CHAPTER II

REVIEW OF RELATED LITERATURE

A number of studies touching various aspects of risk and uncertainty in agriculture are available. In order to prepare a review of these studies, we have grouped them into three broad themes though some overlapping could not be avoided.

1. Studies dealing with uncertainty from farmers' angle and modelling farmers' decision making process; their attitude towards adjustment to risk and uncertainty.

2. Studies mainly devoted to analysis of weather behaviour, rainfall and its variability, crop-weather relationship, use of weather as an exogenous variable, separation of not weather effects etc.


Modelling for Decision Making under Uncertainty:

Decision making under uncertainty at farmers level has been a subject of discussion in the recent past. Many studies have used different types of decision theory
models and these can be grouped into three broad groups. 1
Firstly, there are the models based on the minimisation
of risk or uncertainty subject to some constraints using
linear or non-linear programming. Secondly, there are
models based on Game theory using expected utility and
Bayesian/Bernoullian models. These models consider
different phases of the factors governing uncertainty
and the strategy adopted by the decision maker in these
models is to fish out the least variance attached to it
as an efficient strategy. The Bayesian or Bernoullian
type of models make use of the decision maker's knowledge
of past probability to generate future strategy of
minimum risk. Thirdly, we have Lexicographic Safety
First (LSF) type of models which intend to maximise
expected value whenever the chance constraint is met
and minimise the probability of disaster when it was

1. James A. Roumaas et al., *Rice and Risk: Decision Making
among Low Income Farmers*, North Holland 1976;
Decision Analysis*, Iowa, 1977; James A. Roumas et al.,
Jean-Marc Bousard and Inderjit Singh (Eds.), *Risk and
Uncertainty in Agricultural Development*, SEARCA & ADC,
1979; R. B. How and P. B. R. Hazell, *Use of Quadratic
Programming in Farm Planning Under Uncertainty*, Cornell
University Press, 1968; P. B. R. Hazell, "A Linear
Alternative to Quadratic and Semi-Variance Programming
for Farm Planning Under Uncertainty", *AJAE*, Vol. 53(1),
1971, pp. 53-62; Mruthyunjaya, *An Economic Analysis of
Risk on Drought prone Farms in Bijapur, Karnataka,
not.\(^2\)

The models mentioned above are essentially used with the farm level data and the results suggested by them are of little use in handling broader level planning problems, since much greater knowledge is needed about different groups of farmers in different regions.\(^3\) An objective assessment of the nature, magnitude and impact of uncertainty and optimization at regional level has been out of the scope of these type of studies. Secondly, some of the above studies are normative in character and intended to prescribe what is desirable to the farmers under certain assumptions about the risk attitudes indicated by them (even sometimes assumed). Even at the micro level these models won't fetch desired success unless we have information about the differential risk attitudes of the cross section of farmers and their ways of adjustments.

A study by Binswanger to assess the risk attitudes of rural households in semi-arid tropics of India assumes

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2. Here we have not discussed all the types of models based on decision making under uncertainty since they are out of the scope of the present study. Our attempt here is only to indicate the trends in the decision theory and not to give an exhaustive review. For a detailed review, please see J. A. Roumasset, Jean-Mare Boussard and Inderjit Singh (ed.), _Risk, Citi.

importance in this context. His findings show that higher level of risk in such areas leads to under-investment in agriculture relative to the expected profit maximising levels. He found that the progressive farmers are slightly less risk averse than average farmers at high pay/levels. He noted a negative relationship—though not strong, between risk aversion and size of landholding. If the holdings had been standardised for irrigation differences, the negative relation would perhaps have emerged stronger than what he encountered. He also found that farmers belonging to the areas which had the worst history of droughts, were more risk averse than their counterparts in other areas. This was evinced by the higher risk aversion among farmers belonging to Sholapur as compared to those of Akola or Mahbubnagar.

However, the drought situation cannot just be analysed in the context of risk taking or risk averting attitudes, especially so in the case of small farmers in droughtprone areas. The destitution and loss of assets that each drought brings to the farmers leads them towards pauperisation. Their adjustment mechanisms prove to be ineffective. Jodha’s study on the effectiveness of farmers’ adjustments to droughts, examined this

aspect. He documented the available evidence about farmers' adjustment to droughts through (1) reduction in consumption, (2) asset depletion, (3) out migration, (4) borrowings in cash and kind and (5) traditional informal cooperation. In the case of the small and marginal farmers, the adjustments through disposal of that assets, pauperise them to such extent that they even tend to lose the wherewithal to undertake cultivation in the next season. This sometimes results in shifting of their occupation from cultivation to casual/agricultural labour. Jodha has pointed out how badly the small and marginal farmers are placed as far as these mechanisms go, and how drought has its effects fully realised in the case of these classes.

Uncertainty in agriculture can also modify institutional structure in agriculture, though of course it cannot be the only factor determining it and, historical and politico-economic factors also play an important role. In this context Hanumantha Rao's study assumes importance. He observed that the crop sharing type of arrangements were common in the areas where decision making had a very little role to play i.e., in the areas

of relative economic certainty and where entrepreneurial profits were very low. On the other hand, in the areas where decision making had a significant scope, crops concerned were highly profitable and fixed cash rents seemed to be common.

II. Weather and Uncertainty:

Weather is one of the important determinants of uncertainty in agriculture especially when it comes to drought-prone areas. Weather in itself is a complex of all the parameters excluding those controlled by man. Rainfall serves as a closest proxy for weather, since weather is not easily quantifiable.

We are interested not in rainfall per se but in its effects on crop production. Our interest centres around three themes in the study of rainfall data, namely prediction of rainfall or droughts, patterns in its incidence and variability and the periodicity of occurrence with the focus on explaining yield uncertainty.

Harold Mann's study can be considered as the first of its kind in India. Mann examined most of the aspects mentioned above. He noticed that the "effective

rainfall did not show any tendency to increase or decrease over years. It also did not indicate any kind of cycles and/or periodicities. The prediction of seasonal rainfall based on the pre-season showers was ruled out due to very low correlations. The study confirmed the relationship between "wetness" and "agricultural success", though it did not give any clue to the prediction of famines in future. In a followup study Rangarao and Panditrao extended the analysis for the same stations over some more years. They also obtained similar kind of results and did not see any diversion in the patterns of correlates observed in the earlier period. However, they noted that the rainfall data of a single rain gauge station cannot be taken as a representative of the district as a whole and that the yield data from crop estimation surveys should be used rather than those based on 'annavaxi' estimates. Hence it is necessary to use average rainfall of the standard rain gauge stations at district level while using crop production data of a

8. Mann arrives at the effective rainfall through some kind of subjective rules, it is the amount of rainfall needed for plant growth excluding run off and evaporation. One cannot deny the practical applicability of these rules even overlooking the subjectivity gone into framing them.


10. We find an indirect confirmation of the absence of trend in the rainfall data over these stations, since the results are almost similar for the two periods.
Scientists at the Indian Meteorological Department (IMD) have done substantial work on analysis of rainfall data. The National Commission on Agriculture (NCA) in one of its volumes reviewed in brief the studies on the nature and variation of rainfall, its frequency distribution, break periods, meteorology of crop production, crop-weather studies, drought prediction, forecasting and other allied aspects.\(^\text{11}\) Greater stress was given on rainfall regionalisation, taking into consideration the normal monthly distribution and recommending suitable crop pattern for the rainfall regions.\(^\text{12}\) The intra-subdivisional - across months - and the inter-subdivisional correlations did not yield any fruitful results as far as predictability of rainfall for a particular month or subdivision is concerned.\(^\text{13}\)

Attempts to establish existence of periodicity or cycles in the rainfall series if any, have invariably

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\(^{12}\) Ibid., p.21 and also see B C Biswas and N N Khambhat, "Reorientation of Cropping Pattern on the Basis of Probabilistic Moisture Availability Index", *IJAF*, Vol.35(2), April–June 1980.

\(^{13}\) K N Rao, S Jayanti and V K Bhargava, "Indian Monsoon Correlations for all the Meteorological Subdivisions of India", *Meteorological Monograph* No.4, IMD, Pune, 1972.
attracted the concern of researchers dealing with rainfall data, but it has met with very limited success.

A study by Louis Bean\textsuperscript{14} established some kind of "Retro-Symmetry" in the rainfall series of Akola, Ludhiana, Patna and Madras. He argued that rainfall patterns are similar on two sides of the 'focal point's, and that the tracing of these points will help in predicting rainfall. However, another study of over 150 years of Madras ruled out any kind of periodicity or cycles.\textsuperscript{15} Evidence from several other studies refute any presence of cycles or periodicities in rainfall series and hold that occurrence of rainfall is a random phenomenon.\textsuperscript{16} The report of the National Commission on Agriculture avowedly records that, by and large, no success has been achieved in forecasting rainfall in advance.\textsuperscript{17}

\textsuperscript{14} Louis Bean, "A New Approach to Statistical Forecasting of Next Years Weather and Crops", \textit{Agricultural Situation in India}, March 1969.


\textsuperscript{17} \textit{Op. Cit.}, Report of the National Commission on Agriculture, pp.22, 37 and 38.
On the other hand, a study by Raghavendra on the
trends and periodicities of Meteorological Subdivisions
of Maharashtra raises some hopes to re-examine the
existence of periodicities.\textsuperscript{18} He concludes that the
annual and monsoon rainfall of Konkan indicates presence
of some cyclical phenomenon. However, the author himself
cautions about the usefulness of results of his analysis
in a similar manner as that of a 'periodicity' analysis.

Economists have been interested in weather mainly
from the point of its relationship with output. The
interest in crop-weather relationship is fairly old;
a complete book on the problem of forecasting crop
output with the help of weather variables came out in
the early fifties itself.\textsuperscript{19} In the recent past three
national level symposia were held on this problem.\textsuperscript{20}
The studies fall into three broad categories:

\begin{itemize}
\item \textsuperscript{18} V K Raghavendra, "Trends and Periodicities of Rainfall
in Sub-divisions of Maharashtra State", \textit{Indian Journal
\item \textsuperscript{19} Fred H Sanderson, \textit{Methods of Crop Forecasting},
\item \textsuperscript{20} (i) Symposium on "Crop, Weather and Water Relationship
in Agricultural Production", Indian Society of
Agricultural Statistics, Dec., 1969; See for
Proceedings, \textit{Journal of Indian Society of Agricultural
\item \textsuperscript{(ii)} Symposium on "Effects of Weather on Agricultural
Production", Feb. 1979, University of Kalyani,
Kalyani (WB).
\item \textsuperscript{(iii)} Symposium on "Crop-Weather Relationship", Indian
\end{itemize}
(i) Studies intending to forecast crop yield (sometimes area or production) on the basis of *a priori*, information about weather factors. An important issue dealt quite often in these studies is to find the crucial weather factors that affect (explain) the dependent variable.

(ii) Those studies for which it becomes necessary to net out the impact of weather and allied factors while assessing the contribution of input and technology to the growth in crop yields. Studies dealing with this sort of problem many times use a consolidated measure for weather.

(iii) Thirdly, studies for which the interest in crop-weather relationship arose out of the need to have a better estimation of trend undisturbed by weather. This assumed importance in the light of the controversies on growth deceleration hypothesis.

Though the main objective of the different studies falling in first group are more or less similar, the results obtained and the techniques of analysis differ. Regression and correlation are the two time honoured techniques used quite frequently in crop forecasting research. Apart from using correlations for tracing the association, it is often used to choose the variables
while deciding the model in studies using regressions.

Fisher's "Regression Integral Technique" has been used by some of the researchers in recent past. This method has an advantage of taking into consideration the distribution of rainfall throughout the year. 21

Majority of the studies on crop-weather relationship attempt to find out the particular seasons/months weather parameters which affect the crop prospects. 22 This is


essential to regulate irrigation and also to plan farm activities. Another important issue is regarding the role of irrigation as a protective measure against weather fluctuations. Very few of the studies used irrigation as an additional variable in explaining crop yields. Herdt's findings indicated that the yields of even irrigated crops like wheat, grapes, and sugarcane got affected due to variation in rainfall. This may be one of those indirect type of effects i.e., rainfall and weather factors alter the water availability from the source of irrigation and this in turn affects the crop prospects. Rao concluded that the influence of irrigation on yield/acreage is independent of weather factors and also that irrigation alone has no capacity either to take full advantage of favourable weather factors. However, we hardly find any study investigating the influence of weather on water availability from the irrigation sources.

Quite a few studies aim at forecasting of crop yields/acreage using certain climatological or weather

23. A W Herdt, Ibid.
factors. Data on climatological variables are made available without much time lag unlike crop yield data. The forecasts prepared at IMD are sent to Department of Agriculture almost coinciding with the harvest season. The forecasts obtained from these models were found to be within the 10 per cent error margin. However, a serious limitation of these models is that though the forecasts came very near the realised production (yield) in the weatherwise normal (or near normal) years, they fail miserably (with larger errors) when the year happens to be climatically abnormal.

There are a few shortcomings of the studies reviewed so far. Some of these studies have used State as an unit for analysis and this is a serious limitation when one


studies the effect of climatic variables on agricultural production. This is because one cannot assume homogeneous agro-climatic conditions to prevail over a vast area like a State, which are politico-administrative units. The studies using meteorological subdivisions as an unit for analysis too face similar difficulty, though the climatic conditions are near-homogeneous here, the other factors like crop-pattern, irrigation availability and cultivation practices need not be homogeneous, since a meteorological sub-division runs across quite a few districts and covers a large area. Hence there is a need to carry out an analysis at a smaller geographical unit say district (taluk level data on agricultural production are not available over longer time series), which will give more meaningful results for planning purposes.

In addition to the above there are some fundamental methodological questions that can be raised about the crop-weather relationship studies. It is argued that the filtering of the explanatory variables based on the

27. This is a basic point of Srivastava's criticism of Ram Dayal's Study, cf. S S Srivastava, "Impact of Rainfall on Crop Yields and Acreage: A Comment", IJAE, Vol.21(2), April-June 1966.

correlations and also on the coefficient of determination ($R^2$) is arbitrary. The variables to be used should be those which matter in the plant growth (agronomically). The filtering out is often based merely on statistical correlations which automatically ensures a good fit and higher $R^2$ for the model. Another factor which is often referred to is the choice of functional form. No strong theoretical justification can be given for any particular form and it has always depended on trials. From among the Fisher's regression integral technique and the linear multiple regressions, the latter explained higher variation in crop yields.\(^{29}\) Rainfall and the weather variables, moreover, need not be related to crop production as a continuous function. A discontinuity may exist in the relationship. The presence of such discontinuity has already been established by Nadkarni and Ghosh,\(^{30}\) rainfall above certain level having a less significant to lower impact than below that critical level. But such a critical level itself has to be found through trials.

Coming now to the second type of studies referred above, the need for the specification of weather has been recognised

\(^{29}\) See P S Srinivasan (1973), *Op Cit*.

\(^{30}\) M V Nadkarni and P K Ghosh, "Instability in Rainfall and Agricultural Yields in a Droughtprone District, Tumkur (Karnataka)", *IJAЕ* Vol.33(2), April-June 1978.
in dealing with production functions and supply response of crops. V M Rao made a strong plea for specification of weather and its inclusion for deriving farm production function even in cross-section data and also indicated an approach for doing so. He demonstrated the use of a priori information in farm production function as a proxy for weather, instead of the usual straight away pooling of cross section data.

The specification of weather has received attention in supply response studies too. Many such studies have used actual annual/seasonal rainfall as a proxy for weather. However, the need to express numerous weather factors into a single indicator like "weather index" has also been strongly felt. Attempts towards construction of such weather indices can be broadly grouped into two groups. The first one is to look at weather as an effect rather than cause and measure the impact of weather which could be straight away used as weather index. The second are those who have used meteorological variables to arrive at a consolidated measure of weather.

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The variation in crop yields can be attributed to i) controlled inputs and ii) uncontrolled inputs. If the level of controlled inputs is maintained constant, the remaining variation can be attributed to weather factors.  

The exercises using weather index based on this formulation gave good results when the data were drawn from experimental stations. The primary difficulty in these kind of 'indexes' is the use of production function - a theoretically weak proposition. It is further questionable as to how 'Weather' is held responsible for the "error" (taking into consideration the linear regression formulation used by Stallings and Shaw) which includes error due to measurement, specification of model or the sampling error.

The other procedure of arriving at weather indices involves the complex of meteorological variable and the


choice depends on the investigator. It is sometimes one or more than one weather parameter pooled together to form a composite index. Cummings and Roy constructed the indices based on the rainfall data on meteorological subdivisions. Their rainfall indices explained about 70 per cent of variation in cereal yields. Roy in a follow up study used these indices for explaining crop output variation and found that the rainfall indices explained more than 70 per cent of variation.

Given the regional variation in crop output and yields across States and within States across the varied agro-climatic conditions, one is tempted to question the justification for using weather indices at a broader regional level. Though the case for including weather as an explanatory variable is strong, care should be exercised so as not to get spurious results. A study at disaggregated level can avoid many of these shortcomings.


Adopting a different approach, Mukhopadhyay first fitted production function on pooled time-series and cross-section data, and then decomposed the error-term into spatial and temporal effects. The temporal effects are then sought to be explained through weather parameters (rainfall, temperature and humidity). Two important points of his analysis were that the protective role of irrigation was questionable in the wake of weather fluctuations and the vagaries of weather were no less severe in the districts with higher "productive efficiency."

Vaidyanathan took up the issue of calculating trends undisturbed by weather factors using crop yield and rainfall data for meteorological subdivisions of Andhra Pradesh. Though the meteorological subdivisions are homogeneous as far as climatic conditions are concerned, they need not be homogeneous agriculturally. He has used South West Monsoon, Seasonal rainfall, total rainfall and input index to explain variations in crop yields. In a follow up study, Mukherji and Vaidyanathan extended this analysis to ten more States (taking State as a unit for observation).


Two interesting points may be noted here: (i) the level of fluctuations in yields reduces as the level of input rises, and (ii) at a lower level of inputs weather contributes a major share in variation in yields.

**Nature, Magnitude and Impact of Uncertainty:**

The micro level view of farmers' adjustments to risk/uncertainty assumes that they are exogenous factors and that farmers can play safe. It also assumes that there is generally a trade-off between playing safe and higher profits, or between uncertainty and growth. The consensus of most researchers seem to be that in playing safe growth is sacrificed; in other words, presence of risk/uncertainty inhibits growth. The crop-weather relationship studies also were instruments of micro-level economics intended to measure the magnitude of exogenous impact on an endogenous objective function so that production functions and supply responses can be more clearly understood. The framework of these studies did not permit an examination of the inter-relation between growth and uncertainty at aggregate national or regional levels, and the impact of human behaviour on uncertainty which in turn could have an impact on human behaviour at micro-level.

For a long time agricultural economists were content paying attention to only micro level questions. It is only recently that more attention is being given to
broader problems such as the impact of human behaviour on uncertainty or the growth-uncertainty nexus. The macro-relationship between growth and uncertainty at the national or regional level can be perceived in two different ways, namely, (i) overtime and (ii) across regions or sub-regions. Secondly, the association can be hypothesised as either a direct or an inverse relationship. The direct relationship can arise under two different situations viz., a growth-push causing higher uncertainty (uncertainty as an opportunity cost of growth) or lower growth in the presence of low uncertainty (where the growth factors could not utilise the advantages of low uncertainty). Similarly, the inverse relationship originates either in the context of highest growth attained taking advantage of lower level of uncertainty or, uncertainty inhibiting growth. The observed relationships at regional levels can also throw insights for decision making at micro-level.

In his pioneering work Sen observed a direct relationship between growth and uncertainty. Analysing time series data on foodgrains production for over six decades (prior to introduction of HYV) he observed that instability increased with a growth-push. His analysis revealed that during the first 24 years there was a slight

growth with an increasing instability in foodgrains production (increased divergence between peaks and troughs experienced in the production series) the next 24 years were marked by declining production with converging peaks and troughs. This was followed by an unprecedented growth accompanied by higher instability in the early post-independence period (again divergence between peaks and troughs). The three phases clearly indicated a positive relationship between growth and instability in the pre-technology period. Advancing a 'tentative speculation' as an explanation, he observed that the growth in the early post-independence period was attained mainly through extending cultivated area to marginal lands, more prone to be adversely affected by weather hazards like droughts. He also observed that this hypothesis needed further testing at disaggregated levels (since the aggregate level analysis may have mutually nullifying factors). Sen's hypothesis of positive relation between instability and growth needs to be tested also in different contexts of growth.

The context of growth assumes importance because new forces have come into the picture after the introduction of the new technology. A pertinent question crops up here whether the introduction of HYVs increased uncertainty. Hanumantha Rao has observed that since yield is
the major component of growth in the new technology period and also it accounts for major part of fluctuations in output, this ultimately results in increased instability in production. But he did not empirically test his observation here. In another study however, he noted that there was no declining trend in the negative deviations in foodgrains output and the level of uncertainty remained as high as it was earlier. This implied that no unique a priori relationship between growth and uncertainty could be taken for granted and that it was the context of growth that decided the relationship.

The question relating to the impact of new technology on uncertainty was taken up subsequently by Mehra who concluded that instability in both yield and production has increased in the HYV period. Mehra found that out of the 18 individual crops as many as 12 crops recorded an increase in instability in production where fluctuations

41. C H Hanumantha Rao, Technological Change and Distribution of Gains in Indian Agriculture, Macmillan, Delhi, 1975, p.16


in yields played an important role. She confirmed a positive relation between growth and instability for the total period and also when it is split into pre and post technology period. However, her demarcation of periods excluded the two drought years 1965-66 and 1966-67 from both the pre and post technology periods as being abnormal, though the latter did include the drought year of 1972-73. This must have affected the relationship to some extent. Though a positive relationship was noted for five of the cereal crops which have substantial area under HYV, the association seemed moderated or reduced with the availability of irrigation. Mehra stressed on the package aspect of new technology, i.e., adoption of new technology with assured irrigation and proper use of fertilisers which she believed would bring down the level of instability.

Another important query is, whether there is anything inherent in the new technology which increases instability or that the high instability is due to the higher commercialisation of agriculture. Though the marketable surplus of crops has not increased except in the case of a few crops the dependence on factor market (for modern inputs like fertilisers, pesticides, and machines) has increased substantially. This in turn has caused a shift in crop pattern in favour of high value crops and further increased the cash requirement of the farmers. In the event of a
foreseen drought there would be a tendency to reduce such inputs thereby causing more decline in output and yields.

Taking the cue from Mehra's study, Hazell tried to decompose instability and explain why it could have increased in the context of the new technology. He observed a greater synchronisation of year to year fluctuations in yields of different crops. In other words, the increased instability is attributed to an increase in intercrop production covariances. Further, Hazell argued that developing stable variety crops may not be enough but a strategy of stabilisation of supply of inputs would help in the stabilisation of output. Another approach to reduce instability advanced by Hazell is to take advantage of the covariances and distribute production as between crops and States in a more risk efficient way.

The experience, however, seems to be in the opposite direction. Nadkarni and Deshpande observed in the context of Karnataka that in the course of growth, crop combinations having negative or a weak correlation in their which yields, gave way to those combinations had strong positive

correlations, thus causing an increase in instability. In other words the mutual offsetting effects of crop failures got reduced when the crop composition changed in this way. If growth push is extended towards negatively or weakly correlated crops it may help in reducing uncertainty.

As regards the change in the level of uncertainty over time at district level there are two studies which analyse this issue. Nadkarni and Deshpande in their study observed that the trends in peaks and troughs are divergent both in the case of yield and production, indicating increased instability across districts in Karnataka during the recent past. A similar view was endorsed by Parthasarathy (though not through trends in peaks and troughs) in the case of district level instability in Andhra Pradesh, Andhra Pradesh as well as Karnataka experienced the gains of new technology almost simultaneously around 1967. Similarly both the States present a situation where growth is accompanied by instability (a positive association). It needs to be tested, what


46. M V Nadkarni and R S Deshpande (1983), Ibid.

experience or association holds in the case of a State like Maharashtra which has experienced low growth and where the gains of new technology were experienced much later (which is proposed to be done in this thesis).

The role of HYVs in the increased instability is sometimes indirect i.e., through causing relative neglect of certain crops. This is evident in the case of pulses and a few oilseeds. While the role of this factor cannot be altogether denied, the frequency of failure in output of pulses was more in the pre-technology period.\(^{48}\)

Commenting on the role of HYV in the increased instability, Nadkarni concludes that "...on the whole, the HYV technology so far at least appears to have diminished the rigour of droughts let alone increased it".\(^{49}\) In fact he noted convergence of trends in troughs and peaks after 1965-66 at the All-India level and not divergence unlike during the preceding period.

Another important issue raised by the studies conducted for various regions, is regarding the differential nature of uncertainty across regions and its association with growth. It is contended that the drought-prone areas with relatively less assured irrigation face high uncertainty. Sen in his work classified the country into four


\(^{49}\) M V Nadkarni, Ibid.
categories based on susceptibility to droughts and availability of irrigation. He argued that the areas where there is high dependence on monsoon rains and drought frequency is also relatively high, contribute higher share to instability in agricultural production at national level. Similar observation was made by Jose in a State level study. He confirmed that the States with less assured irrigation and non-dependable monsoon face higher instability apart from registering lower rates of growth. Similarly, Shingarey in a districtwise study of Maharashtra over 1951-52 to 1965-66, expressed that the districts with non-dependable monsoon and less assured irrigation showed high uncertainty. However, there are also instances of regions where instability in yields showed some independence from instability in rainfall. In a district level study of Andhra Pradesh, it was shown that some non-drought prone districts (Srikakulam, Visakhapatnam) have shown as high instability as in drought prone districts; whereas, a drought prone district


like Nalgonda showed high growth rates with low instability. 53 In an earlier district level study, Nadkarni and Dashpande indicated the existence of some districts in Karnataka, of the following types (i) with high instability in rainfall and yet low instability in productivity (Bijapur) and (ii) with low instability in rainfall and yet with high instability in productivity (Shimoga). 54 This indicates that in spite of unfavourable climatic factors, some regions could still stay with lower level of yield uncertainty, either due to a drought proofing techniques like soil conservation, irrigation or suitable crop combinations.

Another important factor for the differential uncertainty across regions is the context in which the growth-uncertainty relation arises across regions. Making use of an aggregate agricultural production index, Jose classified the States into different categories based on the growth-uncertainty relationship. 55 An important observation he made was that there are states showing both positive and negative association between the two. Mohra also examined the relationship between growth (represented by adoption of new technology) and instability. 56 She found a positive relationship between the two across States.

(excluding a few states with assured irrigation). The same results were confirmed when the relationship was worked out for pre and post-technology period.

The issue was also researched at disaggregated level. Nadkarni analysed the growth uncertainty relationship across crops at State level for Maharashtra. He found a positive relationship between growth and uncertainty across crops but a negative association across districts for a single crop—cotton. Irrigation was not found to be explaining the inter-district variation in uncertainty. The correlation between the two was not significant across districts.

Usually uncertainty is understood to be growth inhibiting. The drought-prone areas and rainfed crops could be expected to have lower growth coupled with high uncertainty in yields. However, this proposition needs further research through a more detailed study probing into the different contexts of growth. The studies by Nadkarni and Deshpande on Karnataka attempted to clarify a few of these issues. They classified the districts into different groups based on a cross classification of uncertainty in yields and growth rates. In general, pattern indicated a positive relationship between growth.

and uncertainty. However, there were instances of crops/districts indicating negative association. Hence, they opined that uncertainty need not be an inevitable accompaniment of growth. The fluctuations tended to diverge and uncertainty has increased in the latter phase. Neither of the extension/cultivated area nor the proportions of area under irrigation could explain the interdistrict variation in uncertainty. They suggested other plausible causes originating from human and institutional framework, in particular a backlash of new technology on the resource base of agriculture, reflected in the neglect of land and overemphasis on fertilizers and water.

A knowledge of probability of occurrence of yields gives a clearer understanding of uncertainty, especially when yield rates tend to show some kind of bunchy character. In such situations the growth-uncertainty relation may get distorted due to bunchiness of yields. The contributions of Day and Luttrell and Gilbert are worth citing here in this context. Both the studies have tried to detect cycles or bunchiness in the probability distribution of crop yields and tested randomness of the yield series.

Day found that the yield distributions were non-normal and also non-lognormal, and that the degree of uncertainty was crop specific and depended on the levels of inputs. Luttrell and Gilbert's study also corroborated these findings. They also did not get any evidence of cycles or bunchiness in yield series.

Fluctuations in crop yields are yet to be subjected to such a detailed analysis in India. One exercise made in the case of production of principal crops of Karnataka may be mentioned here. This study attempted to separate deviations from what is called 'non-systematic' deviations arising from the existence of 'peaks' and 'troughs' in a series. The method employed gave better estimation of trend in growth-free of the non-systematic fluctuations. An interesting point that emerged was that the crops which have recorded higher rates of growth in production also have more number of years with non-systematic fluctuations (a case of positive relation between growth and fluctuations).

To sum up: Most of the micro-level studies especially those dealing with decision making models are not amenable for any kind of generalisation. These studies consider

uncertainty as an exogenous factor. An essential research problem is identification of broad regional patterns emerging out of the nature and magnitude of yield uncertainty and the context in which such patterns emerge. Any such analysis will help in careful planning for coping with uncertainty in yields in particular and droughtproneness in general.

Rainfall is one of the major components of the weather family. Though there are a number of studies dealing with rainfall and weather, only a few studies have attempted analysis of the nature and variations in rainfall at district level data. An understanding of rainfall behaviour over a long time series will help in clarifying quite a few issues in crop planning at district level. Furthermore it will also help in placing the role of climatic factors in droughtprone economy in proper perspective. These results if juxtaposed with the analysis of yield uncertainty at district level, will help in a better understanding of the mechanics of uncertainty.

An analysis of the nature and magnitude of yield uncertainty will go a long way in formulating development plans and an appropriate strategy for the droughtprone regions and this will particularly be useful for a State
like Maharashtra which is characterised by high uncertainty and low growth combination and also has its major portion falling under broad drought zone. It is essential to test and find out if uncertainty (instability) show any pattern across districts and if there is any divergence or convergence in the peaks and troughs. Apart from helping to understand the theoretical issue of growth-uncertainty nexus, this analysis would also help in analysing the impact of new technology on the nature and behaviour of yield uncertainty.