V. EMPIRICAL ANALYSIS
CHAPTER V

Empirical Analysis

5.1. Introduction: The aim of the present study is to analyse the growth rates of total foodgrains and to show their variation among different states of the north eastern region during the period from 1969-70 to 1977-78. The north eastern region comprises five states and two union territories viz., 1. Assam, 2. Manipur, 3. Tripura, 4. Meghalaya, 5. Nagaland, 6. Mizoram and 7. Arunachal Pradesh. For this purpose data on yield of total foodgrains of each state and union territory of this region from 1969-70 to 1977-78 have been collected.¹

5.2. Empirical analysis: Data on yield of total foodgrains of different states and union territories of the north-eastern region from 1969-70 have been arranged in the same order as shown in the frame of reference of the previous chapter (page 54).

As these data shown in Table 1 on yield (Kg.) per hectare represent non-linear trends, these data

¹ Directorate of Economics and Statistics; Ministry of Agriculture and Irrigation, Govt. of India, cited by Basic Statistics of the North Eastern Region, 1977 and 1930, North Eastern Council Secretariat, Shillong.
have been transformed into a linear function by converting all variables of table - 1 into logarithms. These data transformed to logarithms have been shown in table - 2.

The variables introduced in the above working frame are:

\[ X_{ij} = \text{Yield per hectare for any specific crop for the } i^{th} \text{ state for the } t^{th} \text{ period.} \]

\[ Z_j = \text{The trend variable for any specific time period } j. \]

\[ Y_i = \text{location factor or variable, i.e., any of the } i^{th} \text{ state of the region.} \]

It could be mentioned that the reaction synonymously stands for yield per hectare for the \( i^{th} \) region or state in the \( j^{th} \) time period. The problem is here that unlike the conventional production function or more appropriately the growth function in the present analysis the output is not simply considered as function of time. Here resulting function is the output as a response of particular state or region for any particular time period with respect to the crop in question. The more detailed discussion about \( Y \) and \( T \) would follow later in the chapter.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Arunachal Pradesh</td>
<td>823</td>
<td>847</td>
<td>864</td>
<td>877</td>
<td>883</td>
<td>926</td>
<td>896</td>
<td>900</td>
<td>915</td>
<td>7936</td>
<td>831.78</td>
</tr>
<tr>
<td>Assam</td>
<td>831</td>
<td>973</td>
<td>945</td>
<td>1042</td>
<td>971</td>
<td>943</td>
<td>996</td>
<td>913</td>
<td>997</td>
<td>8651</td>
<td>962.22</td>
</tr>
<tr>
<td>Manipur</td>
<td>1629</td>
<td>1154</td>
<td>1240</td>
<td>1084</td>
<td>1433</td>
<td>1533</td>
<td>1560</td>
<td>1486</td>
<td>1626</td>
<td>12750</td>
<td>1416.67</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>1017</td>
<td>1023</td>
<td>1006</td>
<td>1042</td>
<td>1030</td>
<td>1010</td>
<td>1079</td>
<td>1123</td>
<td>1152</td>
<td>9487</td>
<td>1054.11</td>
</tr>
<tr>
<td>Mizoram</td>
<td>931</td>
<td>969</td>
<td>930</td>
<td>863</td>
<td>822</td>
<td>743</td>
<td>835</td>
<td>650</td>
<td>650</td>
<td>7593</td>
<td>843.57</td>
</tr>
<tr>
<td>Nagaland</td>
<td>827</td>
<td>893</td>
<td>531</td>
<td>581</td>
<td>573</td>
<td>612</td>
<td>879</td>
<td>905</td>
<td>924</td>
<td>6750</td>
<td>747.73</td>
</tr>
<tr>
<td>Tripura</td>
<td>875</td>
<td>943</td>
<td>973</td>
<td>651</td>
<td>1204</td>
<td>1086</td>
<td>1216</td>
<td>1119</td>
<td>1224</td>
<td>9296</td>
<td>1032.89</td>
</tr>
<tr>
<td>Total $\sum X_{ij}$</td>
<td>7033</td>
<td>6807</td>
<td>6539</td>
<td>6240</td>
<td>6926</td>
<td>6953</td>
<td>7461</td>
<td>7101</td>
<td>7473</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average $\langle X_{ij} \rangle$</td>
<td>1005.43</td>
<td>972.43</td>
<td>934.14</td>
<td>891.43</td>
<td>989.43</td>
<td>979</td>
<td>1055.86</td>
<td>1014.43</td>
<td>1063.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td>1959-70</td>
<td>1970-71</td>
<td>1971-72</td>
<td>1972-73</td>
<td>1973-74</td>
<td>1974-75</td>
<td>1975-76</td>
<td>1976-77</td>
<td>1977-78</td>
<td>Total ( \Sigma x_{ij} )</td>
<td>Average ( \frac{\Sigma x_{ij}}{9} )</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>---------</td>
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<td>---------</td>
<td>---------</td>
<td>---------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>2.9130</td>
<td>2.9279</td>
<td>2.9365</td>
<td>2.9430</td>
<td>2.9460</td>
<td>2.9666</td>
<td>2.9523</td>
<td>2.9543</td>
<td>2.9614</td>
<td>26.5059</td>
<td>2.95</td>
</tr>
<tr>
<td>Assam</td>
<td>2.9450</td>
<td>2.9881</td>
<td>2.9754</td>
<td>3.0179</td>
<td>2.9972</td>
<td>2.9745</td>
<td>2.9963</td>
<td>2.9605</td>
<td>2.9943</td>
<td>26.3412</td>
<td>2.93</td>
</tr>
<tr>
<td>Mizoram</td>
<td>2.9917</td>
<td>2.9863</td>
<td>2.9912</td>
<td>2.9856</td>
<td>2.9149</td>
<td>2.9710</td>
<td>2.9217</td>
<td>2.8129</td>
<td>2.8129</td>
<td>26.2862</td>
<td>2.92</td>
</tr>
<tr>
<td>Nagaland</td>
<td>2.9175</td>
<td>2.9509</td>
<td>2.7251</td>
<td>2.7642</td>
<td>2.7657</td>
<td>2.7868</td>
<td>2.9440</td>
<td>2.9566</td>
<td>2.9657</td>
<td>26.7765</td>
<td>2.86</td>
</tr>
<tr>
<td>Tripura</td>
<td>2.9420</td>
<td>2.9768</td>
<td>2.9361</td>
<td>2.8136</td>
<td>3.0806</td>
<td>3.0358</td>
<td>3.0849</td>
<td>3.0483</td>
<td>3.0873</td>
<td>27.0584</td>
<td>3.00</td>
</tr>
<tr>
<td>Average ( \frac{\Sigma x_{ij}}{9} )</td>
<td>2.99</td>
<td>2.93</td>
<td>2.95</td>
<td>2.94</td>
<td>2.93</td>
<td>2.97</td>
<td>3.01</td>
<td>2.99</td>
<td>3.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.3. Regression Analysis of Trend: In section (4.1) we have presented some regression functions which are usually adopted for analysis of time series data. This type of analysis is done for each state and the estimating equation are:

\[ X_i = X(t) \]  \hspace{1cm} (5.3.1)

\[ X_i = a + bt \]  \hspace{1cm} (5.3.2)

\[ \log X_i = a + bt \]  \hspace{1cm} (5.3.3)

where, \( X_i \) = yield per hectare for the \( i \)th state
\( t \) = trend variable
\( a, b \) = parameters of the equation.

The other estimating equations are presented in section (4.2). Now we shall be discussing about the exogenous variables and their effects on the growth of agricultural output in the region. We must admit that the location variable, i.e., the states in the question of the N.E. region comprises most of the predominant variables that appear in a micro production function. The effects of agricultural infra-structures and infra-structures symbolizing the very appearance of economic development on agricultural growth are prima facie basic. On the other hand, the effect of other capital inputs in terms of irrigation, fertilizer, seed etc. are direct on the growth of agricultural output. In the next section we shall discuss these variables in more detail.
5.4. **Explanation of the exogenous variables**: In the above model mentioned in section 5.2. and discussed in detail in section 4.2., we have taken location and the trend as exogenous variables which influence the growth of agricultural output. Now, in this section we shall explain the reasons behind taking them as the important variables for analysing the pattern of growth.

5.4.1. **Location factors**:

**Land**: As regards the position of land for agricultural purpose in the North Eastern region it is observed that most of the areas of lands are merely useless and fallow in view of the fact that vast areas are practically unsuitable for cultivation either due to rocky and rugged terrain or inaccessibility. This observation is made clear from verification of statistics of cultivable area. Out of a total reporting area of about 23 million hectares, 2.9 million hectares in the hills and forest are under shifting cultivation.

Again when Assam's cultivable area formed 37.2 percent of the total geographical area, it was about 8 to 9 percent in Meghalaya, Manipur and Nagaland, 20 percent in Tripura and about 3.4 percent in

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Arunachal Pradesh as against 50 percent in the country as a whole.\(^3\) Thus, excepting Assam and Tripura availability of land for agricultural purposes is extremely limited in all other states of the North Eastern region. So far the food crops produced out of the total cropped area, occupy a sizeable proportion (about 78%). Variations in soil in different states of the North Eastern region, have already been discussed in Chapter 3.

**Transport**: It is an admitted fact that the transport system in the North-Eastern region specially after the partition of the country has got a great set-back. Now the region is land locked and its only link with the rest of the country is a narrow strip of land through North-Bengal. So the transport link is very light and difficult. Only this strip of land is to be utilised for railway and road transport purposes outside the region. There is one important metre gauge railway system from Tezpur to Pakiragaon. Therefrom it has bifurcated towards Golakganj and Siliguri on the Northern bank of Brahmaputra. Again on the southern bank of Brahmaputra another line runs from Guwahati to

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Lakshapani along with a short southward extension to Cachar district and to Tripura. From the point of transport disadvantages it needs mention that out of the collective area of 2.55 lakh sq.kms. in the North Eastern region 70% is full of hilly areas. The rest 30% is plains area but it is also crisscrossed by streams, rivers and rivulets of uncertain nature. As a result the road development of the region faces a lot of difficulties. Hence, the road links are not sufficient excepting a few National Highways.

So far as the Air links are concerned, it is apparent that Assam has the advantage of having large number of airfields. There are in all thirteen airports. These are as follows :- seven are for heavy aircrafts, four for medium aircrafts and two for light aircrafts.

Thus, inadequate transport facilities in the region itself has greatly affected the development process. Since agricultural development depends largely on free flow of fertilisers and improved technology and also on increase in income from the Marketable surplus of agricultural produces, development of an efficient system of transport and communication requires priority.
Agricultural Holding: The size of operational holding is the main basis of the productivity of agriculture. Moreover, application of new or improved technique of production, irrigation etc. depend largely on the size of operational holdings. But the size of operational holdings has become very small and dispersed over a wide area in the North Eastern region owing to the fact that land for agricultural purposes is extremely limited here and there is also heavy pressure of population on land.

The size of operational holdings are shown in the following table:
### Operational Holdings According to Size

<table>
<thead>
<tr>
<th>Size Class (hectares)</th>
<th>Arunachal Pradesh</th>
<th>Assam</th>
<th>Manipur</th>
<th>Meghalaya</th>
<th>Mizoram</th>
<th>Nagaland</th>
<th>Tripura</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 0.5</td>
<td>2,350</td>
<td>651,992</td>
<td>9,203</td>
<td>21,000</td>
<td>-</td>
<td>2,487</td>
<td>114,486</td>
</tr>
<tr>
<td>0.5 - 1.0</td>
<td>3,710</td>
<td>468,413</td>
<td>23,474</td>
<td>34,100</td>
<td>-</td>
<td>6,311</td>
<td>58,944</td>
</tr>
<tr>
<td>1.0 - 2.0</td>
<td>9,450</td>
<td>466,691</td>
<td>34,270</td>
<td>51,750</td>
<td>-</td>
<td>16,397</td>
<td>47,049</td>
</tr>
<tr>
<td>2.0 - 3.0</td>
<td>12,200</td>
<td>189,089</td>
<td>9,776</td>
<td>27,250</td>
<td>-</td>
<td>17,070</td>
<td>15,976</td>
</tr>
<tr>
<td>3.0 - 4.0</td>
<td>8,270</td>
<td>86,691</td>
<td>2,203</td>
<td>8,850</td>
<td>-</td>
<td>8,853</td>
<td>6,242</td>
</tr>
<tr>
<td>4.0 - 5.0</td>
<td>9,860</td>
<td>43,540</td>
<td>659</td>
<td>4,150</td>
<td>-</td>
<td>11,390</td>
<td>3,043</td>
</tr>
<tr>
<td>5.0 -10.0</td>
<td>18,890</td>
<td>50,334</td>
<td>316</td>
<td>2,350</td>
<td>-</td>
<td>13,077</td>
<td>3,409</td>
</tr>
<tr>
<td>10.0-20.0</td>
<td>10,750</td>
<td>5,962</td>
<td>15</td>
<td>250</td>
<td>-</td>
<td>9,536</td>
<td>509</td>
</tr>
<tr>
<td>20.0-30.0</td>
<td>2,730</td>
<td>593</td>
<td>4</td>
<td>-</td>
<td>-</td>
<td>1,876</td>
<td>37</td>
</tr>
<tr>
<td>30.0-40.0</td>
<td>510</td>
<td>181</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>652</td>
<td>10</td>
</tr>
<tr>
<td>40.0-50.0</td>
<td>140</td>
<td>88</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>270</td>
<td>15</td>
</tr>
<tr>
<td>50.0 and above</td>
<td>130</td>
<td>752</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>334</td>
<td>54</td>
</tr>
</tbody>
</table>

Financial Institutions: Owing to natural backwardness and difficulties existing in the North Eastern region it has not been possible for the financial institutions to make headway in the matter of giving financial loans to entrepreneurs on easy terms. This is why a very small number of bank branches has so far been established in the states and union territories of the region. Of course, in this respect the position of Assam is a bit better. As on 30.6.1978 the total number of bank branches in the entire region was 610. It was 13 in Arunachal Pradesh, 414 in Assam, 32 in Manipur, 49 in Meghalaya, 6 in Mizoram, 29 in Nagaland and 67 in Tripura. The funds advanced from these institutions have also been very low as shown in the following table:

<table>
<thead>
<tr>
<th>Particulars</th>
<th>Unit</th>
<th>Arunachal Pradesh</th>
<th>Assam</th>
<th>Manipur</th>
<th>Meghalaya</th>
<th>Mizoram</th>
<th>Nagaland</th>
<th>Tripura</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Direct Finance (Amount Outstanding)</td>
<td>Rs. in crores</td>
<td>0.01</td>
<td>0.45</td>
<td>0.57</td>
<td>0.01</td>
<td>0.11</td>
<td>1.16</td>
<td>6.30</td>
<td></td>
</tr>
<tr>
<td>2. Indirect Finance (Amount Outstanding)</td>
<td>Rs. in crores</td>
<td>3.89</td>
<td>0.12</td>
<td>neg</td>
<td>0.09</td>
<td>0.24</td>
<td>4.34</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

similarly the numbers of Primary Agricultural Credit Societies (1975-76) was very low. It was 3519 in Assam, 657 in Manipur, 548 in Meghalaya, 101 in Mizoram, 356 in Tripura and 163 in Nagaland. Total loans advanced by these institutions was Rs. 28 lakhs in Assam, Rs. 13 lakhs in Manipur, Rs. 2 lakhs in Nagaland and Rs. 47 lakhs in Tripura.\(^4\)

Studies made by Dr. D.D. Malî\(^5\) and others show that non-institutional sources, such as friends and relatives and money lenders are playing most important role in providing credit specially in the villages of hilly region. Hence, the role of institutional source is not very significant in these areas. Moreover, due to the operation of money lenders credit is made available only for a short period and naturally the price of rural credit is high.

**Agro-based Industries:** Agro-based Industries in North Eastern region have not developed for various reasons. Except for tea plantation and sugar factory in Assam there are no major industries worth mentioning. Production distribution of entrepreneur in agro based industries in the North Eastern Region will be clear from the following table:


Production Distribution of Entrepreneurs in Agro-based Industries (Number of Units)

<table>
<thead>
<tr>
<th>Product</th>
<th>Arunachal Pradesh</th>
<th>Assam</th>
<th>Manipur</th>
<th>Meghalaya</th>
<th>Mizoram</th>
<th>Nagaland</th>
<th>Tripura</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agro - based</td>
<td>16</td>
<td>833</td>
<td>22</td>
<td>86</td>
<td>53</td>
<td>47</td>
<td>110</td>
<td>1,167</td>
</tr>
</tbody>
</table>

Source: [Study of Entrepreneurial and Managerial Needs of the N.E. Region - Interim Report - Small Industries Extension Training Institute, Hyderabad, 1976.]

Number of persons employed in industries producing food products is also very insignificant: 1,288 in Assam, 85 in Manipur, 141 in Meghalaya, 24 in Nagaland and 328 in Tripura. 6

It should be mentioned here that all available studies reveal the potential of such industries based on locally available resources. Many parts of the region are suitable for plantation crops such as tea, coffee, rubber, black pepper, jute and agricultural equipment.

Marketing: Inadequate transport facilities in the region has laid much hindrance in matter of marketing and storage. Practically, speaking, it has been a constant difficulty on the part of the farmers to market their surplus produce and procure fertiliser and finished goods particularly from the remote and interior areas of the hilly region. The effect of this is that while the farmers have to pay more for fertilisers and other inputs for agriculture and other consumer goods their income from the marketable surplus of agricultural produce is low. In 1977, the total number of wholesale markets in the entire northeastern region was only 183. It was 23 in Arunachal Pradesh, 103 in Assam, 16 in Manipur, 3 in Meghalaya and 33 in Tripura. Thus, the rich hinterland of the region with vast agricultural resources remain untapped because of transport bottlenecks and as such consequent inadequate marketing facilities.

Irrigation: In North Eastern region natural rainfall is the main source for agricultural products as there are no sufficient irrigation facilities. Hence, agricultural is dependable to the largest extent on natural rainfall. In 1972-73, 16.47 percent of cultivated area

was under irrigation for the whole of North-Eastern region compared to the all India figure of 20.67 percent. Of this 20.57 percent was in Assam, 13.41 percent in Manipur, 3.72 percent in Meghalaya, 18.23 percent in Nagaland, 4.03 percent in Tripura, 6.28 percent in Arunachal Pradesh and 0.29 percent in Mizoram. Cropwise the largest amount of irrigated area is under rice cultivation which covers an area of 739,000 hectares.

Technological Factor:

Fertiliser and H.Y.V.: Fertiliser and High-yielding varieties of seeds are the two most important inputs required for increased agricultural production. But in respect of North Eastern region as a whole it will take more time to apply to a considerable extent these two important inputs. Their application depends to a large extent on assured water supply (i.e., irrigation) but already we have shown that artificial water supply facilities have not so far been extensive in the North Eastern region. However, so far the area under H.Y.V. in different states of the North Eastern region is concerned the position of 1973-74 is shown in the following table:

---

<table>
<thead>
<tr>
<th>Unit</th>
<th>Area Under Foodgrains (000 hectares)</th>
<th>Area Under H.Y.V. (000 hectares)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assam</td>
<td>2236.9</td>
<td>340.0</td>
</tr>
<tr>
<td>Manipur</td>
<td>179.2</td>
<td>35.0</td>
</tr>
<tr>
<td>Nagaland</td>
<td>95.2</td>
<td>11.11</td>
</tr>
<tr>
<td>Meghalaya</td>
<td>119.9</td>
<td>7.5</td>
</tr>
<tr>
<td>Tripura</td>
<td>304.9</td>
<td>52.16</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>62.3</td>
<td>5.40</td>
</tr>
<tr>
<td>Mizoram</td>
<td>77.6</td>
<td>0.60</td>
</tr>
</tbody>
</table>


Likewise if we observe data on total consumption of fertiliser per hectare of agricultural land we find that the position of this region in this respect is not at all satisfactory. In 1973-74, it was 0.35 Kgs. per hectare for Arunachal Pradesh, 2.47 Kgs. for Assam, 8.86 Kgs. for Manipur, 1.23 Kgs. for Meghalaya, 0.31 Kgs. for Mizoram, 0.97 Kgs. for Nagaland, 3.67 for Tripura as against 15.37 Kgs. per hectare in the country. Again, in 1974-75, it was 0.35 Kgs. for Arunachal Pradesh, 2.30 Kgs. for Assam, 10.90 Kgs. for Manipur, 11.40 Kgs. for Meghalaya, 0.31 Kgs. for Mizoram, 3.10 Kgs. for Tripura compared to all India
Modern Agricultural Implements: The supply position of farm power and improved agricultural implements in the North Eastern region is not hopeful. Hence this region constantly suffers from adequate supply of these implements. In the face of such inadequacy most of the farmers have not shown much interest in accepting such improved practices. This may be due to the fact that most of the farmers are small farmers who are not fully acquainted with the use and utility of such agricultural implements. It has therefore, resulted in the absence of Agro Service Centre so far in this region.

5.4.2. Trend Factor

Length of the season: The entire North Eastern region is blessed with a high monsoon rainfall. South west monsoon period covers the months from June to September. Pre-monsoon period covers the months from March to May. The North East monsoon period covers January and February and post monsoon period covers the months from October to December. Rice is the most important crop in the region. In Assam and Tripura winter rice is the most important crop, it is sown in the month of June - July and harvested in December - January. In Manipur autumn rice is the most important crop which is sown.

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9. Indian Fertiliser Statistics, 1974-75, Govt. of India.
in early June and harvested in August-September. In hill areas the first crop is sown during March-April in upland soil depending upon the pre-monsoon rain. In Jhum land also rice is sown at the same time.

Rainfall and humidity: The monsoon winds coming from the Bay of Bengal having been obstructed by the hills in the region cause heavy rainfall. The rainfall is however greater in the hill slopes than in the valleys. In summer this region is quite hot in the plain but in the hills temperature cannot be high due to elevation. In winter it is very cold in the hill areas but in the plain the temperature is not so low. The winter is practically dry. (Distribution of rainfall and humidity in each state of the North Eastern region have been discussed in detail in Chapter III).

It needs mention here that trend factor includes factors like climatic condition viz., rainfall, humidity, length of the season etc. In fact, these factors are common to both trend and location factors.

5.5. Estimation: In this section we are presenting the graphical analysis of the agricultural growth using the probabilistic model, i.e., the Reaction function. We have already presented the estimating equation in section 4.2.

The estimation of parameters is made
graphically by the principle of marginal probability. The regression lines are expected to be proportional and linear. The intercepts could be read from the graph. The graphical estimates of the other regression coefficient, i.e., $\beta$ should be nearly the same to confirm proportionality. However, we shall have two types of analysis - one for the location factor and the other for the trend factor.

Yield per hectare of total foodgrains (transformed into logarithms) for the period 1969-70, 1977-78 of each state of the North Eastern Region ($X_{ij}$) have been plotted in the graph papers against the average yield per hectare (of all states) of the whole North Eastern region ($X_{.j}$). These graphs as shown below reflect statewise variation in productivity in the region during the period 1969-70 - 1977-78.
STATEWISE YIELD PER HECTARE (LOG) OF EACH YEAR DURING THE PERIOD 1970-78, i.e. $X_{ij}$ AGAINST TOTAL AVERAGE YIELD OF ALL STATES, i.e. $X_j$.
Similarly, in order to show yearwise variation in growth of agricultural output, yield per hectare of total food-grains for each year of different states ($X_{ij}$) have been plotted against the average yield per hectare of the whole period from 1969-70 to 1977-78 ($X_i$). These graphs are shown below:
YEARWISE YIELD PER HECTARE (log) OF ALL STATES OF NORTH EASTERN REGION in X_i,j AGAINST TOTAL AVERAGE YIELD in X_{ij} FOR THE PERIOD 1969-70-1977-78

1969-1970
(8)

1970-1971
(9)
1975-1976
(14)

1976-1977
(15)
$x_{ij}$

1977 - 78

(16)
From these graphs it is observed that statewise variations in yield per hectare do not show any trend. This, however, means that there is no significant variation in growth or yield per hectare among different states of the North Eastern region during the period 1969-70 - 1977-78. Whereas yearwise variations in yield per hectare show linear trend. This means that there have been significant variations in yield per hectare among different years of the period considered, i.e., over time.

In the present analysis statewise variation is considered to be due to location factor whereas yearwise variation is due to trend factor.

5.6. Empirical Regression Models: In this section we are estimating the parameters of the regression function in which trend \( t \) is the only explanatory variable. The models have been described in section 5.3. The estimating equation is

\[ X_t = a + b_t \]

The same equation can be written as

\[ Y = a + b X \]

where \( Y \) = yield/per hectare for any period,

\( X \) = trend variable,

\( a \) & \( b \) = parameters of the equation.
The resulting equations for each state of the North-Eastern region are as follows:

1. Arunachal Pradesh:
   \[ Y = 881.87 + 10.33 X \]

2. Assam:
   \[ Y = 961.22 + 4.1167 X \]

3. Manipur:
   \[ Y = 1416.66 + 34.55 X \]

4. Meghalaya:
   \[ Y = 1054.11 + 1615 X \]

5. Mizoram:
   \[ Y = 843.67 - 46.52 X \]

6. Nagaland:
   \[ Y = 747.78 + 19.18 X \]

7. Tripura:
   \[ Y = 1032.89 + 47.17 X \]

Putting the exponential equation in logarithmic form gives:

\[ \log Y_0 = \log a + b \log X \]

Whereas we take the semi-log model,

\[ \log X_t = a + bt \] (section 5.3)

The trend equations in logarithmic form for each state are:

1. Arunachal Pradesh:
   \[ \log Y_0 = 2.9451 + .005128 X \]
2. Assam:
\[ \log Y_0 = 2.982356 + 0.001946 X \]

3. Manipur:
\[ \log Y_0 = 3.1469 + 0.01127 X \]

4. Meghalaya:
\[ \log Y_0 = 3.022339 + 0.006513 X \]

5. Mizoram:
\[ \log Y_0 = 2.920639 - 0.024783 X \]

6. Nagaland:
\[ \log Y_0 = 2.864056 + 0.0111716 X \]

7. Tripura:
\[ \log Y_0 = 3.006439 + 0.02025 X \]
5.7. **Conclusion**: The graphical estimates given by the probability model is explicit in the sense that in the absence of rigid economic theory on growth of agricultural output, the results reveal no linearity in spatial and trend factor (figs. 1-7). This may not be taken as a final verdict, since we have only a limited data. Time series type of analysis requires data over a longer period of time. Again, with this type of model, where the exogenous variable, i.e., the total over all the states is not free from the intrinsic effect of spatial difference, although such differences are distributed over all the years.

However, when we look at the other side of analysis that is when log value of output of each year for each state plotted against log value of average over the years we find significantly linear relationship. This could be interpreted that the trend is more influencing factor, which can be accounted for all the states. It can also be seen that as per dictum of marginal probability law, the tangent of the lines are almost the same for all the states (figs. 8-16).

Coming to empirical linear regression lines, we have a poor picture of the trend factor. The fluctuations in the growth rates of outputs are
varying from year to year. The log-linear equations, on the other hand, support the fact that there is trend in growth rates, as supported by the results given by the application of probabilistic model.

The difficulty for a complete comparability among the results given by regression model and probabilistic model is both logical and technical in nature. Probabilistic model splits the location factor and the trend factor and the regression model takes one factor at a time. The previous studies into regional variation cited in the chapter II of this dissertation have no analytical base except for the fact that two regions give two different yields per acre.