CHAPTER III

RESEARCH METHODOLOGY

This chapter is divided into two parts. Part I deals with the sources of data collected for the study. Part II dealing with the methodology adopted and techniques used for analysis is subdivided into three sections. Section A deals with choice of districts and criteria adopted, agro-climatic zones of Telangana, statistical tools and techniques employed to measure the growth, the decomposition of change in average production and production variance between pre- and post-green revolution phase into different components and measurement of instability in rice production. Section B deals with factors influencing instability in rice production. Included in Section C are the limitations inherent in the study.

PART I

Sources of Data

This study is based on both primary and secondary sources of data. Standard Government of India publications like "Agriculture in Brief", and "Agricultural Statistics at a Glance" were referred to. Further, relevant reports of "Farm Management Studies" were also consulted. District wise data on area, production and yield of rice for the period 1956-57 to 1986-87 were obtained from various issues of "Statistical Abstract - Andhra Pradesh" published by the Directorate of Economics & Statistics, Government of Andhra Pradesh, Hyderabad. The data relating to Telangana region for these years were also taken from these Abstracts. The data relating to Telangana region in respect of area under high yielding varieties, sources of irrigation, rainfall during the South-West monsoon were available from 1966-67 and were taken from "Season and Crop Reports". Government of Andhra Pradesh. The information on the amount of nitrogenous fertiliser used (since nitrogen is the basic requirement for plant growth) was collected from "Season and Crop" Reports, Government of Andhra Pradesh. Fifty percent of the total consumption was considered as being used for rice. This quantum was based on discussions with the staff of the Department of Agriculture, Andhra Pradesh and personal discussions with the farmers. Information on liquid formulation was collected from the Department of Agriculture and from "Season and Crop" Reports. Here again based on discussions with departmental staff and discussions with farmers, 25 percent of the total consumption at the district level was considered as being used for rice. This procedure was adopted as the exact quantity used for rice is not given in any publication. The above percentage is now accepted and hence included.
PART II

SECTION A

Choice of Districts and Criteria

Data for the period 1956-57 to 1986-87 for the six selected districts in Telangana region of Andhra Pradesh were collected from the "Statistical Abstracts - Andhra Pradesh". As the district of Ranga Reddy was carved out in 1978-79 from the erstwhile Hyderabad district, complete data from 1956-57 were not available and hence, Ranga Reddy district was not included in the study. Hyderabad district being an urban metropolitan area with less rice acreage was not considered. Adilabad is a forested area with 42.40 percent of the total geographical area under thick forest coverage (Season & Crop Reports 1987-88). Warangal district is known for cash crops and is a market place. Further, rice in Warangal had been often (till recent times) subjected to insect attack resulting in fluctuation both in production and in productivity. Hence, this was also not included in the study. Thus, leaving these four districts, six were selected for the study. These are Nalgonda, Karimnagar, Khammam, Medak, Mahaboobnagar and Nizamabad. Yield of rice and rice acreage were adopted as the basis for the grouping of the districts. On this basis, Nalgonda, Karimnagar and Nizamabad have been taken in one category while Khammam, Medak and Mahaboobnagar are included in the second category. Together, these 6 districts accounted for 76.3 percentage of Telangana's rice acreage and 82.7 percent of the region's rice production in 1986-87 and 77.7 and 79.0 percent respectively during 1990-91.

Agro-Climatic Zones of Telangana

The Telangana region has 4 agro-climatic zones as detailed below:

1. Krishna - Godavari Zone:- Consists of East Godavari (excluding uplands), West Godavari, Krishna, Guntur and the contiguous areas of Khammam, Nalgonda and Prakasam.

2. Northern Telangana Zone:- Comprises of Adilabad, Karimnagar, Nizamabad, Medak (except Southern borders), Warangal (except North-Western portion), Eastern tip of Nalgonda and Khammam (except Southern and Eastern parts).

3. Southern Telangana zone :- Includes Ranga Reddy, Mahaboobnagar (except Southern border), Nalgonda (except South-Eastern border), North-Western part of Warangal, Medak (South) and Hyderabad.

4. High Altitude and Tribal Area Zone :- Comprises of areas along the Northern borders of the state in the districts of Srikakulam, Vizianagaram, Visakhapatnam, East Godavari and Khammam.
The districts selected broadly fall in all the four agro-climatic zones of Telangana region. Khammam was chosen (in preference to Warangal) as it falls in the High Altitude and Tribal Area Zone. Further, this choice gives a representative picture of Telangana region. (Fig 1)

Figures for area, production and yield of rice for the period 1956-57 to 1986-87 were included without eliminating any observation. The period is considered in two phases i.e., pre-green revolution phase I (1956-57 to 1966-67) and post green revolution/phase II (1967-68 to 1986-87). The year 1967-68 was taken as the beginning of phase II as it was a year of higher production and lower variability. This year also marks the starting point of agricultural growth analysis in Andhra Pradesh.

Rice was taken as the subject of study as this principal Kharif grain forms the staple food for the vast majority of the population in Telangana region, Andhra Pradesh and the country.

The area, production and yield figures of rice for the six districts and for Telangana region for 1956-67, 1966-67, 1976-77 and 1986-87 are given in Table 3.1. Year-wise data are furnished in Annexures I-III.
Fig. 1

TELANGANA REGION (A.P.)
AGROCLIMATIC ZONES

INDEX

- SOUTHERN TELANGANA
- NORTHERN TELANGANA
- SCARCE RAINFALL
- HIGH ALTITUDE & TRIBAL AREA
- KRISHNA-GODAVARI ZONES
Table 3.1: Area, Production and Yield of Rice in Selected Districts and in Telangana Region (Dicennial)

<table>
<thead>
<tr>
<th>Year</th>
<th>District/Region</th>
<th>Area (‘000 ha.)</th>
<th>Production (‘000 tonnes)</th>
<th>Yield (tonnes/ha.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1956-57</td>
<td>Nalgonda</td>
<td>129.7</td>
<td>097.2</td>
<td>0.75</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>111.2</td>
<td>105.4</td>
<td>0.95</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>249.6</td>
<td>388.7</td>
<td>1.55</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>171.2</td>
<td>470.2</td>
<td>2.74</td>
</tr>
<tr>
<td>1956-57</td>
<td>Karimnagar</td>
<td>127.6</td>
<td>080.7</td>
<td>0.63</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>150.0</td>
<td>199.5</td>
<td>1.33</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>164.2</td>
<td>270.1</td>
<td>1.64</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>145.0</td>
<td>307.6</td>
<td>2.12</td>
</tr>
<tr>
<td>1956-57</td>
<td>Khammam</td>
<td>056.7</td>
<td>040.6</td>
<td>0.71</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>099.8</td>
<td>088.5</td>
<td>0.89</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>106.0</td>
<td>115.7</td>
<td>1.10</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>129.0</td>
<td>199.3</td>
<td>1.54</td>
</tr>
<tr>
<td>1956-57</td>
<td>Medak</td>
<td>114.0</td>
<td>086.3</td>
<td>0.76</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>097.0</td>
<td>137.7</td>
<td>1.42</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>107.1</td>
<td>174.7</td>
<td>1.63</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>074.5</td>
<td>081.8</td>
<td>1.10</td>
</tr>
<tr>
<td>1956-57</td>
<td>Mahaboobnagar</td>
<td>126.1</td>
<td>084.1</td>
<td>0.67</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>107.2</td>
<td>127.1</td>
<td>1.18</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>148.6</td>
<td>186.6</td>
<td>1.25</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>044.8</td>
<td>053.5</td>
<td>1.20</td>
</tr>
<tr>
<td>1956-57</td>
<td>Nizamabad</td>
<td>115.0</td>
<td>108.3</td>
<td>0.94</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>124.5</td>
<td>264.5</td>
<td>2.12</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>133.8</td>
<td>237.5</td>
<td>1.78</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>128.3</td>
<td>196.1</td>
<td>1.53</td>
</tr>
<tr>
<td>1956-57</td>
<td>Telangana</td>
<td>0892.0</td>
<td>0648.4</td>
<td>0.73</td>
</tr>
<tr>
<td>1966-67</td>
<td></td>
<td>0923.0</td>
<td>1202.6</td>
<td>1.30</td>
</tr>
<tr>
<td>1976-77</td>
<td></td>
<td>1174.0</td>
<td>1790.6</td>
<td>1.52</td>
</tr>
<tr>
<td>1986-87</td>
<td></td>
<td>0908.5</td>
<td>1582.5</td>
<td>1.74</td>
</tr>
</tbody>
</table>

Districtwise growth rates for area, production and yield were estimated in 1960 by the Ministry of Food and Agriculture, Government of India adopting the following formula:-

\[ Y = a + bt \quad \text{(i)} \]

Subsequently, the formula was improved upon by Dandekar (1980) by fitting the exponential function. The modified formula is:-

\[ Y = AB^t \]

By taking logarithms on both sides of the equation, we have,

\[ \log Y = \log A + t \log B \]

If we put \( \log A \) as equal to 'a' and \( \log B \) as equal to 'b', then, the equation becomes

\[ \log Y = a + bt \quad \text{(ii)} \]

where,

\[ Y = \text{area/production/yield}; \text{ and}, \]

\[ t = \text{time period} \]

This improved version is used in this study as it helps us to even out fluctuations over a period of time.

The Compound Annual Rate of Growth (r) is then given by the formula:-

\[ r = (e^b - 1) \times 100 \quad \text{(iii)} \]

where, the value of e is 2.718281

To test whether 'r' differs significantly from zero, its Standard Error was calculated by using the formula:-

\[
\text{SE} (r) = \frac{100B}{\log_{10} e} \sqrt{\frac{\sum_{i=1}^{n} (\log Y)^2 - (\sum_{i=1}^{n} \log Y)^2}{n} - \frac{(\sum_{i=1}^{n} (t-\bar{t})^2)}{(n-2)}}
\]

\[ \bar{t} = \frac{r}{\text{SE} (r)} \]

't' follows Student's t- distribution with (n-2) degrees of freedom.
For decomposition analysis, area and yield data are essential. Separate regressions were fitted for phase I and II to ensure that \( \sum e_i = 0 \) for each period. Mehra (1981) used log-linear forms; but, this equation in contrast does not assume a deterministic part to any relation between variance of area or yield and time `t'. The variance of area or yield in this equation is simply CV. By estimating separate equations for two period, the estimated variances can take on any relation to each other. The production of rice can be written as:-

\[
P = AY \quad \text{(v)}
\]

P refers to production of rice;
A represents area of rice; and,
Y is yield of rice.

For decomposition analysis, area and yield data are essential. Separate regressions were fitted for phase I and II to ensure that \( \sum e_i = 0 \) for each period.

Average production of rice in phase I is written as follows:-

\[
E(P) = E(A, Y)
\]

\[
= A_1Y_1 + \text{Cov}(A, Y) \quad \text{(vi)}
\]

and, in the second period (phase II), it is -

\[
E(P) = A_2Y_2 + \text{Cov}(A, Y) \quad \text{(vii)}
\]

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 eg.,

\[
\begin{align*}
\Delta A & = \Delta A_1 + A_1 \quad \text{(viii)}
\end{align*}
\]

\[
\begin{align*}
\Delta Y & = \Delta Y_1 + Y_1 \quad \text{(viii (a))}
\end{align*}
\]

Equation (vii) can therefore be written as

\[
E(P) = (A_1 + \Delta A)(Y_1 + \Delta Y) + \text{Cov}(A, Y) \quad \text{(ix)}
\]

Change in average production: \( E(P) \) is then obtained by subtracting (vi) from (ix). This reduces to -

\[
E(P) = E(P) - E(P)
\]

\[
= A_1\Delta Y + Y_1 \Delta A + \Delta A \Delta Y + \delta \text{Cov}(A, Y) \quad \text{(x)}
\]

43
This can be arranged as presented below in Table 3.2

### Table 3.2: Components of Change in Average Production

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Symbol</th>
<th>Components of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Change in Mean Yield</td>
<td>$\triangle Y$</td>
<td>$A \cdot \triangle Y$</td>
</tr>
<tr>
<td>2.</td>
<td>Change in Mean Area</td>
<td>$\triangle A$</td>
<td>$Y_1 \cdot \triangle A$</td>
</tr>
<tr>
<td>3.</td>
<td>Interaction between changes in Mean Area and Mean Yield</td>
<td>$\triangle \bar{A}, \triangle \bar{Y}$</td>
<td>$\triangle \bar{A} \cdot \triangle \bar{Y}$</td>
</tr>
<tr>
<td>4.</td>
<td>Change in Area - Yield Covariance</td>
<td>$\triangle \text{Cov}(A, Y)$</td>
<td>$\triangle \text{Cov}(A, Y)$</td>
</tr>
</tbody>
</table>

The first two parts $\triangle \bar{A} \cdot \triangle \bar{Y}$ and $Y_1 \cdot \triangle A$ arise from the changes in mean yield and mean area and are called 'pure effects'. They arise even if there are no other sources of change. The term $\triangle \bar{A} \cdot \triangle \bar{Y}$ is an interaction effect which arises from the simultaneous occurrence of changes in mean yield and mean area. The last term $\triangle \text{Cov}(A, Y)$ arises from changes in the variability of area and yield. The contribution of each component was judged with their percent share in the total change in average production between phase I and II.

### Measurement of Instability in Rice Production

In order to measure the extent of instability in rice production, the coefficient of variation in production of rice was calculated for Phase I and II as well as for the combined period. To test the change in the variability of area, production and yield of rice between the two periods, F-ratios were calculated using variances in the two periods as below:

Let $S^2_1$ and $S^2_2$ be variance in periods I and II calculated from $n_1$ and $n_2$ observations respectively. The ratio is:

$$F = \frac{S^2_1}{S^2_2}$$

where

$$S^2_i = \frac{1}{n_i - 1} \sum_{i=1}^{n_i} (x_i - \bar{x}_i)^2, \quad i = 1, 2$$

is distributed as F-distribution with $n_1 - 1$ and $n_2 - 1$ degree of freedom.
Factors Influencing Instability

To study the factors affecting growth and stability/or instability in rice output, an approach incorporating both man-made and natural factors was constructed. Rice output is dependent on two types of factors. The first type consists of man-made factors i.e., within limits they are amenable to control by man. These include social, political, institutional and economic such as land tenure, credit and marketing as well as material inputs such as irrigation and fertilisers. The second type of factors called 'weather'/natural factors include rainfall, temperature, humidity and all other natural phenomena which affect crop output. To measure the impact of forces causing growth and instability in crop production, it is necessary to include both the above types of factors. Their inclusion should provide valuable policy leads for devising appropriate measures for maintaining growth and stability in production at desired levels.

The major sources of production instability are 'yield fluctuations and synchronised movements in year to year changes in the components determining the level of production.' (Ray, 1983). In the present study, an attempt is made to relate production levels with some of the man-made (control) and natural factors. The function considered in this regard is:

\[ Y = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + b_4 x_4 + b_5 x_5 + b_6 x_6 + e_t \]  \hspace{1cm} \text{(xii)}

where,

- \( Y \) is production of rice;
- \( x_1 \) is June rainfall;
- \( x_2 \) is July rainfall;
- \( x_3 \) is August rainfall;
- \( x_4 \) is September rainfall;
- \( x_5 \) is Nitrogen consumption; and,
- \( x_6 \) is liquid formulation

Controlled Variables

Area under High Yielding Varieties:- Percent area of high yielding varieties of rice (year/district-wise) was used as an explanatory variable in the regression analysis. The percentage was calculated with reference to gross cropped area under rice.
Irrigated Crop Area: Irrigation is the 'leading input in increasing rice output.' (Ishikawa, 1967). Irrigation plays different roles at different levels of development - stabilisation of harvest fluctuations arising from variable rainfall, allowing the introduction of a second crop, increasing land productivity arising from an increase in crops per hectare rather than in yield per hectare/crop, makes possible increased fertiliser application, use of seeds of high yielding varieties, introduction of improved techniques and adoption of components of new technology. The Gross Irrigated Area (GIA) was calculated by summing the area under various sources of irrigation and dividing it by the Gross Cropped Area under rice so as to arrive at the proportion of Gross Irrigated Area to Gross Cropped Area. This proportion is another explanatory variable in the regression equation.

Fertiliser: The application of fertiliser is to increase crop productivity besides maintaining nutrient status of the soil. The major nutrients applied for rice are nitrogen, phosphorus and potash. The soils in India are deficient in nitrogen. A considerable amount of nitrogen in rice ecosystem is lost to the atmosphere through volatalization and denitrification, washed away in runoff water, leached away in drainage water, or fixed in clay minerals or organic matter. Among the three nutrients, nitrogen consumption is the largest and its offtake, the maximum.

Details regarding the amount of nitrogen applied cropwise are not available. In the absence of such information, it was decided to take 50 percent of total nitrogen consumed as the intake of nitrogen for rice. This percentage is taken in the normal course for rice in several studies and is also based on discussions with staff of the Directorate of Agriculture.

The other two major nutrients, viz., phosphorus and potash were not considered in the analysis for the following reasons. Firstly, the soils in India are not generally deficient in phosphorus. The response in terms of yield to the applied phosphorus is also low except in soils highly deficient in phosphorus. The plants are able to get their requirement from the soil itself.

As regards potash, soils in India have in general sufficient potash. The requirement of crop is also limited. Further, whatever is required by the crop is met with from the soil itself. Thus, the contribution of these two nutrients was not considered.

Insecticides: Use of insecticides and/or pesticides is another variable. The formulation is generally of two types viz., liquid and dust formulation. Liquid formulation is largely used for rice. Hence, this variable was considered. Here too, data on liquid formulation are not available cropwise. Twenty five (25) percent of the total liquid formulation used was taken as having been used for rice.
Uncontrolled Variables

Rainfall and temperature have been singled out as important factors (Oury, 1965). In the present study, rainfall was incorporated as a variable.

Rainfall: Rice is a *kharif* crop grown under different water regimes and is also subjected to periodic floods. During the *kharif* season, the South-West monsoon dominates. In case of rice, it is known that it is not the total rainfall *per se* that matters, but the pattern of its distribution during June to September. In fact, the success or failure of rice during *kharif* could often depend upon the distribution pattern. Bearing this in mind, rainfall distribution during these four months was considered for analysis.

SECTION C

Limitations in the Study

This part deals with the limitations inherent in studies of this nature. The limitations are:

1. Agricultural data at the district level suffer from area limitations. Estimates of area under rice crop at the district level are obtained from revenue records, whereas production figures come from the crop cutting experiments. The crop cutting experiments are based on cuts from a sample of fields. This sample is primarily designed to give statistically reliable estimates at the state-level and may be a small sample only to provide a good base for reliable estimates at the district level. These limitations are inherent.

2. Productivity is expressed in terms of yield/hectare. The average yield by its very nature conceals differences in soil fertility, rainfall, irrigation, human factor *etc*.

3. The sources of irrigation and the net and gross area irrigated by different sources are obtained from “Season and Crop Reports” of the Directorate of Economics and Statistics of the Government of Andhra Pradesh. The number of tanks presumably refers to functioning sources. It does not contain ‘tanks in existence’. There is, thus, considerable year to year fluctuation. Further, it is not clear as to how exactly the various sources of information was collected. Such limitations are unavoidable.

4. A district could be too large an aggregate and the fertiliser use is taking place in pockets having adequate moisture availability. This would influence the average for the district *i.e.*, co-existence of inadequate moisture and high fertiliser use.

5. Fertiliser reportedly consumed/distributed is not necessarily consumed there. This discrepancy could be significant in some border districts.
6. The instability in output would tend to be high in cases where there is genuine substitution of fertilisers for moisture inadequacy.

7. Annual fluctuations in rice output are noticed - both weather induced and to other causes. Such fluctuations pose problems in detecting and measuring the trend movements of production arising out of area increase and yield improvement. This process is rendered more difficult in the context of high production due to a 'package of practices' and weather induced peaks and troughs.

8. Comparisons of instability based on fixed periods have their limitations. Even an omission of one bad year would change the degree of instability. In the present study, all years were included to get a true picture of instability.

9. Given the year-to-year variation, growth measurements are sensitive to choice of end years. Different sets of end years could lead to different results thus influencing interpretation.

10. Factors such as land tenure, credit availability, marketing facility etc., influence output. Information on land tenure is available only on quinquennial basis. Farmers obtain credit/loans from different agencies. Moreover, the amount advanced is used for various purposes besides rice cultivation. Such exact figures are difficult to obtain. As regards market facility, regulated markets are few. Coupled with this, is the period of distress sales where the money lenders and private financiers play a significant role often detrimental to farmers' interest. Further, the private money lenders through their various methods (often dubious) of funding and on different interest rates significantly influence production especially by marginal and small farmers. These factors are related and complex and were not considered in this study.

11. This study is not extended to 'cost and return' analysis. The output and yield trends are not assessed in monetary units. The analysis carried out at the district level is in physical units.

12. Refinements in methodology and in statistical tools for a measurement of growth rate have been made from time to time; but with all such refinements, a computed growth rate could only be an 'estimate'. Being so, it is not uncommon to arrive at different estimates of growth for the same period in the context of the availability of models and underlying assumptions.

13. In all time series data, autocorrelation of first order is unavoidable.