CHAPTER VII

YIELD UNCERTAINTY: AN EXPLANATION

We have noted above that prior to 1971, uncertainty seems to have accompanied stagnation rather than growth (a case of inverse relationship) and that the relationship underwent a significant change in the recent past. In the spatial (across district intra-sub-period) analysis positive relation seem to be dominating the growth-uncertainty nexus in the post-technology (post 1973 period) period. However, the relationship between growth and uncertainty as also the change in the relationship, is not exactly the same between the groups of DP and NDP districts. This raises the question of what explains the differential behaviour of uncertainty across districts.

Our classification of the districts into two groups of DP and NDP districts rests mainly on the climatic criteria. Hence, obviously the interest centres around the role of climatic (taking rainfall as the nearest proxy) factors in explaining uncertainty. This analysis is by no means striking although in the current literature a problem of this kind has received limited attention. Another important factor is the availability of irrigation and its impact on the level
of uncertainty across districts. As indicated elsewhere this will also help in testing the protective role of irrigation. It assumes additional importance because it is being analysed for a State with a vast drought zone and limited irrigation facilities. Our review of literature indicated a few explanatory variables of yield uncertainty apart from climate and irrigation, viz., extension of cultivation to marginal lands, improper use of new technology, greater synchronisation of yields, institutional factors etc. The focus of the present chapter is to attempt an explanation of the differential yield uncertainty in the inter-district context. We shall deal here only with the following questions: In particular,

(I) What is the role of climate (using rainfall as a nearest proxy) in explaining - inter-district variation in yield uncertainty and the year to year variation in yield?

(II) How far has irrigation been helpful in mitigating effects of climatic fluctuations? What is the role of irrigation in explaining inter-district variation in yield uncertainty? How far is the area irrigated itself sensitive to fluctuations in rainfall?
(III) What is the role of structural and institutional variables in explaining the inter-district variation in level of uncertainty? This includes testing of different hypotheses raised in the literature apart from probing into the explanation of uncertainty.

Rainfall and Yield Uncertainty:

We shall first take a look at the relationship between the level of rainfall (as a proxy for climate) and yield uncertainty across districts. This exercise is limited only to crop groups. Table 7.1 presents rank correlations between the level of rainfall with growth and uncertainty parameters of the districts.

Table 7.1: RANK CORRELATIONS BETWEEN LEVEL OF RAINFALL AND GROWTH AND UNCERTAINTY PARAMETERS 1951-52 to 1980-81

<table>
<thead>
<tr>
<th>CROP GROUPS</th>
<th>CROP GROUPS</th>
<th>CROP GROUPS</th>
<th>CROP GROUPS</th>
<th>CROP GROUPS</th>
<th>CROP GROUPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rank correlations of Normal Annual Rainfall with</td>
<td>Total Cereals</td>
<td>Total Pulses</td>
<td>Total Foodgrains</td>
<td>$A_{pc} a_c$</td>
<td>$A_{pc} a_v$</td>
</tr>
<tr>
<td>Growth Rates in Yields</td>
<td>$-0.09^{ns}$</td>
<td>$-0.08^{ns}$</td>
<td>$0.006^{ns}$</td>
<td>$0.07^{ns}$</td>
<td>$-0.26^{ns}$</td>
</tr>
<tr>
<td>Average yield per hectare</td>
<td>$0.68^{***}$</td>
<td>$0.18^{ns}$</td>
<td>$0.75^{***}$</td>
<td>$0.51^{***}$</td>
<td>$0.49^{**}$</td>
</tr>
<tr>
<td>CV/CVT in yield per hectare</td>
<td>$-0.54^{***}$</td>
<td>$-0.27^{ns}$</td>
<td>$-0.55^{***}$</td>
<td>$-0.24^{ns}$</td>
<td>$-0.28^{ns}$</td>
</tr>
<tr>
<td>Crop Loss Ratio in yield per hectare</td>
<td>$-0.43^{**}$</td>
<td>$-0.27^{ns}$</td>
<td>$-0.46^{**}$</td>
<td>$-0.26^{ns}$</td>
<td>$-0.23^{ns}$</td>
</tr>
<tr>
<td>Probability of failure in yield per hectare</td>
<td>$-0.18^{ns}$</td>
<td>$-0.08^{ns}$</td>
<td>$-0.25^{ns}$</td>
<td>$-0.28^{ns}$</td>
<td>$-0.14^{ns}$</td>
</tr>
</tbody>
</table>

Note: 1. Level of significance as used in the earlier chapters.
2. Rank correlations of yield uncertainty with variability in rainfall were also computed across drought-prone districts. Except a few all the correlation coefficients were statistically not significant even at 10 per cent hence are not presented here.
Apart from indicating the association of climate with the growth and uncertainty parameters, the correlations with level of normal rainfall also bring forth the relation of these parameters vis-a-vis drought-prone-ness of the districts. As expected, growth rates do not show any significant association with normal rainfall indicating that growth is not confined only to high rainfall (non-drought-prone) regions. However, normal annual rainfall has a positive association with average yield rates of total cereals, foodgrains and the two aggregate yield formulations. This brings forth the fact that high yield rates are still a prerogative of high rainfall regions.

As between the measures of yield uncertainty and level of normal rainfall majority of the correlations are low and statistically non-significant. It is only in the case of total cereals and total foodgrains that we come across statistically significant correlations of the degree of uncertainty with annual rainfall, though negative. This indicates higher yield uncertainty in the low rainfall regions for these two crop groups. Further, we also tested the relationship between rainfall variability (given by CV and PF in annual rainfall) and yield uncertainty for crop groups across drought-prone districts. The exercise yielded only a few statistically significant relationships. Probability of failure in annual
rainfall emerged with positive and significant association in a few cases, which indicates an obvious conclusion that uncertainty in yield is higher in the regions of high probability of failure.

In order to assess the impact of rainfall parameters on yield uncertainty, we have also worked out single variable linear regressions taking level of annual rainfall and its variability as independent variables, with yield uncertainty of crop groups as dependent variable. This provides us with a basis to test crop-weather relationship in greater details. We have restricted our analysis to three major crop groups (viz., Total Foodgrains, $A_{Y_{pc}}$ and $A_{Y_{pc_f}}$). Our explanatory variables include Normal rainfall (given by IMD sources), CV in annual rainfall and probability of failure of annual rainfall below 25 per cent of the average. Table 7.2 presents the results of our analysis.

Our analysis indicates how far the climatic variability (rainfall as a proxy) explains the inter district variation in yield uncertainty across crop groups. It may be noted that out of 16 equations only in the case of eight does the rainfall parameter emerge with a statistically significant slope coefficient. All the coefficients, however, have the expected sign. Normal Rainfall shows a negative sign indicating higher level
### Table 7.2
SLOPE COEFFICIENTS FOR RAINFALL PARAMETERS EXPLAINING YIELD UNCERTAINTY FOR CROP GROUPS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Dependent Variable</th>
<th>Normal Slope Coefficients</th>
<th>cv in Annual Rainfall Coefficients</th>
<th>PF in Annual Rainfall Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Slope</td>
<td>CV</td>
<td>PF</td>
</tr>
<tr>
<td>1.</td>
<td>CV/cv in Total Food Grains Yield</td>
<td>-0.006***</td>
<td>0.540** ns</td>
<td>0.565** ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.94)</td>
<td>(1.62)</td>
<td>(3.11)</td>
</tr>
<tr>
<td>2.</td>
<td>CV/cv in AY Pc³c</td>
<td>-0.004***</td>
<td>0.318⁴ ns</td>
<td>0.170⁴ ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.24)</td>
<td>(0.78)</td>
<td>(0.51)</td>
</tr>
<tr>
<td>3.</td>
<td>CV/cv in AY Pc³v</td>
<td>-0.004***</td>
<td>0.472⁴ ns</td>
<td>0.140⁴ ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.40)</td>
<td>(1.16)</td>
<td>(0.48)</td>
</tr>
<tr>
<td>4.</td>
<td>PF in Total Food Grains Yield</td>
<td>-0.004*</td>
<td>0.870*</td>
<td>0.611*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.84)</td>
<td>(1.97)</td>
<td>(2.07)</td>
</tr>
<tr>
<td>5.</td>
<td>PF in AY Pc³c</td>
<td>-0.003⁴ ns</td>
<td>0.684⁴ ns</td>
<td>0.775⁴</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.26)</td>
<td>(1.01)</td>
<td>(1.85)</td>
</tr>
<tr>
<td>6.</td>
<td>PF in AY Pc³v</td>
<td>-0.003⁴ ns</td>
<td>0.715⁴ ns</td>
<td>0.562⁴ ns</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.61)</td>
<td>(0.97)</td>
<td>(1.14)</td>
</tr>
</tbody>
</table>

**Notes:**
1. Based on cross-section of DP districts in the case of.
2. Figures in brackets are t values of the coefficients.
3. Level of significance as used in earlier chapter.
4. CV and PF in annual rainfall based on the longer time series of 71 years.

of yield uncertainty in low rainfall regions (the slope coefficients pertaining to normal rainfall include drought prone as well as non-drought prone districts). On the other hand variables representing rainfall uncertainty did not emerge significant except in four cases.
A limitation of the slope coefficients is that they do not indicate the variation explained in the dependent variable. It was noted that none of these variables could explain more than half of the variation in the dependent variable. Highest explained variation was 49 per cent in the equation pertaining to probability annual of failure in foodgrains yield and average rainfall, whereas, the lowest variation explained is in the case of two aggregate yield formulations explained by average annual rainfall and rainfall uncertainty indicators.

This brings out the role of climatic factors in explaining yield uncertainty in the inter-regional context. The variation unexplained by the climatic factors can be attributed to resource base, irrigation and other institutional variables. Moreover, this calls for a further analysis to assess the impact of rainfall on year to year variation in yield.

Crop-Weather Relationship:

The explanation of yield uncertainty with the help of climatic variability across districts only indicates the role of climatic factors in the inter-regional perspective and not intra-regional one. Regions as well

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1. In the inter-regional context, especially when the region is a district, the question of accurate specification of climate to explain adequately the variation in yield uncertainty across district does not arise. We have stated elsewhere that though the proper definition of climate sounds as an important argument - the meticulousness in the its definition at district level would not be very meaningful, especially when we are using yield data at district level. It is better to leave such minuteness in the definition of climate to the studies using data from experimental stations.
as crops may react in different way under different situations of climatic variability. Hence we have tried to examine the crop-weather relationship for a few important crops of the State. This will help us in knowing as to how much of the crop yield variation is explained by climate (rainfall as a nearest proxy).

For the purpose of our analysis we have selected six dry land crops (those which are mainly grown under rainfed conditions at times with supportive irrigation) namely: Kharif Jowar, Rabi Jowar, Bajra, Wheat, Cotton and Groundnut. The study period chosen for this analysis is the pre-technology period i.e. 1951-52 to 1971-72. This is done mainly to avoid the structural break due to technological change which occurred during 1973-74 in the State. Moreover, the role of climate was more prominent in the pre 1971 period than post 1973 period.

In order to overcome the problem of limited degrees of freedom we have pooled the districts-cropwise. Only those districts were selected for pooling which have relatively homogeneous agro-climatic and regional characteristics.

The pooling of districts is done as follows: Satara, Sangli and Beed for Kharif Jowar; Ahmednagar, Sholapur, Beed and Aurangabad for Rabi Jowar; Ahmednagar and Sholapur for Bajra (1st group) and Pune, Satara and Sangli for Bajra (2nd group); Aurangabad, Beed and
Osmanabad for wheat; Jalgaon and Buldhana for cotton; and Sangli, Satara and Sholapur for groundnut. While pooling the districts we have also considered the growing conditions of crops and hence bajra is split into two groups - the first group include chronic drought-prone districts of Ahmednagar and Sholapur, where the bajra is grown in a drought-prone environment whereas in the second group we have Pune, Satara and Sangli where the conditions are different. It is grown on hill slopes in Pune, Satara and Sangli districts.

The variables used in our regression equations are as follows:

\[ Y = \text{Yield per hectare of the crop concerned in Kgs/hec} \]

\[ Y' = \text{Detrended yield per hectare of the crop.} \]

\[ \text{Irri} = \text{Proportion of sown area irrigated under the crop.} \]

April, May = Actual Rainfall in mms for the concerned month.

\[ \text{AR} = \text{Average Annual Rainfall of the district, used as a proxy for inter-district differences.} \]

\[ \sum_{j=1}^{m} RF = \text{Sum of the monthly rainfall over the sowing and/or growing seasons (} m \text{ months).} \]

\[ T = \text{Time (used only when dependent variable } Y \text{ is unadjusted for trend) i.e., serial number of years.} \]

\[ \text{SNID} = \text{Seasonal Negative Deviation Index (negative sign ignored).} \]
### Table 1.3

**Regression Equations Pertaining to Crop-Weather Relationship**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Dependent Variable</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop - Kharif Jowar (n = 63)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Detrended Yield Rate</td>
<td>$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \epsilon$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$= 533.16 + 84.98 \text{ Irr } + 2.20 \text{ April } + 1.09 \text{ May } + 0.16 \text{ June} + 0.04 \text{ July}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.74) (1.98) (0.02) (1.72) (0.35) (0.20)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.28$</td>
<td>$DW = 1.18$</td>
</tr>
<tr>
<td><strong>Crop - Rabi Jowar (n = 64)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Detrended Yield Rate</td>
<td>$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \epsilon$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$= 677.19 + 86.42 \text{ Irr } - 17.70 \text{ SN D} + 0.07 \sum_{t=1}^{m} \text{ RF } + 0.003 \text{ AR}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(9.68) (3.96) (0.99) (0.34) (0.01)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.19$</td>
<td>$DW = 0.92$</td>
</tr>
<tr>
<td><strong>Crop - Wheat (n = 63)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Actual Yield rate</td>
<td>$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \epsilon$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$= -291.46 + 11.64 \text{ Irr } - 0.14 \text{ June} + 0.57 \text{ July } + 0.25 \text{ Aug} + 0.35 \text{ Sept}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.50) (2.02) (0.46) (1.20) (1.71)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.28$</td>
<td>$DW = 1.26$</td>
</tr>
<tr>
<td>5.</td>
<td>Actual Yield rate</td>
<td>$y = -385.35 + 12.96 \text{ Irr } + 19.07 \text{ SN D + 0.41 } \sum_{t=1}^{m} \text{ RF } + 0.70 \text{ AR } - 4.47$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.16) (2.37) (1.17) (2.58) (2.31) (1.51)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.27$</td>
<td>$DW = 1.42$</td>
</tr>
<tr>
<td><strong>Crop - Rabi Group 1 (n = 62)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Actual Yield rate</td>
<td>$y = 423.3 + 6.06 \text{ Irr } + 0.23 \text{ Aug } - 0.095 \text{ Sept } + 0.26 \text{ Oct } + 0.11 \text{ Nov}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.64) (1.85) (2.06) (0.63) (1.14) (0.36)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.02$</td>
<td>$DW = 2.03$</td>
</tr>
<tr>
<td>7.</td>
<td>Actual Yield rate</td>
<td>$y = 431.32 + 5.96 \text{ Irr } + 13.78 \text{ SN D } + 0.17 \sum_{t=1}^{m} \text{ RF } + 0.37 \text{ AR } + 0.69$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.54) (1.86) (1.40) (1.99) (1.64) (0.31)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.07$</td>
<td>$DW = 1.88$</td>
</tr>
<tr>
<td><strong>Crop - Rabi Group 2 (n = 62)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Actual Yield rate</td>
<td>$y = 1313.31 + 0.29 \text{ Irr } + 0.46 \text{ April } - 0.30 \text{ May } + 0.30 \text{ June } - 0.16 \text{ July}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(6.01) (0.05) (0.57) (1.13) (1.54) (0.50)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.55$</td>
<td>$DW = 1.78$</td>
</tr>
<tr>
<td>10.</td>
<td>Actual Yield rate</td>
<td>$y = 1330.14 + 1.03 \text{ Irr } - 13.08 \text{ SN D } - 0.06 \sum_{t=1}^{m} \text{ RF } - 2.78 \text{ AR } + 4.33$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.52) (0.18) (1.47) (0.65) (1.56) (2.54)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.57$</td>
<td>$DW = 1.81$</td>
</tr>
<tr>
<td>11.</td>
<td>Actual Yield rate</td>
<td>$y = 261.02 + 0.05 \text{ April } - 0.69 \text{ May } + 0.08 \text{ June } - 0.57 \text{ July } + 0.09 \text{ Aug}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(4.53) (0.04) (1.76) (0.27) (2.28) (0.45)</td>
</tr>
<tr>
<td></td>
<td>$R^2 = 0.01$</td>
<td>$DW = 1.00$</td>
</tr>
<tr>
<td>No.</td>
<td>Dependent Variable</td>
<td>Equation</td>
</tr>
<tr>
<td>-----</td>
<td>-------------------</td>
<td>----------</td>
</tr>
</tbody>
</table>
| 12  | Detrended Yield  | \[ Y' = 72.38 + 25.58 \text{Irri}^{***} - 1.05 \text{April}^{**} - 0.39 \text{May}^{*} - 0.03 \text{June}_{ns}^{ns} \\
|     | rate             | (1.82)   | (2.20)   |
|     |                  | (5.25)   | (1.81)   |
|     |                  | (2.06)   | (0.24)   |
|     |                  | - 0.003 \text{July}_{ns}^{ns} + 0.01 \text{Aug}_{ns}^{ns} + 0.04 \text{Sept}_{ns}^{ns} + 0.13 \text{AR}^{**} \\
|     |                  | (0.05)   | (0.13)   |
|     |                  | (0.33)   | (2.34)   |
|     |                  | \[ R^2 = 0.53, DW = 1.73 \] | |
| 13  | Detrended Yield  | \[ Y' = 9.12^{ns} + 26.13 \text{Irri}^{***} - 5.16 \text{SNDI}_{ns}^{ns} - 0.09 \sum_{j=1}^{n} \text{RF}^{ns} + 0.25 \text{AR}^{***} \\
|     | rate             | (0.27)   | (5.35)   |
|     |                  | (0.91)   | (1.43)   |
|     |                  | (2.80)   | (2.80)   |
|     |                  | \[ R^2 = 0.50, DW = 1.43 \] | |
| 14  | Actual Yield     | \[ Y = 462.44^{***} - 1.03 \text{Irri}_{ns}^{ns} + 0.01 \text{June}_{ns}^{ns} + 0.06 \text{July}_{ns}^{ns} - 0.10 \text{Aug}^{**} \\
|     | rate             | (3.04)   | (0.24)   |
|     |                  | (0.09)   | (0.74)   |
|     |                  | (2.06)   | (2.06)   |
|     |                  | - 0.05 \text{Sept}_{ns}^{ns} - 0.04 \text{Dec}_{ns}^{ns} - 0.46 \text{AR}^{**} \\
|     |                  | (0.99)   | (0.61)   |
|     |                  | (2.40)   | (2.40)   |
|     |                  | \[ R^2 = 0.11, DW = 2.01 \] | |
| 15  | Actual Yield     | \[ Y = 442.55^{**} - 0.18 \text{Irri}_{ns}^{ns} - 0.41 \text{SNDI}^{**} - 0.09 \sum_{j=1}^{n} \text{RF}^{***} - 0.35 \text{AR}^{*} \\
|     | rate             | (3.14)   | (0.04)   |
|     |                  | (2.38)   | (2.89)   |
|     |                  | (1.89)   | (1.89)   |
|     |                  | \[ R^2 = 0.22, DW = 1.87 \] | |
| 16  | Actual Yield     | \[ Y = 176.26^{**} - 9.10 \text{Irri}^{*} + 0.62 \text{May}_{ns}^{ns} + 0.85 \text{June}^{**} + 0.06 \text{July}_{ns}^{ns} \\
|     | rate             | (2.10)   | (1.93)   |
|     |                  | (1.19)   | (2.27)   |
|     |                  | (0.32)   | (1.45)   |
|     |                  | + 0.34 \text{Aug}_{ns}^{ns} + 0.04 \text{Sept}_{ns}^{ns} + 0.40 \text{AR}^{***} + 5.12 \text{T}^{ns} \\
|     |                  | (1.46)   | (2.97)   |
|     |                  | (2.97)   | (1.45)   |
|     |                  | \[ R^2 = 0.61, DW = 1.74 \] | |
| 17  | Actual Yield     | \[ Y = 223.39^{***} - 3.47 \text{Irri}^{*} - 1.80 \text{SNDI}_{ns}^{ns} + 0.19 \sum_{j=1}^{n} \text{RF}_{ns}^{ns} + 0.44 \text{AR}^{**} + 2.62 \text{T}_{ns}^{ns} \\
|     | rate             | (2.81)   | (1.79)   |
|     |                  | (0.12)   | (1.22)   |
|     |                  | (2.17)   | (1.79)   |
|     |                  | \[ R^2 = 0.59, DW = 1.92 \] | |

**Notes:**
1. Levels of significance as indicated in earlier tables.
2. Figures in brackets are t values.
3. Farrar-Glauber's Test: Multicollinearity indicated no presence of multicollinearity in the above equations.
It may be mentioned here that several alternative exercises were tried to find out which models gave the best results in terms of higher explanatory power, lower standard error of the equation and also the significance of individual variables and the degree of auto-correlation. The results are presented in Table 7.3.

As regards the rainfall variables each crop has a distinct behaviour with respect to the variables used. We have taken care while choosing the sowing and growing periods of the crops. In the case of kharif, jowar, April, May rainfall has a positive and significant impact on yield and September rainfall shows a negative and significant coefficient. This brings out the importance of pre-sowing moisture for the crop. Whereas, the September rainfall affects adversely reducing crop yields. Kharif jowar is prone to pests and diseases with a shower or two especially at the flowering stage or after that.

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2. This was accomplished with the help of: Indian Crop Calendar, (enlarged edition), Directorate of Economics and Statistics, Government of India, New Delhi, 1967.

3. Higher rainfall in the period when the crop is at flowering stage not only affects the quality of grains (yielding inferior red to brown colour grains) but also reduces its yield.
Timeliness in rainfall has its own importance as noted above, for kharif jowar but the Seasonal Negative Deviation Index (SNDI) does not emerge statistically significant, though it shows the expected negative sign (i.e., increase in the SNDI decreases the yield of the crop).

For rabi jowar, July and September rainfall emerged with positive and significant coefficients. This shows that it is not only the pre-sowing moisture that is important in the case of rabi jowar but also the growing season’s rainfall (September). Rainfall emerges as an important variable (apart from irrigation) in the case of rabi jowar. But the SNDI neither shows the expected sign nor is the coefficient, statistically significant.

Wheat is a rabi season crop and the equation explaining wheat yield brings out the importance of mid-season rainfall (i.e., for August) displaying a statistically significant coefficient for the same. Similarly, apart from irrigation, the seasonal total rainfall also emerged as a significant variable. However, timeliness of rainfall represented by SNDI did not emerge with statistically significant coefficient.

In the case of bajra we have different results for the two groups. In the first group which includes
Sholapur and Ahmednagar (chronically drought-prone districts of the State), we find that rainfall emerges with a statistically significant coefficient only in the case of two months.\textsuperscript{4} Even for these the sign is negative exhibiting adverse impact of April-May rainfall on bajra yield. It may be noted that bajra is a drought tolerant crop and its area is highly sensitive to the rainfall behaviour. In the event of an early season drought farmers tend to put their lands under bajra cultivation, which otherwise would have been used for other crops. On the other hand, the better prospects of the kharif season indicated by good pre-monsoon precipitation brings down the use of resources (in terms of area sown as well as purchased inputs) for this crop, consequently bringing down the yield of the crop.\textsuperscript{5} Hence, it is not necessary that only in the event of a drought that the yield rate of bajra should decline; it even shows troughs in the weatherwise good years.

Similar results hold true in the case of bajra for the second group of districts also except that irrigation emerges as a statistically significant variable in the second group.

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\textsuperscript{4} For equation no. 11 where May and July rainfall emerges statistically significant with a negative sign.

\textsuperscript{5} This is mainly because bajra is a low value crop, having lower yield rates and hence fetches very low gross returns per hectare.
Groundnut and cotton are the rainfed commercial crops of the drought-prone areas. In the case of cotton, SNDI (variable indicating timeliness of rainfall) emerged to be significant with the expected negative sign indicating the larger role of timeliness of rainfall in explaining variation in cotton yield. Among the monthly rainfall, the regression coefficient for August rainfall turned out statistically significant but with a negative sign. Given the disease-prone characteristic of cotton, the August rainfall hampers the crop yield rather than helping it. It is not the lack of rainfall but rather of the excess rainfall during August which harms the crop. Groundnut yield, on the other hand, responds positively to monthly rainfall and precipitation in the month of June turns out a statistically significant coefficient in the equation.

Though rainfall variables emerge with statistically significant coefficients in most of the equations, rainfall per se does not explain the major portion in yield variation. In fact, it was noted that rainfall (monthly, annual and even SNDI) does not explain more than 22 per cent of the total year to year variation in yield for these crops excluding groundnut. Rainfall explains

6. We came across two types of relationships here, the first being the relationship with early season’s rainfall and second with the later season’s rainfall. Each of these types can be effectively met by introducing proper type of new varieties. We shall discuss this point in the concluding chapter.
nearly 56 per cent of the variation in Groundnut yield. The rest of the variation in yield can be attributed to inputs, institutional variables and other structural characteristics. Irrigation is one such important variable causing year to year fluctuations in yield.

We have included irrigation as an additional variable in the analysis above. In almost half of the equations it turned out with a statistically significant coefficient. Kharif jowar, rabi jowar, wheat and bajra showed positive and significant regression coefficient for proportion of irrigated area indicating that there is a scope for increasing yield rates by bringing additional area under irrigation. There is however a paradoxical situation in the case of cotton and groundnut. The regression coefficients with respect to irrigation are negative but significant only in the case of groundnut. Both cotton and groundnut are mainly grown under rainfed conditions and irrigation is used in order to protect sudden drop in crop yields due to rainfall failure in crucial seasons. Hence, irrigation comes into picture when some damage is already done. The negative sign of the coefficients may be attributed to these reasons rather than interpreting it as a direct impact of irrigation.

Role of Irrigation in Stabilising Crop Yields:

Development of irrigation has been looked upon as an important strategy to cope with yield uncertainty.
The emphasis on irrigation in the development planning literature on Maharashtra State originates as much from its production (or gross income) augmenting role as from the yield stabilising role. Moreover, its importance was recognised as long back as the Royal Famine Commission in 1898. As regards the impact of irrigation on instability, Mehra felt that higher percentage of area under assured irrigation (tube wells in the case of Punjab) is likely to work as a force in stabilising yield. In two State level studies of Karnataka and Tamil Nadu, however, a contrary view was taken, it was observed that irrigation did not play a significant role in stabilising yields, and did not offer enough protection during severe drought since irrigated output tends to slump a little more than the output under dry farming. The quality as well as the use of irrigation can differ widely, accounting for a differential impact on stability across States. After all yield uncertainty across States has different factors affecting it, some of which may undergo change.


along with the development of irrigation and hence the experiences of the States will differ from one another.

We are interested here in the stabilising role of irrigation for yield uncertainty in Maharashtra. In the State, introduction of irrigation marked a change in cropping pattern and this change favoured cash crops, especially sugarcane. This tendency has put large chunk of irrigated area under sugarcane leaving food-grains and other crops vulnerable. The most appropriate method of assessing the impact of irrigation on stability is to compare instability under irrigated and unirrigated conditions. Data for this kind of exercise are, however, not available for Maharashtra State at district level. Moreover, across time period or cross-section it is difficult to specify situations on the basis of presence or absence of irrigation. Further, the proportion of area irrigated can serve as an independent variable in explaining variation in yield.

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10. Attwood argued his hypothesis of irrigation not helping to mitigate income instability somewhat on similar grounds. This holds true especially when irrigation beneficiaries change over from subsistence crops to cash crops. cf. D W Attwood, Raising Cane: The Political Economy of Sugarcane in Western Maharashtra, Ph D thesis, University of Pune, 1977.
tainty across districts.  

Table 7.4 presents results of our exercise.  

We have taken average proportion of irrigation for the 27 years period ending at 1977-78, because the data on irrigated area were not available for the latest years even at the Department of Agriculture at the time of processing. The equations pertaining to the set including only drought-prone districts did not yield any significant coefficients for irrigation, however, four out of the six equations tried for a cross-section of all districts (including DP and NDP districts) merged with statistically significant coefficient for irrigation. The exercise brings forth two implications regarding irrigation. Firstly, the equations pertaining to drought-prone districts suggest unresponsiveness of uncertainty with respect to irrigation, though the correlations between level of irrigation and uncertainty in the crop

11. It is better to use level of irrigation (represented by proportion of sown area irrigated) than growth rate in irrigation across districts. The latter may give spurious results especially when the base period level of irrigation is very low and it increases at a faster rate even when the end year proportion of irrigated land may be the lowest in that particular district.

12. We have tried two sets of data one with pooled cross-section of all the districts, whereas, the other only with 12 drought-prone districts.
TABLE 7.4

REgressions EXPLAINING IMPACT OF IRRIGATION ON YIELD
UNCERTAINTY

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Dependent Variable</th>
<th>Intercept</th>
<th>Normal Proportion of Rainfall</th>
<th>Irrigated Area</th>
<th>$r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Equations for All Districts - (n=25)

1. CV/cv in total foodgrains yield
   $33.75^{***}$ - $0.006^{***}$ - $0.232^*$
   (17.64) (5.66) (2.16) 0.60

2. PF in total foodgrains yield
   $40.78^{***}$ - $0.005^{**}$ - $0.546^{**}$
   (11.59) (2.63) (2.76) 0.35

3. PF in AY $p_{c,c}$
   $35.64^{***}$ - $0.004^*$ - $0.549^{**}$
   (9.31) (1.85) (2.57) 0.28

4. PF in AY $p_{c,v}$
   $35.952^{***}$ - $0.004^*$ - $0.345^*$
   (10.21) (1.97) (1.76) 0.21

Notes:
1. Normal rainfall as given in the publication of Indian Meteorological Department.
2. Proportion of Irrigated area for foodgrains is used as explanatory variable in the equations pertaining yield uncertainty in foodgrains. Whereas proportion of gross irrigated area to Gross sown area is used in the case of other variables. This is based on average of the period ending at 1977-78 (period for which data on irrigated area were available at the time of processing).
3. Level of significance as indicated in earlier tables.
4. The equations which did not yield a statistically significant coefficient with respect to irrigation variable are not presented here.
5. CV - coefficient of variation adjusted for linear trend and PF is probability of failure 10 per cent below the trend value.
groups indicate a negative association between the two. A similar situation was observed across crops in our earlier analysis. In other words the variation in uncertainty within the group of drought-prone districts is not explained by irrigation.

Secondly, irrigation turns out to be significantly influencing uncertainty in the analysis across all the districts. All the four equations (table 7.4) explaining uncertainty show statistically significant coefficients with respect to both the variables. The coefficients for irrigation show a consistent negative sign indicating lower uncertainty in high irrigated tracts or higher uncertainty in relatively unirrigated regions. These findings are important especially in the background of Attwood's thesis that irrigation did not help in mitigating instability in gross income in Western Maharashtra. Our results, however, do not support this view at macro level even for the same region. This calls for a proper irrigation strategy to help in stabilising yield.

13. Correlations between irrigation and uncertainty across DPDs are not of very high order and statistically not significant in most of the cases.

14. It may be noted that we did not get significant correlation in the group of DP districts. Hence, these results cannot be straightaway interpreted as an indication of irrigation helping stability (because of the negative sign of the coefficients).

Any such irrigation policy has to take into consideration the variation in irrigation (or water availability to be specific) due to climatic factors. The variation in irrigation can be analysed in two ways—firstly, through the variation in source-wise irrigation in response to climatic factors and second through the itself response of irrigated area under different crops to the climatic factors (especially in the period when crop yields were experiencing fluctuations more due to climatic factors). The response equations of source-wise irrigation to climatic factors will indicate the stability of the source of irrigation independent of climatic fluctuations.

For the purpose of our analysis we have chosen one each district which based on its dominant source of irrigation from among drought-prone districts. The variables used are as follows:

Y - Irrigated area under Canal irrigation for Ahmadnagar
- Irrigated area under Tank Irrigation for Beed
- Irrigated area under Well Irrigation for Sholapur
RF - Annual rainfall in the district
T - Variable used as a proxy for time trend,
### Table 7.5

**Equations giving response functions for source-wise irrigation to rainfall: 1951-52 to 1974-75**

**Ahmednagar: Canal Irrigation**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y = 435.309^{***} - 0.003 RF^{ns} + 2.071 T^{ns}$</td>
<td>(8.91)</td>
<td>(0.05)</td>
<td>(1.46)</td>
</tr>
<tr>
<td>$R^2 = 0.10$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sholapur: Well Irrigation**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y = 419.294^{<em><strong>} + 0.368 RF^{</strong></em>} + 10.33 T^{***}$</td>
<td>(5.274)</td>
<td>(3.53)</td>
<td>(4.03)</td>
</tr>
<tr>
<td>$R^2 = 0.58$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Beg: Tank Irrigation**

<table>
<thead>
<tr>
<th>Equation</th>
<th>Coefficient</th>
<th>Standard Error</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$Y = -56.63^{ns} + 0.067 RF^{ns} + 6.346 T^{***}$</td>
<td>(1.59)</td>
<td>(1.59)</td>
<td>(7.10)</td>
</tr>
<tr>
<td>$R^2 = 0.71$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

1. Level of significance as indicated earlier.
2. Data on source-wise irrigation were published only up to 1974-75 after which it is given only for two groups i.e., surface irrigation and well irrigation. Hence, the exercise could not be extended up to 1980-81.
Among the three sources of irrigation, tank irrigation shows highest coefficient of variation (CV) in area under tank irrigation. The CV for area under tank irrigation for Beed is 76.6 per cent as against 15.8 per cent for well irrigation in Sholapur and 9.8 per cent for canal irrigation in Ahmednagar. Annual rainfall seems to be significantly influencing the area under well irrigation for Sholapur. In the other two cases (canal and tank) it does not give a statistically significant coefficient. To some extent this indicates the vulnerability of well irrigation as a source of irrigation especially in Sholapur district. The positive sign of the coefficient indicates lower area under well irrigation in low rainfall years and higher area in the years of good rainfall. This is a typical characteristic of drought prone areas.

The non-significant regression coefficient with respect to rainfall in the case of canal and tank irrigation need not be taken as an indicator of non-sensitivity of these sources to rainfall. In fact it shows that canal irrigated area is fairly independent of fluctuations in rainfall at sub-regional or district levels, though even canal irrigation has to depend on rainfall in catchment areas. Canal irrigation is relatively more successful in stabilising yields because it can spread the risk of failure of rainfall over regions; whereas, in well irrigation, such independence from local rainfall is not demonstrated.
Our analysis above, however, brought forth an interesting result i.e., there is no unique source of dependable irrigation and the dependability of a source varies from region to region.\textsuperscript{16} Moreover, the process of decision making for irrigated area involves quite a few complex variables. The timeliness of rainfall is one such variable which induces the decision regarding area under irrigation. A dry spell in growing season compels to bring in more area under irrigation which again depends upon the individual crop and availability of irrigation. Hence, in order to analyse the decision mechanism with respect to area under irrigation we undertook an exercise explaining (through regression analysis) the variation in irrigated area under the crops with the help of monthly rainfall.

We have used the proportion of sown area irrigated under the crop as a dependent variable with the monthly rainfall over sowing and growing period as explanatory variables. Again we have pooled the data over the drought prone districts with similar agro-climatic

\textsuperscript{16} Well irrigation was noted as a stable source of irrigation for Punjab - cf. Shakuntala Mehra, \textit{Op. Cit.}
characteristics. 17 The analysis was carried out for the period 1951-52 to 1971-72. This is done to avoid the distortion of relationship due to structural break which occurred during 1973. Results of our analysis are presented in table 7.6.

We find that in most of the cases the intercepts emerge significant, from this it may be inferred that certain amount of irrigated area is assured, independent of rainfall. This was also observed in our exercise dealing with source-wise irrigation.

Rainfall in August emerges as a significant independent variable in the case of kharif jowar, rabi jowar and wheat. For all the three crops, the regression coefficient is negative indicating that 1 per cent decline in rainfall for August will induce 0.2, 0.1 and 0.4 per cent increase in the area irrigated under kharif jowar, rabi jowar, and cotton respectively. This is of course subject to the availability of irrigation and shows the inadequate protection available through irrigation. 18

17. We have used same districts across crops as are indicated in the section on Crop-Weather Relationship.

18. The average proportion of area irrigated under these crops and the variation therein is as follows:

<table>
<thead>
<tr>
<th>Crops</th>
<th>Average Proportion</th>
<th>CV</th>
<th>Crops</th>
<th>Average Proportion</th>
<th>CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif Jowar</td>
<td>1.73</td>
<td>68.8</td>
<td>Wheat</td>
<td>17.75</td>
<td>24.6</td>
</tr>
<tr>
<td>Rabi Jowar</td>
<td>8.16</td>
<td>38.1</td>
<td>Cotton</td>
<td>0.86</td>
<td>137.2</td>
</tr>
<tr>
<td>Bajra I</td>
<td>3.52</td>
<td>56.0</td>
<td>Groundnut</td>
<td>2.69</td>
<td>174.7</td>
</tr>
<tr>
<td>Bajra II</td>
<td>3.90</td>
<td>45.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 7.6

**SENSITIVITY OF AREA IRRIGATED UNDER CROPS TO SEASONAL RAINFALL: 1951-52 to 1971-72**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Dependent Variable</th>
<th>Crops</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Proportion of Irrigated Area</td>
<td>Kharif Jowar</td>
<td>$2.48^{**<em>} - 0.003$ April $^{nb} - 0.0001$ May $^{nb} - 0.0005$ June $^{nb} + 0.0001$ July $^{nb} - 0.002$ Aug $^{</em>} - 0.002$ Sept $^{ns}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(5.76)$ $(0.12)$ $(0.03)$ $(0.18)$ $(0.14)$ $(1.88)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$R^2 = 0.08$ $DW = 0.87$</td>
</tr>
<tr>
<td>2.</td>
<td>Rabi Jowar</td>
<td>$10.61^{<em><strong>} + 0.005$ June $^{nb} - 0.008$ July $^{nb} - 0.013$ Aug $^{</strong></em>} + 0.003$ Sept $^{nb} - 0.009$ Oct $^{nb}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(6.42)$ $(1.60)$ $(3.25)$ $(0.67)$ $(1.35)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$R^2 = 0.21$ $DW = 1.07$</td>
</tr>
<tr>
<td>3.</td>
<td>Bajra II</td>
<td>$3.55^{**<em>} - 0.027$ April $^{</em>} + 0.005$ May $^{nb} + 0.005$ June $^{nb} + 0.001$ July $^{nb} - 0.0005$ Aug $^{nb}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(5.32)$ $(0.84)$ $(1.49)$ $(0.89)$ $(0.21)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$R^2 = 0.12$ $DW = 1.02$</td>
</tr>
<tr>
<td>4.</td>
<td>Wheat</td>
<td>$4.99^{<em><strong>} - 0.004$ Aug $^{</strong>} - 0.01$ Sept $^{</em>**} - 0.002$ Oct $^{nb} - 0.006$ Nov $^{nb} - 0.003$ Dec $^{nb}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(8.10)$ $(2.39)$ $(5.06)$ $(0.74)$ $(1.45)$ $(0.42)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$R^2 = 0.38$ $DW = 1.79$</td>
</tr>
<tr>
<td>5.</td>
<td>Cotton</td>
<td>$7.29^{<em><strong>} - 0.008$ June $^{</strong>} - 0.01$ July $^{</em><strong>} - 0.002$ Aug $^{*} - 0.005$ Sept $^{</strong>} - 0.006$ Oct $^{**}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(7.82)$ $(2.65)$ $(0.85)$ $(2.33)$ $(2.09)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$R^2 = 0.51$ $DW = 2.15$</td>
</tr>
<tr>
<td>6.</td>
<td>Groundnut</td>
<td>$2.52^{**<em>} - 0.002$ May $^{nb} + 0.007$ June $^{nb} - 0.001$ July $^{nb} + 0.003$ Aug $^{nb} - 0.006$ Sept $^{</em>}$</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$(2.93)$ $(0.22)$ $(1.33)$ $(0.50)$ $(0.75)$ $(1.80)$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$R^2 = 0.08$ $DW = 1.34$</td>
</tr>
</tbody>
</table>

**Notes:**
1. Level of significance as indicated in Table 7.1.
2. Variables indicated by month names stand for the monthly rainfall in the indicated month.
It may be recalled that rainfall in August contributes between 13 to 22 per cent to the annual total in drought-prone districts and any shortfall in August rainfall ought to enhance irrigated area under the crops. Similar situation is in evidence for groundnut, proportion of irrigated area under groundnut is also sensitive to stress in September rainfall.

Bajra is basically a drought tolerant crop with very little area under irrigation. No meaningful conclusions can be reached from the results obtained for bajra I (the group of two chronic drought-prone districts), since most of the coefficients emerged statistically non significant. However, in the case of bajra in group II (districts of Pune, Satara and Sangli), the coefficient of April rainfall emerges significant with a negative sign. This demonstrates that failure of early season’s rainfall also increases area under irrigation. Any failure in pre-sowing rainfall brings down the soil moisture availability required for proper germination and hence needs higher proportion of area under irrigation.

Cotton is a commercial crop grown on deep black cotton soils especially in the Vidharbha region of the State. The variation in irrigated area under cotton is the second highest among the crops. We find that
this the irrigated area under crop is quite sensitive to fluctuations in monthly rainfall. Any failure of rainfall during June, July, September or October induces increase in proportion of area irrigated. Regression coefficients for these months emerge with statistically significant coefficients and also we note that more than 50 per cent of the variations in the proportion of irrigated area is explained by climatic factors.

Decision regarding irrigation rests on two basic considerations. Firstly, proportion of area irrigated under a crop increases with the failure of early season's rainfall in order to retain proper level of soil moisture. Secondly, the growing season's failure of rainfall is the most important in the life span of a crop and this failure quite often induces higher proportion of irrigated area subject to its availability. Moreover, when we consider the response of proportion of area irrigated under individual crops to rainfall, it is no longer only a question of how irrigation is susceptible to rainfall, but also one of how reallocation could take place from one crop to another within the irrigated area available. Irrigated area under a given crop would therefore, be more susceptible to rainfall than total irrigated area in a year. Moreover, gross irrigated area (total of all crops) may be still more susceptible than not irrigated area.
Sen's, Mehra's and Hazell's hypotheses tested for Maharashtra:

Given that the climate (represented by rainfall) and irrigation explain only a portion of the variation in yield uncertainty and both being non-consistent in their behaviour, one tends to question as to what are the other factors explaining yield uncertainty? In this context Sen, Mehra and Hazell have put forward a few interesting hypotheses. 19 Sen in his work while speculating about the factors behind increased instability asserted that the extension of cultivation to marginal land tends to increase uncertainty, especially when the growth in production comes via area augmentation. 20 We have noted earlier that area augmentation is still an important source of growth in Maharashtra, though not the highest contributing component of growth. In this context the extension of cultivation to new lands (quality of land—marginal or sub-marginal—cannot


20. Sen puts it as ....... "As acreage extends relatively marginal land: tends to be put under crops and such land is prone to be more adversely affected by weather hazards like drought" .... Op., Cit., p.7.
be straight away ascertained from secondary data will be represented by growth rate in gross cropped area.
In fact taking a second crop in a season of unassured water supply is equivalent to extension of cultivation to marginal lands.

Mehra's study also shows increased instability in the post new technology era. While looking into the causes of increased instability she came across positive association between the per cent of area under HYV and change in instability in yields.  
She further argues that irrigation helps in stabilising yield provided irrigation itself is stable.  Coming to the question of variations in the proportion of area under small/large farms across States and instability, she argued that small farms have less fluctuations. Taking cue from the argument of Rudra and Amartya Sen about the system of farming (whether it is wage based or family

22. This portion was tested in the earlier section.
based) she argued that intensive use of family labour and better irrigation on small farms are instrumental in reducing yield variability.  

In an inter-State analysis Hazell argued that increased instability can be mainly attributed to increase in the inter-crop and inter-State yield covariances.  

His argument shows that higher the synchronisation of yields in the inter-crop or inter-State situations – higher will be the instability. While giving explanation for the increased yield covariances he extends two reasons – firstly, because of the narrowing of the genetic base for rice and wheat resulting from wide spread adoption of high yielding varieties the inter-crop covariances have increased and second, the increased use of fertilizers and irrigation on cereal crops at a time when the supplies of these inputs have become more erratic.  

The hypotheses put forward by Sen, Mehra and Hazell are very interesting and need to be tested in the context of our study. Maharashtra offers a totally different canvas to test these hypotheses especially in the inter-district – intra-State situation. Here again we have made

26. Ibid., p.308.
use of regression analysis taking yield uncertainty for crop groups as dependent variables. The crop groups considered here are total foodgrains, $AY_{PcC}$ and $AY_{PcV}$. We have used here two measures of uncertainty in yields, namely, CV/CVT (coefficient of variation adjusted for trend) and probability of failure (PF) below 10 per cent of trend. The variables are as follows:

- $CV_1$ - CV/CVT in Foodgrain Yield
- $PF_1$ - PF in Foodgrain Yield
- $CV_2$ - CV/CVT in $AY_{PcC}$
- $PF_2$ - PF in $AY_{PcC}$
- $CV_3$ - CV/CVT in $AY_{PcV}$
- $PF_3$ - PF in $AY_{PcV}$
- NRF - Normal Rainfall for District (based on IMD Publications)
- ARF - Average annual rainfall of the period 1951-52 to 1980-81.
- CVR - Coefficient of variation in annual rainfall 1951-52 to 1980-81
- PFR - Probability of Failure in annual rainfall 1951-52 to 1980-81
- $IRRI_1$ - Proportion of area irrigated under Foodgrains
- $IRRI_2$ - Proportion of Gross Cropped area irrigated

27. We have used NRF and ARF here mainly because, ARF is not available for NDP districts and in such cases using NRF of NDP and ARF for DP districts would affect the results.
GRY1 - Growth rate in yield of total Foodgrains
GRY2 - Growth rate in aggregate yield (AY \_pc \_c^{a})
GRY3 - Growth rate in aggregate yield (AY \_pc \_v^{a})^{28}
GRGS - Growth Rate in Gross Cropped Area.

We have presented in table 7.7 two sets of equations, the first set is for the pooled observations of drought-prone and non-drought-prone districts, whereas, the second set gives equations pertaining only to the drought-prone districts.

Normal Rainfall emerged significant for three out of the four equations presented in the first set, whereas, in the second set variables representing uncertainty in rainfall did not emerge with significant coefficients for all but one equation. Secondly, irrigation also comes out with statistically significant coefficients in the case of two equations. Both the variables have expected relationship with yield uncertainty and the findings have conform to our earlier analysis.

In both the sets we have some equations with significant coefficients for growth rate in gross sown area. The variable shows direct relationship with yield uncertainty, or in other words, uncertainty is higher in the districts with higher growth rates in gross sown area.

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28. In case the growth rates are not significant we have taken zero instead of taking its actual value.
## TABLE 7.7
REGRESSION EQUATIONS EXPLAINING YIELD UNCERTAINTY

<table>
<thead>
<tr>
<th>Eqn</th>
<th>Dependent Variables</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) All Districts (n = 25)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Pf₁</td>
<td>42.330*** - 0.003 NA₁F₁** - 0.372 IRRI₁* - 5.328 GRY₁*** + 2.722 GRG₁ns (15.68) (2.33) (2.63) (3.94) (1.10)</td>
</tr>
<tr>
<td>2.</td>
<td>CV₁</td>
<td>33.119*** - 0.006*** NA₁F₁ - 0.217 IRRI₁* - 0.334 GRY₁** + 2.477 GRG₁ns (15.60) (5.33) (1.96) (0.32) (1.28)</td>
</tr>
<tr>
<td>3.</td>
<td>Pf₂</td>
<td>36.074*** - 0.002 NA₁F₁** - 0.261 IRRI₂* - 6.794 GRY₂** + 3.78 GRG₂ns (11.02) (1.28) (1.48) (3.75) (1.43)</td>
</tr>
<tr>
<td>4.</td>
<td>CV₂</td>
<td>23.342*** - 0.004 NA₁F₁** - 0.060 IRRI₂* - 0.290 GRY₂** + 4.223 GRG₂ns (10.83) (3.44) (0.51) (0.24) (2.45)</td>
</tr>
<tr>
<td>(B) Drought-prone Districts (n = 12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Pf₁</td>
<td>21.353* + 0.665 CV₁ns - 0.702 IRRI₁* - 2.124 GRY₁** + 2.455 GRG₁ns (2.12) (1.83) (2.28) (1.26) (0.91)</td>
</tr>
<tr>
<td>6.</td>
<td>CV₁</td>
<td>24.558*** + 0.326 PF₁** - 0.281 IRRI₁* - 0.968 GRY₁** + 4.555 GRG₁ns (7.47) (2.37) (1.81) (1.05) (3.21)</td>
</tr>
<tr>
<td>7.</td>
<td>Pf₂</td>
<td>42.270*** - 0.221 PF₁ns - 0.504 IRRI₂* - 7.732 GRY₂** + 8.527 GRG₂ns (4.72) (0.50) (1.47) (3.42) (2.31)</td>
</tr>
<tr>
<td>8.</td>
<td>CV₂</td>
<td>26.375*** - 0.209 PF₁ns - 0.160 IRRI₂* - 0.642 GRY₂** + 8.288 GRG₂ns (4.26) (0.62) (0.71) (0.41) (3.25)</td>
</tr>
</tbody>
</table>

Notes: 1. Level of significance as indicated in earlier tables.
2. Multicollinearity was tested for each of the equation with the help of Farez-Glauber’s test and it was not a serious problem for the equations presented here.
3. Figures in brackets are t values of the coefficients.
4. We also tried equations for All districts, taking a dummy variable for the two groups of DP and NDP districts. But the dummy variable did not give statistically significant results and hence dropped out.
This supports Sen's hypothesis in the case of inter-district picture for Maharashtra. The new land brought under cultivation seems to have contributed to the increase in uncertainty in those regions where such a phenomenon is predominant. These new lands are more vulnerable to weather fluctuation and especially when irrigation cannot be extended to such areas. Among the regions growth in gross sown area is more pronounced in the non-drought-prone districts.²⁹

Our analysis in table 7.7 brings forth four important points. Firstly, climatic factors as represented by level of rainfall and variation in it emerge with significant of the coefficients in some equations, but these variables do not seem to be acting as the major deciding factor of the variation in uncertainty.³⁰ Secondly, irrigation shows a strong protective role with consistent negative sign and statistically significant coefficients in a few equations.

²⁹ We have noted earlier that uncertainty is also high in the case of some of these non-drought-prone districts.

³⁰ In fact we find negative sign for the variable representing probability of failure in rainfall in the case of equations 7 and 8. Though the coefficients are not statistically significant the negative sign seem to indicate that within drought prone areas, higher probability of failure of rainfall need not always result into higher yield uncertainty. In fact, the impact of the higher probability of failure in rainfall is to a large extent nullified by adjustment mechanisms in the agrarian system of drought prone areas.
Thirdly, growth rate in yield of the crop groups concerned also shows a consistent negative sign and statistically significant coefficients in the case of equations 1, 3 and 7. This conforms to our earlier contention that growth is not confined only to low uncertainty (or non-drought-prone) regions but it has taken place in high uncertainty regions too. Lastly, our analysis confirms, Sen's hypothesis about the higher uncertainty in the regions where cultivation is extended to marginal and sub-marginal lands.

Other important group of variables explaining uncertainty include institutional characteristics of an agrarian economy. We have taken here only four representative variables in order to assess their impact on yield uncertainty namely, proportion of area under small holdings (below 2 hectares), proportion of area under large holdings (above 10 hectares) and average size of holding. Taking each of these variables as independent variable along with the yield uncertainty of crop groups (again we have restricted to only three crop groups (i) \( AY_{P_{C}^{2}} \), (ii) \( AY_{P_{C}^{4}} \), (iii) total foodgrains) as dependent variable, two variable linear relationships were worked out. We have presented the results of this exercise in table 7.8.

31. The data on these three variables pertain to 1976-77 derived from Agricultural Census - 1976-77 - Maharashtra State, Department of Agriculture, Government of Maharashtra, Pune, 1980.

32. Relationship of the type: \( y = a + b_1 x_1 + u \) where \( y \) stands for measure of uncertainty and \( x \) for institutional characteristics, taken one at a time, \( u \) is the usual stochastic disturbance term.
Before we come to the analysis of the results it may be recorded that the relationship between institutional characteristics (represented by three variables given above) and the degree of yield uncertainty is not uni-directional i.e., one being always an explanatory and the other one explained factor. But it is a bi-directional relationship where institutional characteristics decide the level of uncertainty and the level of uncertainty in turn alter the institutional characteristics. We are interested here in the first part of the relationship the latter part will be taken for analysis in the next chapter.

We observe here two types of relationships (see table 7.8) between the institutional parameters and yield uncertainty. Firstly, across districts - proportion of area under small farms show an inverse relationship with degree of uncertainty. This relationship here indicates lower level of yield uncertainty in the regions with the higher share of area under small farms. Secondly, we have direct relationship of the level of uncertainty with proportion of area under large farms and average size of holding across districts. The direct relationship indicates higher uncertainty in the districts with higher proportion of area under large farms and also large size of holding.
### TABLE 7.8
SLOPE COEFFICIENTS FOR INSTITUTIONAL VARIABLES EXPLAINING UNCERTAINTY

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Dependent Variable</th>
<th>Independent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% SF</td>
</tr>
<tr>
<td>1.</td>
<td>PF₁</td>
<td><strong>-0.47</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.21)</td>
</tr>
<tr>
<td>2.</td>
<td>PF₂</td>
<td><strong>-0.48</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.25)</td>
</tr>
<tr>
<td>3.</td>
<td>PF₃</td>
<td>0.37&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.94)</td>
</tr>
<tr>
<td>4.</td>
<td>CV₁</td>
<td><strong>-0.41</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.94)</td>
</tr>
<tr>
<td>5.</td>
<td>CV₂</td>
<td><strong>-0.36</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.31)</td>
</tr>
<tr>
<td>6.</td>
<td>CV₃</td>
<td><strong>-0.32</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(2.56)</td>
</tr>
</tbody>
</table>

**Note:** 1. % SF - Proportion of area under holding below 2 hectares - 1976-77; % LF - Proportion of area under holdings above 10 hectares - 1976-77; ASH - Average size of holding - 1976-77.

2. Codes for dependent variables are as explained in table 7.7.

3. Level of significance as indicated in earlier tables.
The relationships obtained above emerge out of three important theoretical issues namely - small farm efficiency, adjustment to droughts and commercialisation in agriculture. The inverse relationship between proportion of area under small farms and level of uncertainty indicates that the factors which explain why small farms seem to have higher productivity of land (small farm efficiency) - may also cause the inverse relationship - by reducing fluctuations on the small farms.\(^3^3\)

The converse of these arguments will also help in seeking explanation for the direct relationship between - proportion of area under large farms and average size of holding on one hand and level of uncertainty across districts on the other.

The factors dictating small farm efficiency are grouped into forces that drive small farmers to such efforts and the forces that permit them to undertake the efforts leading to reduction in yield uncertainty for a region (district in our case).\(^3^4\) Among the factors that permit a small farmer to reduce yield uncertainty are indivisibility of capital, better quality of land and the

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33. We take here a broader definition of the concept of efficiency i.e., higher productivity with relative stability.

34. This argument is parallel to what is argued by Ashok Audra about small farm efficiency. Here, we include reduction in overt fluctuations in yield (or uncertainty in yield) as a component of efficiency. For the discussion about small farm efficiency, see Ashok Audra: *Indian Agricultural Economics - Myths and Realities*, Chapter 7, Allied, 1982, pp. 150-189.
system of farming (viz., whether family labour or hired labour based). These factors help in improvement of efficiency on small farms and thereby reducing yield uncertainty. Among the forces that drive the small farmers in obtaining higher efficiency – the basic minimum consumption needs of a small farmer and lack of alternative sources of employment and income, are the two most important factors that help the farmer to obtain higher level of efficiency and consequently reduction in overt yield fluctuations (or yield uncertainty). The argument above also derives corroborative evidence from Mehra’s study in the inter-State context.

Availabilty of alternative earning also affect this behaviour. In the past, such opportunities were available only to large farmers. With the drought relief work’s becoming a prominent feature during drought years they have now become available to small farmers. It was observed that in the event of a severe drought a small and/or marginal farmer would prefer to work on relief works (if available) rather than undertaking cultivation. In Maharashtra the drought relief works are organised efficiently and hence one cannot rule out the importance of this factor. Though this mechanism

35. A word of caution will not be out of place here, i.e., the relationship explored above is not at farm level but across districts and hence no firm generalisation should be made out of these tentative speculations.
increase fluctuations in area and consequently production uncertainty it averts a decline in yields and loss of inputs.

However, even without relief works on the scene in a cross section of districts or regions there can exist a negative association between the dominance of relatively small holdings and level of yield uncertainty and consequently a positive association between the dominance of large holdings and uncertainty. This is simply because regions with lower uncertainty and higher yields can make relatively smaller holdings also viable and survivable through droughts, and hence pressure on land increases. In regions with higher uncertainty and lower yields this threshold of survivability has to be necessarily at a higher size of holdings. The argument that small farms are inherently -- without relief works -- better adapters counter to the widely observed phenomenon that they are more vulnerable to droughts.

Another factor which affects the level of uncertainty through modifications in institutional variables is the commercialisation of agriculture. The impact of commercialisation of agriculture on level of uncertainty can be viewed in two ways. Firstly, the increase in commercialisation induces importance of cash crops and as a result other low value crops are neglected for their share of resources. Secondly, commercialisation brings in

38. We shall deal with the working of adjustment mechanisms in the next chapter (Chapter VIII).
now forces of instability like higher role of purchased inputs, market forces etc. This in turn increases instability through changes in crop pattern and cultivation practices. The larger proportion of area under large size of holding indicates the larger share of dynamic (resourceful) farmers and greater possibility of commercialization. This leads to higher uncertainty in yields.

Diversification as an instrument of reducing uncertainty in gross production or aggregate yields also acts through the institutional factors. More diversification is seen in the situation of small farms 39 thereby reducing uncertainty in the regions with larger proportion of area under small holding.

We may now look into the explanation of the variation in level of uncertainty across districts through the main components of new technology. For the purpose of our analysis we have taken two variables representing the role of new technology namely: (i) Proportion of area under High Yielding Varieties (1980-81) and (ii) Per hectare consumption of chemical fertilisers (NPK total)-1980-81. The role of fertiliser use in Maharashtra is limited compared to some other states of India. The State shares only 7.4 per cent of the total fertiliser use of the country. Moreover, fertiliser

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consumption also showed higher inter-district variability in the State. In order to assess the impact of fertiliser use and area under HYV on the inter-district variation of uncertainty in yields we have worked out regressions taking yield uncertainty for crop groups as dependent variable and each of the two as explanatory variable. Results of the analysis are presented in Table 7.9.

**Table 7.9**

Regression Equations showing Impact of Fertiliser Use and HYV on Yield Uncertainty Across Districts

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Dependent Variable</th>
<th>Equation</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PF in Foodgrains Yield</td>
<td>$25.90^{**<em>} + 0.08^{</em>} \text{HYV}^{ns}$</td>
<td>0.03</td>
</tr>
<tr>
<td>2.</td>
<td>CVTin Foodgrains Yield</td>
<td>$22.64^{**<em>} + 0.04^{</em>} \text{HYV}^{ns}$</td>
<td>0.01</td>
</tr>
<tr>
<td>3.</td>
<td>PF in AY $P_{c}^a_c$</td>
<td>$29.19^{*<strong>} - 1.53^{</strong>} \text{FU}^{**}$</td>
<td>0.17</td>
</tr>
<tr>
<td>4.</td>
<td>CVTin Foodgrains Yield</td>
<td>$26.10^{**<em>} - 0.66^{</em>} \text{FU}^{ns}$</td>
<td>0.06</td>
</tr>
<tr>
<td>5.</td>
<td>CVTin AY $P_{c}^a_v$</td>
<td>$22.90^{*<strong>} - 1.22^{</strong>} \text{FU}^{**}$</td>
<td>0.33</td>
</tr>
<tr>
<td>6.</td>
<td>CVTin AY $P_{c}^a_v$</td>
<td>$23.41^{**<em>} - 0.76^{</em>} \text{FU}^{*}$</td>
<td>0.11</td>
</tr>
</tbody>
</table>

*Notes: 1. FU - Fertiliser Use in Kgs per hectare. HYV - Per cent of area under high yielding varieties to total area sown under the crops. 2. Level of significance as indicated in earlier tables.*

---

The relation between uncertainty does not appear to be inherent in the physical character of the technology but seems to arise mainly from its socio-economic context. Firstly, it is commercialization of agriculture due to the advent of new technology and relative neglect of the other crops for resource allocation etc. Secondly, improper adoption of technology especially in the rainfed agriculture and for the crops like jowar, bajra, groundnut and pulses. 41

Our results presented in table 7.9 indicate that proportion of area under HYVs did not emerge with a statistically significant slope coefficient. Moreover, the correlations of per cent area under HYV with uncertainty indicators for crop groups are in the range of 0.05 to 0.18 (all not significant even at 10 per cent level). This suggests very little role of HYVs in explaining the inter-district variation in uncertainty for crop groups. In fact the spread of HYVs in Maharashtra is quite even across districts and we do not come across any clustering of districts in/Adoption of new technology.

Taking fertilizer use as another indicator of new technology, we tried to examine its impact on yield

41. Mohra's argument about the association between the amount of area planted with the HYV's and fluctuations in yields is on similar lines, where, she tried to bring out the role of assured irrigation along with adoption of HYVs or in other words stressed on the package approach of new technology. cf. Shakuntala Mohra, Op. Cit., p.27 and 37.
uncertainty in the inter-district context. While raising issues in the context of growth-instability debate Sen has also pointed out the increased use of fertilisers as a contributory factor in increasing instability if corrective action is not taken simultaneously. In other words, contribution of HYVs to instability is likely to be more if proper land and water management practices are not adopted.

Our results, however, indicate a contrary situation. Per hectare consumption of fertilisers emerged as a significant variable explaining inter-district variation in uncertainty. But the sign of the coefficient is consistently negative thereby indicating that fertiliser use is concentrated in the districts with lower level of yield uncertainty for the crop groups concerned. Moreover, if these results are read with the results of 'non-significant impact' of HYVs area, they suggest a proper adoption of new technology across districts in the State without increasing yield uncertainty.

We have noted in Chapter V earlier that uncertainty in yields has decreased over the sub-period in Maharashtra. This situation is different as compared to the one observed at all India level by Mahra or for States like Andhra.

Pradesh and Karnataka. Moreover, it occurred in a State with vast area under drought zone. In the following paragraphs we intend to seek an explanation for this decreased uncertainty over sub-periods, across districts for the crop groups.

It is important to determine if there is any association between the decreased uncertainty in yield for crop groups and the two variables representing adoption of new technology (i.e., per cent of area under HYV and fertiliser use per hectare) across districts. This is examined by estimating rank correlations between yield uncertainty of the crop group (we have taken again three crop groups (i) total foodgrains, (ii) \( \bar{Y}_{p_{ac}} \), (iii) \( \bar{Y}_{p_{cv}} \) and proportion of area under HYV and fertiliser use per hectare. The results of the exercise are presented in table 7.10.

All the correlations reported in the table are not statistically significant even at 10 per cent level. This is contrary to what Mahra observed at all India level across States. It may be noted that even our earlier

TABLE 7.10
RANK CORRELATIONS BETWEEN PERCENTAGE CHANGE IN UNCERTAINTY IN YIELD OVER SUB-PERIODS AND PROPORTION OF AREA UNDER HYV AND USE OF FERTILISERS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Crop Groups</th>
<th>Rank Correlation of Percentage Change in Yield Uncertainty (CV/CVr) with Proportion of Area Under HYV</th>
<th>Fertiliser Consumption per Hectare</th>
</tr>
</thead>
</table>

Set (A) Across All Districts (n = 25)

1. Total Foodgrains  
2. AY ${P_c}_{oc}$  
3. AY ${P_c}_{ov}$

Set (B) Across Drought-prone Districts (n = 12)

1. Total Foodgrains  
2. AY ${P_c}_{oc}$  
3. AY ${P_c}_{ov}$

Notes: Level of Significance as indicated in earlier tables.

exercise also showed no significant impact of new technology on the variation in yield uncertainty for crop groups across districts. Based on the evidence here we can infer that HYV has no direct impact on either increasing or decreasing uncertainty in the case of Maharashtra. Though we have observed earlier higher use of fertilisers in the districts
with lower uncertainty, even then it cannot be taken as a cause and effect relationship due to the limited evidence. Naturally then the question arises about what caused the decrease in yield uncertainty for crop groups over the sub-periods?

This leads us to the hypothesis raised by Hazell namely ... the increase in inter-State (region) and inter-crop covariances are the main source of increased instability. We, however, do not have a situation of increased uncertainty; on the contrary yield uncertainty has declined in the post-1973 period in the State for the crop groups including total foodgrains. We are on the look out for the case if de-synchronisation of intercrop and inter-district yield variation which should have caused the decrease in the level of uncertainty for crop groups or at State level. We have defined synchronisation of yields as the correlation of yields instead of taking their covariances alone. Apart from testing this at State level we have also taken two cases of chronic drought-prone districts of the State, namely, Sholapur and Ahmednagar. It may be noted that these two districts also had shown decreased uncertainty in foodgrains yield despite being chronic drought-prone districts.

We have worked out inter-crop correlations for the two districts and State, for the detrended yield series for
sub-periods. Table 7.11 presents proportion of intercrop correlations which have decreased or increased over the sub-periods.

**Table 7.11**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Region</th>
<th>Decreased</th>
<th>Increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sholapur</td>
<td>76.2</td>
<td>23.8</td>
</tr>
<tr>
<td>2</td>
<td>Ahmadnagar</td>
<td>65.7</td>
<td>14.3</td>
</tr>
<tr>
<td>3</td>
<td>State</td>
<td>90.5</td>
<td>9.5</td>
</tr>
</tbody>
</table>

It may be noted that the intercrop correlations have decreased in the II sub-period in more than 70 per cent of the cases. The phenomenon is more prominent in the case of intercrop correlations at State level where 90 per cent of the crop combinations show decline in their correlations. Both the chronic drought-prone districts also show decline in their intercrop correlations. This conforms to the expected pattern and the lower uncertainty in yields of foodgrains can be attributed to the increasing intercrop desynchronisation. In fact at State level more than 45 per cent of the intercrop correlations have changed from positive in the I subst-period, to negative in the II subst-period.
This analysis has identified two major components to the change in yield uncertainty of total foodgrains across sub-periods. These are the decrease in the inter-crop correlations for a region (district and State) and such decrease taking place even in the drought-prone districts of the State. One tends to question here—why have these changes occurred? Substantial research has to be done in order to answer this question, but we can give some tentative speculations here based on earlier research done and the insights offered by our earlier analysis. Given the impact of improved technology and the relationship of proportion of area under HYV and fertilizer consumption with the variation in yield uncertainty (across districts or change between sub-periods as observed earlier), it is tempting to conclude that the spread of the new technology is such that it encourages crop combinations which are negatively correlated thereby reducing yield uncertainty for the crop group. Secondly, the history of droughts and famines (or should we call it as experiences with), in the fifties and sixties helped the cultivators to develop crop combinations which are weakly correlated. This helps in harvesting good yield from one of the crops even if the other crop fails. It is a welcome feature that such combinations emerged during the period of new technology. Apart from the above reasons—changing weather and adjustment to this changing pattern, stabilisation
of supply of inputs, and proper adoption of the new technology may also help in explaining this situation.

To sum up, the chapter mainly focused on the explanation of yield uncertainty in Maharashtra with the help of agro-climatic, structural and institutional variables. Climatic variables like normal or average rainfall and variations therein explained up to 49 per cent of the inter-district variation in yield uncertainty. This questions the role of climate (using rainfall as a proxy) in explaining variation in uncertainty across districts. A crop-weather relationship study for six dry-land crops also broadly indicate the limited role of climate. This exercise also brought out the importance of rainfall in early season and growing season for the crops. The exercise suggests development of short duration crops taking advantage of early season rainfall and avoiding late monsoon uncertainty in rainfall, will go a long way in coping with climatic uncertainty.

Development of protective irrigation is a most sought after strategy to meet yield uncertainty. We came across the stabilising impact of irrigation on yield uncertainty. It was noted that as the proportion of irrigation increases - yield uncertainty tends to decline for the cross-section of the districts. Well irrigation in Sholapur district was sensitive to changes
in rainfall suggesting that irrigation itself can be unstable and non-dependable especially in the event of a severe drought. The sensitivity of irrigated area under dryland crops to the monthly rainfall indicated the decision criteria followed in the cultivation practices of different crops. The decision of increasing area under irrigation for a crop rests on two considerations. Firstly, in the event of failure of early season rainfall (especially of August in the case of rabi crops) and secondly, when the growing season rainfall is very scanty and insufficient. This if read along with the instability in the source of irrigation suggests that there is a pressing need to frame a proper irrigation policy in the State to support crop failures, especially in the growing season droughts.

While explaining variation in yield uncertainty across districts, we have also tested different hypotheses raised in the literature. The extension of cultivation to marginal lands seems to be associated with higher yield uncertainty in the inter-district context in Maharashtra. The new areas brought under cultivation (either by cultivating second time or for the first time) seem to be more vulnerable to climatic fluctuations. This phenomenon, however, is prominent among non-droughtprone districts.
Among the institutional variables we noted inverse relationship of the proportion of area under small holdings with uncertainty in crop groups across districts and direct relationship with the proportion of area under large holdings and average size of holding. The factors explaining small farm efficiency, farmer's adjustments to droughts and commercialisation of agriculture also help in explaining these relationships. Institutional characteristics emerged out as an important set of variables in seeking explanation of the inter-district variation in yield uncertainty.

An attempt to seek explanation of inter-district variation in yield uncertainty through the main components of new technology did not conform to the findings of Hazell or Mehta. Both the major components of new technology namely - proportion of area under HYVs and consumption of fertilisers per hectare do not have an uncertainty increasing impact (both across district and over sub-periods). In fact new technology seems to have reduced the rigour of uncertainty, let alone increased it. Greater de-synchronisation of demanded yield of crops was noted in the post technology period (1973-74 to 1980-81). This caused the decrease in uncertainty over the sub-periods. These crop combinations seem to have originated from the interaction of new technology with the experience of droughts in the past. The de-synchronisation was also observed for chronic drought-prone districts like Sholapur and Ahmadnagar, which is a heartening feature.