean areas or yields for each period, \( \bar{Z} \), resulting in detrended time-series data of the form

\[ \bar{Z} = e_t + \bar{Z} \] \hspace{1cm} \ldots (4.3)

These detrended data are used as the basic data for decomposition of changes in average production and changes in variance of foodgrains production.

Hazell decomposed the sources of change in mean production and change in production variance into four and ten components. The Hazell’s decomposition procedure is given below.
Let $P$ denote production, $A$ denote the area sown under a particular crop and $Y$ is the yield per hectare. Then for each crop total output in the state is $P = A \times Y$. The variance of production, $V(P)$ can be expressed as

$$V(P) = \overline{A}^2 V(Y) + \overline{Y}^2 V(A) + 2 \overline{A} \overline{Y} \text{cov}(A, Y) - \text{cov}(A, Y)^2 + R \ldots (4.4)$$

Where $\overline{A}$ and $\overline{Y}$ denote mean area and mean yield respectively. $R$ denote the residual term which is expected to be small. Clearly, a change in any one of these components will lead to a change in $V(P)$ between two periods in time. Similarly, average production, $E(P)$ can be expressed as:

$$E(P) = \overline{A} \overline{Y} + \text{cov}(AY) \quad \ldots (4.5)$$

It is affected by changes in the covariance between area and yield and by changes in mean area and mean yield. The objective of the decomposition analysis is to partition the changes in $V(P)$ and $E(P)$ between the first and the second periods into constituent parts, which can be attributed separately to changes in the means, variances and covariances of area and yield.

**4.2.6.1 Method of Decomposition of Average Production**

Using Eq. (4.5), average production in the first period is

$$E(P_1) = \overline{A}_1 \overline{Y}_1 + \text{cov}(A_1Y_1) \quad \ldots (4.6)$$

and in the second period is

$$E(P_2) = \overline{A}_2 \overline{Y}_2 + \text{cov}(A_2Y_2) \quad \ldots (4.7)$$

Each variable in the second period can be expressed as its counterpart in the first period plus the change in the variable between the two periods. For example,

$$\overline{A}_2 = \overline{A}_1 + \Delta \overline{A}$$

$$\overline{Y}_2 = \overline{Y}_1 + \Delta \overline{Y}$$

$$\text{Cov}(A_2, Y_2) = \text{Cov}(A_1, Y_1) + \Delta \text{Cov}(A_1, Y_1)$$
Eq. (4.7) can, therefore be rewritten as:

\[ E(P_2) = (\overline{A}_1 + \Delta \overline{A})(\overline{Y}_1 + \Delta \overline{Y}) + \text{cov}(A_iY_1) + \Delta \text{cov}(A,Y) \]

\[ = \overline{A}_1 \overline{Y}_1 + \overline{A}_1 \Delta \overline{Y} + \overline{Y}_1 \Delta \overline{A} + \Delta \overline{A} \Delta \overline{Y} + \text{cov}(A_iY_1) + \Delta \text{cov}(A,Y) \] \hspace{1cm} \cdots \hspace{1cm} \text{(4.8)}

The change in average production, \( \Delta E(P) \) is then obtained by subtracting Eq. (4.6) from Eq. (4.8). Thus,

\[ \Delta E(P) = E(P_2) - E(P_1) \]

\[ = \overline{A}_1 \Delta \overline{Y} + \overline{Y}_1 \Delta \overline{A} + \Delta \overline{A} \Delta \overline{Y} + \Delta \text{cov}(A,Y) \] \hspace{1cm} \cdots \hspace{1cm} \text{(4.9)}

Hence there are four sources of change in average production resulted from this equation (4.9) which can be arranged as in Table 4.1. The first two terms, change in the mean yield and change in mean area are called as ‘pure effects’ which arise even if there were no other source of change. The third term is an interaction effect, which arise from the simultaneous occurrence of changes in mean yield and mean area. The fourth term in the equation represents interaction between area and yield covariance.

**Table 4.1: Components of Change in Average Production**

<table>
<thead>
<tr>
<th>Sources of Change</th>
<th>Symbol</th>
<th>Components of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in mean yield</td>
<td>( \Delta \overline{Y} )</td>
<td>( \overline{A}_1 \Delta \overline{Y} )</td>
</tr>
<tr>
<td>Change in mean area</td>
<td>( \Delta \overline{A} )</td>
<td>( \overline{Y}_1 \Delta \overline{A} )</td>
</tr>
<tr>
<td>Interaction between changes in mean yield and mean area</td>
<td>( \Delta \overline{A} \Delta \overline{Y} )</td>
<td>( \Delta \overline{A} \Delta \overline{Y} )</td>
</tr>
<tr>
<td>Change in area–yield covariance</td>
<td>( \Delta \text{cov}(AY) )</td>
<td>( \Delta \text{cov}(AY) )</td>
</tr>
</tbody>
</table>

**4.2.6.2 Methods of Decomposition of the Changes in Variance of Production**

In this section, we will construct a method to partition the changes in variance of production (\( V(P) \)) between the first and the second periods into its constituent parts.

As shown in Eq. (4.4), the variance of production, \( V(P) \) can be expressed as,

\[ V(AY) = \overline{A}^2 V(Y) + \overline{Y}^2 V(A) + 2 \overline{A} \overline{Y} \text{cov}(A,Y) - \text{cov}(A,Y)^2 + R \]
Using Eq. (4.4), variance of production in the first period is

\[ V(P_1) = \overline{A}_1^2 V(Y_1) + \overline{Y}_1^2 V(A_1) + 2\overline{A}_1\overline{Y}_1 \text{cov}(A_1, Y_1) - \text{cov}(A_1, Y_1)^2 + R_1 \ldots (4.10) \]

and in the second period is

\[ V(P_2) = \overline{A}_2^2 V(Y_2) + \overline{Y}_2^2 V(A_2) + 2\overline{A}_2\overline{Y}_2 \text{cov}(A_2, Y_2) - \text{cov}(A_2, Y_2)^2 + R_2 \ldots (4.11) \]

each variable in the second period can be expressed as its counterpart in the first period plus the change in the variable between the two periods, i.e.,

\[ \overline{A}_2 = \overline{A}_1 + \Delta \overline{A} \]

\[ \overline{Y}_2 = \overline{Y}_1 + \Delta \overline{Y} \]

\[ V(A_2) = V(A_1) + \Delta V(A) \]

\[ V(Y_2) = V(Y_1) + \Delta V(Y) \]

\[ \text{Cov}(A_2, Y_2) = \text{Cov}(A_1, Y_1) + \Delta \text{Cov}(A_1, Y_1) \]

Eq. (4.11) can, therefore, be rewritten as

\[ V(P_2) = (\overline{A}_1 + \Delta \overline{A})^2 \{V(Y_1) + \Delta V(Y)\} + (\overline{Y}_1 + \Delta \overline{Y})^2 \{V(A_1) + \Delta V(A)\} + 2(\overline{A}_1 + \Delta \overline{A})(\overline{Y}_1 + \Delta \overline{Y}) \{\text{cov}(A_1, Y_1) + \Delta \text{cov}(A, Y)\} - \{\text{cov}(A_1, Y_1) + \Delta \text{cov}(A, Y)\}^2 + \{R_1 + \Delta R\} \ldots (4.12) \]

which can be expressed as

\[ V(P_2) = \overline{A}_1^2 V(Y_1) + \Delta \overline{A}^2 V(Y_1) + 2\overline{A}_1\Delta \overline{A} V(Y_1) + \overline{A}_1^2 \Delta V(Y) + \Delta \overline{A}^2 \Delta V(Y) \]

\[ + 2\overline{A}_1\Delta \overline{A} \Delta V(Y) + \overline{Y}_1^2 V(A_1) + \Delta \overline{Y}^2 V(A_1) + 2\overline{Y}_1\Delta \overline{Y} V(A_1) + \overline{Y}_1^2 \Delta V(A) \]

\[ + \Delta \overline{Y}^2 \Delta V(A) + 2\overline{Y}_1\Delta \overline{Y} \Delta V(A) + 2\overline{A}_1\overline{Y}_1 \text{cov}(A_1, Y_1) \]

\[ + 2\overline{A}_1\Delta \overline{Y} \text{cov}(A_1, Y_1) + 2\overline{Y}_1\Delta \overline{A} \text{cov}(A_1, Y_1) + 2\Delta \overline{A} \Delta \overline{Y} \text{cov}(A_1, Y_1) \]

\[ + 2\overline{A}_1\overline{Y}_1 \Delta \text{cov}(A, Y) + 2\overline{A}_1\Delta \overline{Y} \Delta \text{cov}(A, Y) + 2\overline{Y}_1\Delta \overline{A} \Delta \text{cov}(A, Y) \]

\[ + 2\overline{A} \Delta \overline{Y} \Delta \text{cov}(A, Y) - \{\text{cov}(A_1, Y_1)\}^2 - \{\Delta \text{cov}(A, Y)\}^2 \]

\[ - 2 \text{cov}(A_1, Y_1) \Delta \text{cov}(A, Y) + R_1 + \Delta R \ldots (4.13) \]

The change in variance of production, \( \Delta V(P) \) is then obtained by subtracting Eq. (4.10) from Eq. (4.13). Thus
\[ \Delta V(P) = V(P_2) - V(P_1) \]

\[ = \Delta \bar{A}^2 V(Y_1) + 2 \bar{A}_i \Delta \bar{A} V(Y_1) + \bar{A}_i^2 \Delta V(Y) + \Delta \bar{A}^2 \Delta V(Y) \]

\[ + 2 \bar{A}_i \Delta \bar{A} \Delta V(Y) + \Delta \bar{Y}^2 V(A_1) + 2 \bar{Y}_i \Delta \bar{Y} V(A_1) + \bar{Y}_i^2 \Delta V(A) \]

\[ + \Delta \bar{Y}^2 \Delta V(A) + 2 \bar{Y}_i \Delta \bar{Y} \Delta V(A) + 2 \bar{A}_i \Delta \bar{Y} \text{cov}(A_1, Y_1) \]

\[ + 2 \bar{Y}_i \Delta \bar{A} \text{cov}(A_i, Y_1) + 2 \Delta \bar{A} \Delta \bar{Y} \text{cov}(A_i, Y_1) \]

\[ + 2 \bar{A}_i \bar{Y}_i \Delta \text{cov}(A, Y) + 2 \bar{A}_i \Delta \bar{Y} \Delta \text{cov}(A, Y) + 2 \bar{Y}_i \Delta \bar{A} \Delta \text{cov}(A, Y) \]

\[ + 2 \Delta \bar{A} \Delta \bar{Y} \Delta \text{cov}(A, Y) - \{\Delta \text{cov}(A, Y)\}^2 \]

\[ - 2 \text{cov}(A_i, Y_i) \Delta \text{cov}(A, Y) + \Delta R \]  \hspace{1cm} \ldots (4.14)

which can be arranged as in Table 4.2.

**Table 4.2: Components of Change in the Variance of Production**

<table>
<thead>
<tr>
<th>Sources of Change</th>
<th>Symbol</th>
<th>Components of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in mean yield</td>
<td>$\Delta \bar{Y}$</td>
<td>$2 \bar{A}_i \Delta \bar{Y} \text{cov}(A_i, Y_1) + {2 \bar{Y}_i \Delta \bar{Y} + (\Delta \bar{Y})^2} V(A_1)$</td>
</tr>
<tr>
<td>Change in mean area</td>
<td>$\Delta \bar{A}$</td>
<td>$2 \bar{Y}_i \Delta \bar{A} \text{cov}(A_i, Y_1) + {2 \bar{A}_i \Delta \bar{A} + (\Delta \bar{A})^2} V(Y_1)$</td>
</tr>
<tr>
<td>Change in yield variance</td>
<td>$\Delta V(Y)$</td>
<td>$\bar{A}_i^2 \Delta V(Y)$</td>
</tr>
<tr>
<td>Change in area variance</td>
<td>$\Delta V(A)$</td>
<td>$\bar{Y}_i^2 \Delta V(A)$</td>
</tr>
<tr>
<td>Interaction between changes in mean yield and mean area</td>
<td>$\Delta \bar{A} \Delta \bar{Y}$</td>
<td>$2 \Delta \bar{A} \Delta \bar{Y} \text{cov}(A_i, Y_1)$</td>
</tr>
<tr>
<td>Change in area–yield Covariance</td>
<td>$\Delta \text{cov}(AY)$</td>
<td>${2 \bar{A}_i \bar{Y}_i - 2 \text{cov}(A_i, Y_1)} \Delta \text{cov}(A, Y) - {\Delta \text{cov}(A, Y)}^2$</td>
</tr>
<tr>
<td>Interaction between changes in mean area and yield variance</td>
<td>$\Delta \bar{A} \Delta V(Y)$</td>
<td>${2 \bar{A}_i \Delta \bar{A} + (\Delta \bar{A})^2} \Delta V(Y)$</td>
</tr>
<tr>
<td>Interaction between changes in yields and area variance</td>
<td>$\Delta \bar{Y} \Delta V(A)$</td>
<td>${2 \bar{Y}_i \Delta \bar{Y} + (\Delta \bar{Y})^2} \Delta V(A)$</td>
</tr>
<tr>
<td>Interaction between changes in mean area and yield and changes in area–yield covariance</td>
<td>$\Delta \bar{A} \Delta \bar{Y} \Delta \text{cov}(AY)$</td>
<td>$(2 \bar{A}_i \Delta \bar{Y} + 2 \bar{Y}_i \Delta \bar{A} + 2 \Delta \bar{A} \Delta \bar{Y}) \Delta \text{cov}(A, Y)$</td>
</tr>
<tr>
<td>Change in residual</td>
<td>$\Delta R$</td>
<td>$\Delta V(AY)$ - Sum of the other components</td>
</tr>
</tbody>
</table>