CHAPTER III

REVIEW OF PAST LITERATURE

INTRODUCTION

In order to have an insight into the types of research work done on the subject of risk and uncertainty in agriculture, this chapter attempts to briefly review the studies on risk and uncertainties in Indian agriculture as also in agriculture of the other countries of the world. Several research workers have examined the above mentioned aspects for different countries and areas under different contexts. The framework of discussion is shown in the chart 3.1 presented here below. As indicated in the chart, the studies reviewed here are divided into two major parts, those in developed countries and those in developing countries.
Chart 3.1

Studies on risks and uncertainties

Studies of Developed Countries

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This section examines major studies on the problem of risk and uncertainties undertaken in developed countries. The discussion under this head is further divided into two parts, viz., macro and micro studies, each of which covers the studies pertaining to foodgrain crops and a mixed pattern of foodgrain and non-foodgrain crops. In the discussion three major aspects are stressed, viz., the types of risk studied, the methods of risk measurement and the measures suggested for the elimination of risks.

(1) Foodgrain Crops

Three major studies have been reviewed in this section. Oral Buller and Wuu-Long\(^1\) (1969) have estimated a linear trend to the 11 years moving average for measuring the effect of weather on food crop production. Several weather elements have been included in computing Palmar's drought severity index. The weather effects included in the study are of both the types direct (such as affecting plant structure, characteristics and growth rate) and

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indirect (such as favouring or checking the development or parasites and weeds). The study has made economic analysis of the productivity of agricultural resources. In the absence of satisfactory method of measuring interaction between direct and indirect weather effects the study did not attempt to separate the above two effects.

Besides, Fisher R. A.² (1924) made an attempt to find out "The Influence of Rainfall Distribution on the Yield of Wheat Crop in England". Similarly, Theodore Brinkmann³ (1935), a German Agricultural Economist analysed the various factors which determine productivity in agriculture and which are least susceptible to correction through changes in techniques, namely, the climatic conditions like temperature.

(2) Non-foodgrain Crops

Trimble R. Hedges⁴ (1963) explained "Uncertainty and Farm Firm Decisions" through major five types of uncertainties and various defences against uncertainty.

This study has examined the possible defences for uncertain situations like: (1) Elimination of uncertainties through direct control, prevention and accommodation, (2) Transfer of uncertainty through leasing arrangement, (3) Discounting of uncertainties through some specific rate of discount, (4) Flexibility by providing flexible decisions and plans at the farm level, (5) Insurance programme either formal or informal by paying specific premium rate, and (6) Forward contracts with specific characteristics. Besides, this study has emphasized the importance of learning and risk assumptions as risk has subjective characteristic. This study has revealed that there is an inverse relationship between the participation of the farmers and the premium rates. He also observed that in absence of formal crop insurance farmers use informal insurance like crop planning, intra-seasonal crops and livestock production.

Gerald A. Carlson (1970) touched the aspects of diseases control and the use of pesticides in his study "A Decision Theoretic Approach to Crop Disease Prediction and Control in Fruits and Peaches". It shows how the complex decision of disease control can be made. He has

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defined economic injury level of lowest pest density that causes damage. The study also specifies the dosage level of pest density as emphasized by economist, in terms of decision theory. Moreover, it asserts that wrong pesticides use may result into loss due to an inappropriate view of the probability of the growth of disease. Thus, this study concludes that human judgement in probability form can be a helpful input in the decision model.

(3) Other Studies

The other studies including those of mixed crops related to farm risk are dealt with here below.

E. O. Heady⁶ (1964) has made available the standard footing to the concept of risk and uncertainty in 'Economics of Agricultural Production and Resource Use', which is well and recognized work in the field of agriculture. He examined all the major types of uncertainties. He has covered foodgrain and non-foodgrain crops in the study. He clearly indicated that risk can be measured empirically with the help of frequency of probability distribution of occurrences, while uncertainty is entirely subjective in nature which cannot be quantitatively measured.

E. O. Heady and Herald R. Jensen⁷ (1954) examined different types of risks and uncertainties and suggested

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various measures in their study "Adjusting to Risk and Uncertainty including Insurance". According to these authors, farmers' guesses are better if he studies, learns and tries to predict the future. But his, i.e. farmer's, prediction always involves uncertainty. The authors have explained uncertainty measures into three major groups, namely: (i) measures to reduce the variability of dispersion of income, (ii) measures to prevent profit from falling below some minimum level, and (iii) measures to increase the farmer's ability to withstand unfavourable economic outcomes. It has also examined the dependence of uncertainty precautions on farmer's capital position, his linking of chance outcomes and his family responsibilities. The authors have examined wheat, cotton, potatoes etc. crops in the context of price uncertainty, yield uncertainty, the uncertainty of government policy, the uncertainty of sickness of the farmer and the uncertainty of the reaction of other farmers.

F. H. Knight\(^8\) (1957) made a pioneering contribution in this field through his book, "Risk, Uncertainty and Profit" to the agriculture sector. He has given several instances and illustrations to make clear the concept of risk, uncertainty and profit. Besides, various aspects and

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types of risks have been thoroughly examined and provided guidelines for further research in the field of risk. He has also referred to J. S. Mill in the view that profit includes an element of the payment for risk and payment to management work which is entirely different from the wages paid to the labourers.

James L. Stallings⁹ (1960) constructed weather indices for corn, oats, barley, wheat, soyabeans, cotton, and tobacco in his study of "Weather Indices". The indices were also constructed for the influence of weather on important measures of agricultural yield and production in U.S.A. The variations in the crop yields were explained through direct and indirect influences of weather. After removing the trend the weather indices were computed from the time series of yield data of experimental plots.

Similarly, Bhargava, P. N., Asha Pradhan and M. N. Das¹⁰ (1974) examined the "Influence of Rainfall on Crop Production". They have covered wheat, paddy, jowar, cotton and groundnut crops in their analysis.

Bernard W. Taylor and Ronald M. North¹¹ (1976) examined the study on "The Measurement of Economic

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Uncertainty in Public Water Resource Development assuming that public reflect a "risk averse" attitude and justifies the safety first criterion. However, it faced the problem of the classification of public as risk takers or risk averters which depends on some amount of speculation. The study has concluded that the people are becoming increasingly hesitant to accept project that has an adverse environmental and social impact, no matter the economic gain.

The most common method suggested to incorporate uncertainty into water resource investment decision is to add a risk premium to the discount rate in the present value. While taking about time uncertainty Taylor\textsuperscript{12} (1976) supported the Eckstein's view that a risk premium of 0.5 to 1.0 per cent may be added to their interest rate appearing in the project evaluation.

C. A. Robertson\textsuperscript{13} explained four types of uncertainties in his study "Risk the Common Concept". He examined different types of uncertainties in foodgrain and non-foodgrain crops, associated with the modern farm management theory. He recommended various strategies like diversification, flexibility and liquidity for proper resource allocation and decision making.


MICRO STUDIES

(1) Foodgrain Crops

T. W. Schultz (1953), in a detailed analysis of nature and factors of yield instability in the United States, has said with particular reference to West Central Regions, both north and south. Despite all the efforts of farmers to counteract the drought of 1934 in United States depressed the yield in a large area. It extended over 75 per cent of its total area and severely affected 27 States. Wheat production fell from 941 million bushels in 1931 to only 552 million bushels in 1933 and 526 million bushels in 1934. The country became substantial importer of wheat in 1934, 1935 and 1936. The yield of feed, forage and pasture were down and a heavy reduction in livestock numbers resulted. All the farms were turned into non-productive land due to dense dust clouds and covered the areas around Washington (see foot-note).


Foot-note : (USDA) "Climate and Man". The yeere book of Agriculture, 1941, p. 504, estimated a bill of insects pest alone was as high as $ 3000 million a year, which is the crucial factor determining success or failure in agriculture enterprise in U.S.A. More recent estimates of the surveys indicates the reduction of agricultural production due to pests to at least 30 per cent annually and the annual loss in food production during 1950-1960 was ranging from 2 to 38 per cent due to plant diseases, 2 to 31 per cent due to insects, 2 to 8 per cent due to nematods and 3 to 25 per cent due to weeds) (USDA = United states Development Agency).
(2) **Non-food grain crops**

Jen Hu-Chang\(^{15}\) (1931) tried to indicate the relationship between radiation and cloudyness in his study "Climate and Agriculture". An Ecological Survey", and observed that the relationship between them is not linear. The comparison between the tropics and temperate region explained that the age of harvest varies with climatic environment. In this context, he referred to sugarcane in Hawai where it is usually 22 to 24 months\(^{3}\) crops in low land areas. Similarly, it has also indicated that air temperature during night is the dominant factor in the growth of potatoes, chillies, tobacco and other plants. The sucrose concentration of both sugarcane and soyabean increases with the decrease of night temperature. In Hawai the sugarcane plantations with a large diluted temperature are known to have better juice quality.

Rudolf J. Freund\(^{16}\) (1956) divided risk programming into two steps, namely, (i) the decision of risk situation in programming model, and (ii) the method of evaluation and choosing an appropriate alternative among risky alternatives. He explained optimum combination of crops for


\(^{3}\) This period is constituted of two crop seasons together.
representative eastern-north Carolina farm by using utility function. This study has shown that high risk bearing crops, like potatoes and cabbage, found relatively more profitable in the long run. But it has also found that the large number of farmers neither willing nor able to endure the extreme fluctuations of net returns. It was also observed in the study that farmers preferred more safety by selecting several crops instead of a single crop.

Robert L. Chritensen and Earl E. Puller\(^{17}\) (1971) have measured the major economic risk and returns involved in forage production. They modified the conventional static production economics to make the use of decision criteria under the conditions of weather risks. They used 26 years rainfall data to compute expected mean for three specified seasons. According to this study decision depends on machinery capacity and the length of the season. Among these two, the latter cannot be controlled and creates risk for the farmers. They suggested various types of data needs to formulate such model, viz., daily rainfall data over a long period, beginning and ending dates of the 3 seasons, area and expected crops, expected yield, machinery performance, per unit crop value, initial machinery costs etc.

The joint study undertaken by Jeffrey Apland, Bruce A. Mercarl and William L. Miller (1980) have evaluated the implications of risk aversion for the derived demand for supplemental irrigation of corn using a case study approach. To explore the impact of risk aversion, the demand functions were generated for decision makers with the three risk postures, viz., risk indifferent, high levels of risk aversion and low levels of risk aversion respectively. The authors have drawn the following major conclusions: (i) The influence of farm manager's risk posture has a marked impact on the farm's demand for irrigation. It also suggests that even at a high irrigation costs and low corn prices, irrigation technology may be employed by the rational farm manager, who is averse to risk. (ii) The demand for irrigation as a factor of production becomes increasingly inelastic when risk aversion is evident, reflecting the farmer's propensity to eliminate the 'risky' non-irrigated crops and maintain a risk averting diversified crop mix. (iii) Agricultural policy makers are increasingly concerned with farm income stabilization. The adoption of irrigation technologies as a risk aversion would be demanded to contribute stability.

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of income with other measures like price support. Thus, the study examines two features viz., implications of risk aversion and demand of irrigation. It is silent about other measures to minimize the impact of risk. They did not examine the impact of risk aversion and demand for irrigation with respect to other non-food crops except soyabean.

(3) Other Studies

Under this head some covering either mixed crops or projects into the context of risk and uncertainty are reviewed.

A.E. Baquet, A. N. Hailter and Frank S. Concklin (1976) jointly examined importance of frost forecasting for orchard production, with the help of (i) probability distribution, (ii) utility functions, and (iii) monetary pay off table. The frost protection decision process is in the context of Bayesian decision making under uncertainty. Using the following three components, namely, (i) stimulated nightly weather, (ii) nightly frost protection decision, and (iii) frost forecast value accounting. The frost forecasting evaluation diagram was presented. The model has provided computer programme and it forecasts the value of frost for the total season as well as for a day on per acre basis.

Wilson Gee (1976) discussed various measures for food and non-foodgrain crops, to reduce risk and uncertainty through farm insurance. He explained one peculiar feature of human psychology that elimination of risks increases the efficiency of agriculture business. The study recommended fire insurance, wind storm insurance and hail insurance after analysing the risk variables. Though, the study remains silent on methods of insurance for different crops in the different areas.

John L. Dillon and Pasquale L. Scandizzo (1978) examined the attitudes of subsistence farmers towards risk in north-east Brazil by posting two sets of experiments involving choice between risky and non-risky alternatives. In the first set, the farmer's total income is uncertain, but his subsistence need is assured, while in the second set his subsistence requirement is also at risk. The following three features were examined on the basis of farmer's response: (i) utility function, (ii) the comparison of risk attitudes of the two groups, and (iii) the use of regression analysis to appraise the possible socio-economic influence on the farmer's risk behaviour.


The study has examined the farmer's behaviour by the following three criteria, viz., (i) risk preferring, (ii) risk neutral, and (iii) risk averse. The major findings of the study are: (i) most but not all peasants are risk averters, (ii) risk aversion tends to be more common and perhaps greater among small farm owners than among the sharecroppers, (iii) in the expected utility context, the distribution of peasant risk attitude coefficient is diverse and not necessarily represented by an average population value, (iv) the value of income and perhaps other socio-economic variables influence peasants' risk attitude, (v) it is possible to gather meaningful informations on the peasant attitude through purposive questioning.

Risk and Developing Countries

This section deals with the major macro and micro studies in the field of risk and uncertainty in developing nations of the world.

MACRO STUDIES

(1) Foodgrain Crops

Clifton R. Wharton 22 compared new varieties of rice in his study "Risk, Uncertainty and Subsistence Farmers".

Three sources of uncertainties for the farmers, viz., yield, cost and product price uncertainties influencing the net returns are emphasized here. On the basis of his experience of IR-8 rice in Phillipines he concluded that the statistical variance in yield per hectare associated with new varieties is considerably larger than that with the traditional varieties.

S. N. Sen (1964) classified various types of risks into following three categories considering risk and uncertainty similar. They are: (i) flood and droughts, (ii) occurrences of pests and diseases, and (iii) economic and market factors. After dividing the Bihar State into three natural regions, viz., (A) South Bihar Plain, (B) North Bihar Plain, and (C) Chhota Nagpur Plateau. The study observed the following four major conclusions:

(1) The floods and droughts appeared to be a recurring and cyclical phenomena in the nine districts of the Bihar State which have affected the area and yield of the crops. More particularly in the case of paddy, as it is exposed to greater risk, the area and yield have been adversely affected.

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(ii) The study also observed that the multiple cropping practices depend on the availability of adequate rainfall and weather conditions. And accordingly the gross cropped area was observed fluctuating between 52 to 61 per cent of the total geographical area of the State. More precisely, the area under kharif and rabi crops were found fluctuating between 37 to 42 per cent and 15 to 21 per cent respectively.

(iii) It is observed that the market forces of demand and supply were also found to be risk involving factors. The parity between the harvest prices and the cost of cultivation was also observed to be a determining factor for extensive cultivation for any crop. Hence, paddy followed by gram or pulses in the sugarcane growing area were reported to be the most competing crops.

(iv) The pests and diseases were also operating as risk factors which nullified all the efforts of the cultivators and cause the crop damage for nearly 10 per cent of the crop yield. For instance, the study estimated the value of loss due to pests and diseases around Rs.16 to Rs.18 crores per annum in the Bihar State excluding the loss noted in the non-foodgrain crops.
B. S. Minhas and A. Vaidyanathan (1965) made the comparison of the yield rates among the different States in their study "Growth of Crop Output in India 1950-54 to 1958-61 - An Analysis by Component Element". The yield variability examined in the study indicates that among the non-foodgrain like groundnut, the yield level achieved by Gujarat is the lowest among all the States. While in the case of sugarcane the yield rate of Gujarat is marginally above the all-India average, but much behind the highest yield rate achieved in Karnataka. Only in the case of cotton, the performance of Gujarat is distinctly superior to the all-India average yield rate. However, it is behind the yield rate attained in the Punjab State.

I. J. Singh (1972) used linear programming model to evaluate the effectiveness of crop insurance or diversification in his study, "A Feasibility Study on Crop Insurance in Uttar Pradesh". The degree of yield variability is measured by the coefficient of variation for the period from 1951 to 1971 for bajari, jowar, wheat, paddy, maize, gram and barley. The efforts are made to estimate how the

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uncertainty of crop yield could be computed into definite cost in the form of a crop insurance premium. The study examined the incidence of crop failure due to weather risks under imperfect knowledge and found that diversification has an edge over crop insurance since it stabilizes expected returns at a higher level than those offered by the crop insurance programme. But due to the lack of financial resources with the farmers, crop insurance would act as an alternative to diversification to protect him against weather risk. The policy implication of these findings is that crop insurance is not only feasible, but it also appears to be self-sustaining in the long run.

S. K. Sinha26 (1981) in his study, "CO₂, Climate and Energy" emphasized the significance of temperature and CO₂ resulting from pollution. Though, it is more true in industrialist western countries than in the developing third world countries. Various other climatic factors like rainfall, windfall, frost etc. are ignored in this study. He disagreed to the view expressed by different participants in the seminar that growing carbon dioxide (CO₂) pollution would raise crop yield in India and the third world. He pointed out that a rise in CO₂ pollution would raise global temperature by 2°C by 2030 A.D. This increase in temperature

and consequently increase evaporation could have serious effects on major crops such as rice and wheat grown in the tropics. He explained through his empirical observations that $2^\circ C$ to $3^\circ C$ increase in temperature could almost cause 25 to 40 per cent loss in the yield of some varieties of rice in India. It also revealed that a change of temperature from $20^\circ C$ to $23^\circ C$ leads to decrease in the number of spinkelets. The rise in temperature will affect grain development and biological fixation of nitrogen. Besides, he pointed out that the higher temperature and humidity could provide favourable conditions for pest and diseases to develop which was the major cause of famine in the past.

(2) Non-Foodgrain Crops

Nirmal Singh and H. S. Bal\textsuperscript{27} (1974) have derived the compound growth rates of area, production, yield and prices with respect to cotton, groundnut and sugarcane for pre and post green revolution periods for the Punjab and emphasized their variability.

L. D. Mellow\textsuperscript{28} (1979) discussed the problems of 'agro-based industries' in India. He drew various interesting conclusions related to non-foodgrain crops of cotton, jute and sugarcane.


and sugarcane. (1) The wide year to year variations in the production of cotton results into uncertain supplies of raw cotton and consequent swing in the prices. (2) The vagaries of monsoon plays an important role for the fluctuations of the indigenous raw cotton. (3) The erratic production of jute resulted in the instability of raw jute prices thereby upsetting the jute economy. The large amplitude of price variation is partly the cause and partly the result of fluctuations in the acreage under jute. (4) The fluctuating prices of jute have adversely affected its acreage due to adverse impact on farm income before 1971, which has resulted in the diversion of crop pattern from jute to paddy. (5) The cyclical trend of the production of sugar has been due to: (A) fluctuations in the acreage of sugarcane consequent upon the variations in its prices, (B) natural vagaries like flood and draughts, and (C) incidence of pests, insects and diseases.

Sanjay Baru (1980) thoroughly examined the trend in sugar prices and production over three years from 1978 to 1980 and found following observations, which indicate how sugar producers want to reduce their risk and uncertainty of raw materials, viz., sugarcane. First, the

development of own cane farms by the sugar producers can assure the required supply of sugarcane which is the major uncertain factor in sugar producing mills. Second conclusion drawn by the study is co-operative sector cannot penalise those farmers who do not fulfill the contract obligation due to reasons like political factor, co-operative law and dependence on nature in agriculture.

Y. S. Negi and M. S. Grewal\(^{30}\) (1981) examined the trends in area under production of sugarcane and the production of sugar in different States with the help of data obtained from Indian sugar mill association. The study clearly indicates that there has been a highly significant increase in the sugarcane acreage in the States like, Tamilnadu, Karnataka, Maharashtra and Gujarat.

(3) Other Studies

The work by Harold H. Mann\(^{31}\) (1938) on "Rainfall and Famine - A Study of Rainfall in Bombay Deccan 1865-1938" is a pioneering work on the relationship between rainfall and agricultural productivity. He explained the relationship


for four districts of Poona, Ahmednagar, Sholapur and Bijapur, but could not find direct and close correlation in general between the extent of rainfall and the goodness of season. But the author discovered some trend in the relationship between the crops and the distribution of rainfall.

B. N. Pal (1959) discussed the natural resources like rainfall and climate and agricultural fluctuations such as physical composition in agricultural set up for different crops. He divided agricultural fluctuations in the different forms, viz., short period price fluctuations, income instability, output and yield variations and mercantile risks. He also has discussed various types of physical and economic risk faced by agricultural producers in India.

Bidyadhar Mishra (1964), has examined various types of uncertainties for foodgrain and commercial crops in India. The major uncertainties faced by the farmers are:

(a) fluctuations of prices, (b) fluctuations of yield, (c) changes in technology, (d) changes in social framework, and (f) changes in legal framework. This study also examined


the reasons for such uncertainties and suggested measures in the following broad ways: 
(i) Education of the farmers, 
(ii) Irrigation, 
(iii) Drainage, 
(iv) Pest and diseases control, 
(v) Credit facilities, 
(vi) Marketing facilities, 
(vii) Price stabilization, and 
(viii) The use of weather information. 

Though, the above suggested measures in the study have not provided any empirical background or they are on general ground instead of any specific data base.

Robert W. Herdt (1972) tried to analyse linear model by ordinary least squares of logs of the data for each of the 12 districts in the erstwhile Punjab State for the period 1907-1947. He examined eight different crops including wheat, gram, cotton, sugarcane etc. for irrigated and non-irrigated regions and tested approximately 384 equations. 

By assuming an appropriate price expectations this study measures the impact of weather, technological change and canal irrigation on agriculture in the Punjab. The study clearly shows that the canal irrigated area has a significant impact, both on area under different crops and their yields. The yields of irrigated wheat, gram and sugarcane and other non-irrigated crops were significantly affected by the variability of rainfall.

A. K. Banerjee and C. R. V. Raman\textsuperscript{35} (1976) examined long period data of rainfall in India. During the deficient rainfall years of the 100 year period from 1874-1974, the agricultural production is reported to have been fallen.

The all-India level study of rainfall of the Reserve Bank of India\textsuperscript{36} (1977) indicates that the bumper crop is only possible when the actual volume and distribution of rainfall are very near to the normal. Though it is only a necessary condition, but not a sufficient condition for bumper crops. In addition, each crop has its own requirement in respect of temperature, sunny days, wind velocity etc. This study has shown the series of data relating to the movement of south-west monsoon during the period 1975 to 1979 with reference to food and non-foodgrain crops. The study used frequency distribution of rainfall on agricultural production. The annual fluctuations in area, yield and total production of foodgrain, non-foodgrain and all crops together were analysed for the period 1950-51 to 1975-76. It also emphasized that to mitigate the erratic behaviour of deficient rainfall, the supplementary measure of

\textsuperscript{35} A. K. Banerjee and S. R. V. Raman, Indian Meteorology Department, "One Hundred Years of South-west Monsoon Rainfall in India", Report of the National Commission on Agriculture, 1976, part IV.

irrigation should be adopted which however involves time-log. According to the National Commission on Agriculture, it is difficult to isolate the contribution of favourable weather to agricultural production, but this study has made efforts to estimate such an impact on agricultural production (see foot-note). Similarly, R. K. Parashar in his study on 'Increasing Aggregate Farm Output and Foreclosed Option', initiated the compilation of rainfall indices for different crops and groups of crops. It also proposes to correlate yields with these indices to assess the effects of rainfall on crop yields as also their forecast.

The study by A. S. Kahlon and Karam Singh (1980) focussed on two major types of uncertainties, which confront the farmers. First, 'on-farm uncertainties' which are concerned with production and farmers' pool of resources and second 'off-farm uncertainties' which are further divided into six sub-groups, viz. price uncertainty,

Foot-note: The fall in agricultural production as a result of severe drought in India was observed to be 16.7 per cent in 1965, 8 per cent in 1972 and 3.5 per cent in 1974 (see, Ku. N. R. Kothare - study).

37 R. K. Parashar, "Increasing Aggregate Farm Output and Foreclosed Option", Agricultural Situation in India, Ministry of Agriculture & Irrigation, July, 1979, p. 221.

production uncertainty, technological uncertainty, political uncertainty, personal uncertainty and other people's uncertain behaviour. With few instances, the study analysed resource uncertainty, e.g. illness of farmer, contract of labour, action of other people, institutional behaviour, the changes in policy of government and institutions, water supply, technical change etc. Similarly, due to natural factors the yield of crops and livestock vary from season to season. For instance, quantity and distribution of rainfall, shift in sowing or harvesting time according to winter and summer seasons, attack of insects in relation to weather, infection to animals, new variety and animal breeds are responsible for production uncertainty. Price uncertainty plays most crucial role as it fluctuates more widely because of inelastic demand and the fluctuating supply due to dependence on natural exogeneous factors. The changes in government policy to support the prices of some products and to change the relative profitability of certain enterprises in order to change the production mix accordingly are a few other cases of price uncertainty.

Hans P. Binswanger, N. S. Jodha and B. G. Barah (1979) have undertaken a series of research projects on the

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role of risk in the semi-arid tropical agriculture of India. They are based on the following three types of data: (i) Macro-data of yield, price and income variability, (ii) Micro-level data of consumption, income and expenditure levels of rural households over drought cycles, and (iii) a set of psychological experiments of risk attitudes. Their joint efforts have brought out the following interesting observations: (i) The level of income risk in the Indian semi-arid tropics is high and comes mostly from production rather than price risk, (ii) Virtually all farmers in the semi-arid tropical Indian agriculture are risk averse although not to an extreme, and (iii) farmers do not have access to cheap self-insurance and risk diffusion devices enabling them to even-out their consumption streams in the face of risky production. Hence, they concluded that risk aversion leads to the underinvestment in semi-arid tropical agriculture.

The policy implications made by the studies can be of three types: (i) it makes no sense to advocate the development of technologies in semi-arid tropical India which differ in their riskiness, so that small farmers may adopt the low yield, low risk methods of production, whereas large farmers adopt the high yield high risk ones. The nature of techniques to measure differences in risk among technologies are still very complicated and need sufficient data, which make differential research strategy appealing. (ii) Risk
attitudes vary across farm size groups, as they are in semi-arid tropical India. The authors have reconsidered the debate about risk aversion versus credit constraint as explanation for low fertilizer use. (iii) The progressive farmers are not much less risk averse than the other farmers. Besides, the reward for innovation is not the reward for superior risk bearing ability as Schumpeter hypothesized, but are the reward to superior human capital and superior human ability to recognise and adjust the new opportunities and constraints.

MICRO STUDIES

This section deals with the major studies undertaken in developing countries based on micro analysis.

(1) Foodgrain Crops

During the early seventies, N. P. Patil and S. L. Hiregoundar (1964) broadly defined the concept of weather and examined yield uncertainty in respect of paddy in Bangalore district. The study divides the factors affecting yield of paddy into two major groups, viz. controllable and uncontrollable factors. The study explained the impact of annual rainfall as well as rainfall in 5

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different periods of a crop season, viz. (1) crop growing period, (ii) sowing season, (iii) critical period of growth, (iv) pre-sowing and actual growth period of crop, and (v) pre-sowing period. The authors explained yield uncertainty with the help of variability in rainfall for quite a long period of 32 years. By using Cobb-Douglas production function this study recommends the management strategy to minimize the yield variability in two major groups: first, the alteration of grain and vegetable crops, and second, various types of flexibilities, i.e. time flexibility, cost flexibility and production flexibility. However, this study is based on a limited sample constituting only 27 farmers from 3 selected villages, it has recommended their preferences for diversification to satisfy home consumption need and maximum returns. As a supplementary measure this study has also recommended the use of irrigation to reduce variability in yield and income. Apart from the above measures the study does not answer the questions like what steps government should take in the context of heavy loss due to weather hazards.

Baidyanath Mishra, H. K. Dasgupta and Jagannath Mishra (1964) have jointly examined risk in agriculture.

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in Cuttak district of Orissa, where they found a complex situation of stability as well as uncertainty. The study covered the crops of paddy, pulses, gram, potatoes, etc. and observed that the canal irrigation tract introducing greater stability in agriculture on one hand and frequently flood occurring tract on the other hand shows risk variable. They observed four major reasons behind such uncertainties in agriculture, viz. (i) complete specialisation, (ii) occurrence of floods, (iii) much dependence on rainfall, and (iv) absence of State enterprise in farm plan. For example, the cultivation of rice is fully dependent on the vagaries of monsoon, the degree of risk and uncertainty in its production is considerable. The study tried to indicate both the extreme types of risks, namely those of floods and droughts during the period 1951-52 to 1961-62 with the help of frequency distribution. They compared the yield per hectare of rice in irrigation and flooded villages to measure the degree of uncertainty.

A comment made by Ram Dayal\textsuperscript{42} (1965) found the impact of rainfall in the relevant months on the production of wheat in the Punjab on the yield rate and acreage by the usual multiple regression analysis. He pointed out that it is

unrealistic to determine the rainfall-crop relationship in a single analysis for any State unless the entire State constitutes a homogeneous region. Obviously, between different districts rainfall shows very wide fluctuations in the Punjab and such a State cannot be considered homogeneous region with regard to rainfall.

M. R. I. Molla (1972), in his study 'Rice Drying Problem During Rainy Season in Bangladesh' examined the climatic variables in an entirely different way from the other studies. He classified the weather situations and available drying hours for three seasonal rice crops namely Aman, Boro and Aus in the year 1970. He examined the element of risk in rice growing areas after dividing hours of the day and days into three classes, i.e. rainy, sunny and cloudy hours and days respectively for each region. On the basis of this analysis, the study shows that during the harvesting season on an average 3.76 and 3.83 hours per day were available for rice drying in Mymensingh and feni regions respectively. The study further estimates that 9 per cent of the total production losses are due to the drying bottleneck only. In other words, the degree of risk element (loss) is faced by 49.4 per cent of the area under crop by quality and grade damage in the area under study.

Sidheswar Raj \(^{44}\) (1981), in his study 'Impact of Rainfall on Crop Yield in West Bengal' established the relationship between productivity of rice (Aman) and monthly rainfall along with the effects of other growth factors with reference to the progressive district of Burdwan and Jalpaiguri, a sub-Himalyan district through multiple regression analysis for the data from 1950-51 to 1970-71. The major conclusions of the study are: (i) The net effect of average monthly rainfall of June-July and November-December on rice productivity is positive, while during August-September it is found to be negative in Burdwan district. But in Jalpaiguri the net effect of average rainfall during July-August is negative and during September it is found to be positive. This indicates that the crop-weather relationship which is valid for one district may not be so for the other district. It is thus difficult to have a macro model for crop-weather relationship for West Bengal as a whole. (ii) In both the above districts, the productivity due to technological progress has undergone a change. (iii) The effect on productivity of other factors is lower during the sixties compared to those in the fifties in both the districts. This may be due

to severe droughts in 1962-63, 1965-66 and 1966-67. One remarkable feature of the study is that the comparison made in the study is lacking in uniformity in the context of monthly rainfall as the comparison of June-July with November-December for Burdwan and July-August with September in Jalpaiguri is incongruous.

(2) Non-foodgrain Crops

S. N. Jatar \(^{45}\) (1945), in his study 'Nature and Role of Risk and Uncertainty in Agriculture' viewed that risk and uncertainty in agriculture can be examined only for crops for which marketable surplus in generated. The marketable surplus being a small portion of the total agricultural production, the element of risk in farmer's calculation or decision making comprehends subjective valuation. The future course of farmer's action also takes into account the governmental action regarding policies. Hence, it is difficult to distinguish between risk and uncertainty as they both involve subjectivity in agricultural decisions. The degree of risk can be found out in agricultural production with probability distribution or by other statistical techniques not only for marketable products, but also for non-marketable products.

M. L. Patel (1964), in his study on 'Role of Risk and Uncertainty in Kangra Tea Plantation', examined the role of technical, psychological, income, yield, contract labour, price, credit and fiscal uncertainties in tea plantation of the Kangra district of the Punjab. The yield uncertainty in tea production is attributed to irregularity of rains, scarcity of garden labour and poor growth of tea leaves due to inadequate pruning, hoeing of bushes and non-levitalisation of exhausted soil. The effect of labour shortage is reflected in rising wages and deterioration of quality of tea leaves due to late plucking. In the case of price uncertainty, the fall in export market and deterioration of old stock were the major reasons for uncertainty. According to this study unlike the medium and large farmers, 33 per cent of the small farmers faced the contractual uncertainty, particularly the short period of contract could not establish any certainty among the tea growers as it is a long duration crop. The low quality of black and green tea of Kangra is also a source of uncertainty as the improvement in quality is not possible due to the bottleneck of short labour supply. All the small tea growers are depending on sunshine to dry the leaves and they are using primitive types of rollers. The credit available from tea board at the rate of 6.25 per cent has

not become popular among the tea growers due to lack of proper time span for recovery instalments. For instance, the loans utilized for extension of tea plantation should be recovered by easy instalments of 5 to 6 years and the loans given for the rationalization of tea factories should be recovered only after 2 to 3 years. Because the repayment of loans can be possible from the returns of the investment made. The frequently increasing excise duty on tea is also a source of uncertainty. The major recommendations made by the study are: (i) to find out new foreign markets, (ii) to provide wage incentives to labourers, (iii) to obtain cheap credit facilities through tea board, (iv) to change land laws for suitable tenure system, and (v) discriminate excise duty pattern according to farm size and guaranteed price supports. But the study remained silent on child and female labour which are the best suited to leaf plucking of tea crop due to their swiftness.

B. V. S. Baliga and S. B. Tambad47 (1964) have jointly undertaken the study on 'Risk and Uncertainty in Irrigated Crops', Bangalore (1964) and examined six types of uncertainties, namely, (i) yield uncertainty, (ii) price uncertainty, (iii) technical uncertainty, (iv) uncertainties of government policies, (v) uncertainties

due other people's action, and (vi) family unforeseen actions. On the basis of 100 sample farmers from 10 villages of red soil area of Bangalore district in 1959-60, they examined that wide fluctuations in rainfall, temperature, humidity, pest attacks and diseases are the responsible factors for yield uncertainty. Similarly the study found that the nature of price variations are seasonal, cyclical and secular or random. With the above variables in view the study examined ragi, potato, cabbage, garlic, onions, beans, mulberry etc. and found that the specialization practice in farming increases income, but decreases its production stability, while in the adoption of diversification production stability increases, but net income goes down. The coefficient of variation indicates that the net returns and variability decrease with the increase in diversity indices. The study also concludes that the farm decisions depend on gross returns, its variability and price variability rather than average net returns.

I. J. Singh (1968) explicated the significance of risk in managerial decision in agriculture after reviewing Jaikrishna and Desai's probabilistic game theory and diversification models of risks and uncertainty for crop

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fertilizer selection programmes. He also reviewed Schulter's study on the interaction of credit and uncertainty in determining the allocation of resources and incomes on small farms of the Surat district of Gujarat. After reviewing the various studies Singh concluded that farmers' tendency to risk aversion is reflected in their attempt to diversify farm enterprises i.e. crop pattern.

D. M. Gopinath, G. Narsimhayya and T. B. R. N. Gupta 49 (1972), worked out indices to study relative growth in their study of 'Growth Trends in Area, Production and Productivity of F.C.V. Tobacco of Andhra Pradesh'. The regression of area, production and productivity indices were represented by linear functions. The study indicates that the rate of increase in production is much larger than the rate of increase in area of production. This contrast contributes to the change in the productivity. Two linear functions for area and production and a polynomial in fifth degree for productivity were fitted by least squares method.

Thomas B. Weins\(^50\) (1976), utilized a quadratic risk programming model to examine the impact of yield uncertainty on peasant allocation of land among crops and the use of hired factor services in his study, "Peasant Risk Aversion and Allocative Behaviour, A Quadratic Programming Experiment". He used historical survey data on a Chinese village to show that optimization qualified by risk aversion proved to be superior to risk neutrality in explaining peasant behaviour. With cotton crop as an example, the study uses sensitivity analysis for small farms and suggests that the effects of policies to reduce risk are technology specific and fertilizer intensive and hence risk aversion tends to increase peasant demand for fertilizer. Nevertheless, since risk is shown to have such an overwhelming role in determining peasant resource allocation, the firm conclusion is that policies to reduce risk would constitute an important instrument for productive change in rural economies.

M. L. Jhala\(^51\) (1980), in his study "The Estimation of Yield - Rainfall Relationship With Reference to Groundnut Regions in India", observed that there are large fluctuations in its output and prices, because of random

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variables associated with climate and their significant influence on producer's behaviour. Of all the environmental factors that contribute to the yield of groundnut, the rainfall and its distribution during the crop season exert the maximum influence. When the rainfall was moderate and well distributed, good yields were obtained on all types of soils. But if the rainfall were deficient or badly distributed the yield of groundnut was adversely affected. Another important observation is that in the area under irrigation, groundnut gives nearly double the yield the one obtained in rainfed conditions. Besides, irrigation brings stability in the yield of groundnut.

Chandrakant T. Patel (1981), developed the "Telephone System", to control insects and pests in the cotton crop. As it is evident from several studies that cotton crop is most susceptible to insects and pests, which cause damage around 30 per cent of the yield. It has, therefore, become crucial to control the uncertainty of pests and insects. Though the system developed here is expensive, costing on an average Rs.500 per hectare per annum (see foot-note), it ensures better exposure to

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Foot-note: As the cost of "Telephone System" per hectare was estimated to Rs.2500, which can serve for 5 years, the per hectare per year expenditure of this system is Rs.500.
sun and more effective spraying resulting in tangible benefits like additional picking from the plants, larger balls and reduction of loss due to the deterioration of balls. According to the estimate of this study instead of 65 lakh hectares of hybrid cotton at present, the intensive cultivation of nearly 2 lakh hectares in Maharashtra and Gujarat would mitigate the country’s need for the import of long staple cotton and spare about a million bales for exports.

(3) Other Studies

N. K. Desai\(^{53}\) (1961), examined mixed farming in Charotar region, which constitutes of whole Borsad, Anand and Petlad talukas and partly Nadiad and Cambay talukas of Kheda district. He discussed peculiar characteristics of Charotar region and found most significant region in Kheda district from the agricultural point of view. According to the study in the pattern of mixed farming the degree of uncertainty is less, but at the same time it gives lower net returns compared to that of specialized farming.

A. S. Kahlon and S. S. Johl\(^{54}\) (1964), in their study "Nature and Role of Risk and Uncertainty in Agriculture".


for Ludhiana district of Punjab covered wheat, gram, maize, rice, cotton, sugarcane and groundnut crops. They examined the proportion of risk money, i.e. financial risk for existing and improved farms. Besides, they explained various uncertainties, viz., weather, flood, drought, price, pests, yield and contractual uncertainties with the help of rainfall over growing period, prices, yield and acreage of different crops. They found that "The rabi crop acreage is much affected by uncertain rain over their growing period". They also observe that the variation in acreage is generally higher in those crops which experienced higher yield variability. The acreage under different crops has also been affected considerably by post-harvest price uncertainty. Thus, they examined the impact of total rainfall and ignored the distribution of rainfall during the year. Similarly, they gave much stress on acreage variability compared to that of yield uncertainty. Yet, the study remains silent on the question, as to what is the impact of price uncertainty on the yield per acre of different crops.

D. P. Apte (1964) has examined uncertainty for jowar, cotton and groundnut with the help of survey and resurvey at different points of time. After comparing

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various crops in kharif and rabi seasons, he concluded that pests and diseases have resulted into considerable loss for cotton and groundnut, hence the acreage allocated to these crops have decreased. The major observation indicates that the decisions of farmers depend on two factors, i.e. (i) to achieve self-sufficiency in respect of jowar, and (ii) non-foodgrain crops and particularly groundnut depend on the availability of seeds. He has pointed out that rainfall during the sowing season is more or less stable in 8 years out of 10 years. He also examined legal framework, indirectly affecting farm decision, e.g. tenancy legislation, leasing-out of land etc. The study also showed farmers' preference for Urid and Karala which yielded definite returns compared to cotton and groundnut. Moreover, mixed farming of Urid, mug, bajara and ambadi has served the object of diversification to take care of uncertainty elements. The findings of the study give much emphasis on family labour, bullocks and price considerations as compared to farmers' decisions. Besides, the wide variations in net returns indicated the highest profitability of kharif jowar followed by cotton and groundnut which is also challengeable.

B. L. Agrawal56 (1964) in his study, "Risk and Uncertainty in Agriculture - Implications for Agricultural Credit", classified risks into five major groups, viz.,

(1) natural hazards, (2) price fluctuations, (3) technological changes, (4) institutional changes, and (5) unfavourable factors affecting the health of the farm operator or his family. According to this study, the probability and extent of losses are likely to affect:

(1) capital investment in agriculture, (2) cost of credit, (3) security of loans, and (4) distribution of loans among different purposes and different periods, i.e. short, medium and long term loans. On the basis of this study, he emphasized the needs of research and services for reducing risk and uncertainty in 3 types of approaches: (a) intensive research for different types and extent of risks and the measurement and identification of farm credit problems arising from such risks, (b) the credit system and its administration adopted by lending institutions, and (c) identification of areas for government policy to reduce risk and uncertainties. Though the study examines various aspects of risk and credit in agriculture, it does not apply any quantitative measurement or statistical tools for the impact of risk on credit system.

Miss M. Meenakshi-Malya\(^5\) (1964) utilized the degree of variations from the normal rainfall as an indicator of

the instability of weather factor influencing the agriculture in her study, 'Nature of Risk Associated with Rainfall and its Effect on Farming - A Case Study of Kurnool District of Andhra Pradesh'. She measured agricultural uncertainties through frequencies of outcomes on a curve of zig zag nature showing fluctuations in risk variables. She also attempted a series of cycles by trial and error method and accounted for normal, below normal and above normal rainfall years. As annual rainfall is a rough measure, the series of pre-seasonal and seasonal rainfall have been discussed in the study. The author also tried to examine the reactions of the farmers to uncertainty by asking them the question, whether the farmers have high preference for survival or they display a gambling.

V. S. Vyas and K. R. Rakhral\(^5\) (1964) examined the "Uncertainty and Crop Planning" in Saurashtra region of Gujarat State, in their study. They explained the role played by uncertainties in yield, price and out-turn for the shift in cropping pattern by coefficient of variations, with a view that risk and uncertainty are synonymous. They covered bajara, jowar, cotton and groundnut crops and arrived at a following three major conclusions: (1) The uncertainty of yield and price is higher in inferior

cereals like bajara and jowar due to low out-turn per acre. Besides, they also observed low elasticity of substitution of commercial crops as a group, for the food crops as a group. The authors, however, emphasized the need for further probe to test this hypothesis because it may not be true for individual crops separately. (2) Secondly, at low level of out-turn, the tendency to bear risk to augment income is higher than the higher level of out-turn. Among groundnut and bajra, the study observed greater uncertainty for bajara than groundnut. (3) Out of the two uncertainties yield uncertainty was found to be more effective than price uncertainty in farm decisions. The authors of the study have pointed out that the conclusions can be treated as hypothesis and further scope of investigation can provide better results.

S. B. Lal Gupta (1964), in his study, "Variability of Yields, Prices and Income for Selected Crops in Varanasi District, (U.P.)", tried to measure risk with the help of variability index. The measurement of variation was based on data of 12 years from 1950-51 to 1961-62 for bajara, jowar, wheat, cotton, sugarcane etc. for 14 selected crops in Varanasi district of Uttar Pradesh. They examined yield variability, price variability and income variability

through the comparison of average yield, average price and average gross income respectively. The study reveals that the variability of rabi crops is lower than that of kharif crops which conforms with the established facts that kharif crops are more open to hazards of weather conditions compared to rabi crops. Another remarkable observation of the study is that the price variability, in general is comparatively lower than yield variability. On the basis of the above findings this study recommended diversified farming to reduce the variability of incomes.

Sipradas Gupta (1976) discussed various types of risk and uncertainties in his book, "Agriculture Producers Rationalities and the Technical Change". They are: (i) climatic conditions and weather uncertainty, (ii) uncertainty of market and price fluctuations, (iii) uncertainty arising from variations in labour requirements, (iv) uncertainties arising from technical changes, and (v) uncertainty arising from legal status of producers. The study examined the impact of yield uncertainties on farm income and cropping pattern in the Punjab State of India. It is also found that income variability arises purely from yield fluctuations due to variable nature of the monsoon rainfall. Another important observations made by this study

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is that the cropping pattern has deliberately switched over to non-foodgrain crops and more specifically towards cotton and sugarcane from bajara, gram, jowar and maize. However, wheat has maintained its significance in the cropping pattern of the State. Among the non-foodgrain crops, the preference is in favour of sugarcane as compared to cotton due to relatively higher net returns per acre in sugarcane.

Baldev Singh⁶¹ (1975) has made the study on "Risk, Productivity and Land Use" with special reference to Surendranagar district of Gujarat. He formed the hypothesis that fluctuations in water supply cause fluctuations in output by influencing, first cultivated acreage and latter, the yield rates. The fluctuations in output are therefore, a function of fluctuations in acreage planted and fluctuation in yield rates. He studied coefficient of variations of area, output and productivity per hectare for various crops like jowar, bajara, wheat, groundnut, sesame, cotton etc. during 25 years from 1950-51 to 1974-75. It also explains regression estimates, crop-wise area, crop-wise output during normal, wet and dry years. Besides, the study also examined the cropping pattern, the coefficient of variation of rainfall, probability of

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rainfall in dry, wet and normal years. One of the remarkable observations of the study, is additional output can be obtained by changing cropping pattern in favour of cotton and jowar in general and groundnut in the wet years and bajara in dry years. Though the availability of water as major farm input is given sufficient importance, but other risk variables like temperature, humidity, frost, hailstorm, insects etc. are not taken into account in this study.

Mruthyunjaya and A. S. Sirohi\(^6\) (1979), in their study "Enterprise System for Stability and Growth in Drought Prone Farms, an Application of Parametric - Linear Programming" examined the effects of resource optimization and better crop technology on land utilization, farm returns and labour employment. The authors tried to establish a model in which the farmer decides between possible crop combination on the basis of expected net returns and the absolute deviations of net returns for each crops from its expected value. The yield uncertainty is observed over whelming in drought prone areas as compared to product price risk and hence they did not consider price variability in their model. Moreover, they assumed

constant input cost to compute net returns. By seeing the returns and the corresponding risk associated with them in existing and optimum farm plan, they intended that by optimising and including better crops farmers can get more returns than at a lower level of risk that they are taking at present. They also found that with one per cent increase in net returns, risk increased by 1.97 per cent on small farms and almost to that extent (2 per cent) on the large farms.

A. K. Agrawal 63 (1979), in his study, "Crop Insurance, Need for a New Approach", examined crop insurance scheme based on area approach as a solution of risks. The study drew following three major conclusions. They are: (1) the time and administrative expenses on individual approach in developed countries indicate that the crop insurance based on area approached is the suitable solution for meeting risk and uncertainties, but it can cover only general calamities. (2) Even after best farm technology, certain range of fluctuations remained in agriculture. Hence, certain other measures with crop insurance are also necessary to apply. (3) On the basis of crop-cutting experiments the homogeneous area is worked out in area approach. It has low administrative cost and elimination of dispute of moral hazards which are the favourable aspects of this scheme.

K. M. B. Rahim and Katar Singh (1978), in their study on, "Identification, Appraisal and Evaluation of Agricultural Projects", examined risk and uncertainty with the help of sensitivity analysis. If price assumptions proved wrong, every agricultural investment proposal should be examined to know its profitability. For this purpose, the alternative assumption about future prices can be made and their effects on net present value determined. This study recommended various ways to mitigate the occurrences of risks, like sensitivity analysis, mathematical expectations, shortening the period of crops, adjustment in rate of interest and safety allowances.

Ishwarbhai J. Patel (1980) observed from his long experience of Agricultural University and several studies made therein that the improvement in agricultural production is possible with the development of newer and better plant types with higher harvest index in a wide group of crops including wheat, rice, pearl-millet, pulses, oilseeds, vegetables, cotton, tobacco, spices and fodders. It is also found that the differential rate of adoption of high yielding varieties of rice and wheat are a function of regional environments including the high degree of uncertainty in high yielding varieties.

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I. J. Singh and K. N. Rai (1980), in their study on "Acreage, Yield, Price and Gross Income Variability of Selected Crops in Dry Farming Area of Haryana", covered the entire dry land tract of Haryana consisting of Hissar, Sirsa, Bhilwani and Mohindergarh districts. The study covered the major crops like jowar, bajara, moong, deshi cotton, wheat, gram, barley, rape and mustard etc. This tract is further divided into two zones based on average yearly rainfall viz., Hissar zone and Narnail zone having 350 mm and more than 350 mm annual rainfall respectively. The study observed that during the period from 1965-66 to 1975-76, the area under almost all crops has been fluctuating as a result of weather fluctuations, extension of irrigation facilities and prices. The crop-wise coefficient of variations are analysed in the study which indicate that almost in all the cases the observed values of the coefficient of variations are more than 20 per cent in the cases of income and yields. The study also suggested the measure of crop insurance for stability of farm income as a safeguard against risks and uncertainties for, it can motivate the farmers to grow more remunerative and risky crops like oilseeds, pulses and non-foodgrain crops, most appropriate with the current national strategy to increase

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the production of pulses, oilseeds and agricultural raw materials for secondary sector.

**SCOPE OF THE PRESENT STUDY**

The important features emerging from the review of the major studies in the field of risk and uncertainties in agriculture can be laid down as follows:

(i) All the types of risks and uncertainties faced in agriculture, i.e. those related to yield, price, technological aspects, legal and institutional aspects etc. have been analysed by these studies. Most of them have touched more than one type of uncertainty, while few have concentrated their work on only one or the other type of uncertainty faced by agriculture.

(ii) The extent of rainfall and the distribution of rainfall are found as the major risk variables in agriculture and they have been widely examined by the different researchers. But none of the studies has tried to evaluate or examine the role of these variables in agriculture.
(iii) The analysis of almost all of the studies have been related to some specific regions. It may be maintained here that the variability in the element of risk and uncertainty is so much that through analysis can hardly be made on the macro ground. The reason behind it is the natural variables are hardly found uniform for the large area like a State or country.

(iv) Two types of data have been used in the above reviewed studies: (i) Primary data collected from selected sample farmers, and (ii) Secondary data collected from either government or other institutional sources. It is also observed that the risk and uncertainty can well be studied for a short period of an year or a part of it as also on the basis of quite a long period data, i.e. 10 year period or longer than even 10 year period.

(v) Most of the studies have analysed risk variables either for one or two major crops grown in the region, while only few studies have examined the risk and uncertainty taking together foodgrain and non-foodgrain crops.
(vi) As risk cannot be avoided for any farm firm, it is necessary to adopt various measures. The suggestions made in above reviewed studies covered a quite long list of measures, which are diversification of crops, multiple cropping, mixed crops, crop rotation, forward contracts, flexible crop plans, crop insurance etc. It is observed that crop insurance measures can be best suited to distribute the element of risk and uncertainty among large number of farmers by paying small amount of charges in the form of premium.

(vii) It is clearly evident from the review of the above studies that the element and extent of risk have much to do with the behaviour of the farmers as they affect the decision-making process. The attitude towards the risk and uncertainty and the reaction toward risk variables depend very much on the farmers' behaviour.

(viii) The coefficient of correlation, coefficient of variation, regression analysis, weather indices, utility function, game theory etc. are the methods used in the above reviewed
studies to measure the degree of risk and uncertainty in agriculture.

In the above context, it should be noted here that the study undertaken here has got specific characteristics which explain the scope and significance of the problem of risk and uncertainty in agriculture.

(i) The study examines the impact of seasonal as well as non-seasonal rainfall on the yield of different crops. Particularly, in Kheda district of Gujarat, non-seasonal rainfall affects adversely to the yield of non-foodgrain crops like cotton, tobacco, sugarcane and some foodgrain crops as well.

(ii) Temperature is the another important factor constituting a significant part of the climate. This study has made an attempt to examine the impact of morning and evening temperature on the crop yield.

(iii) The extent of humidity plays very important role in crop output. In the case of some specific types of crops it becomes an essential gradient. Many a times, large percentage of humidity results into incidence
of insect-pests and at last into loss. This study has selected humidity as one of the variables to explain yield variability.

(iv) Indeed, it is also a micro study as the studies reviewed above, it analysis various types of uncertainties faced in the cultivation of foodgrain and non-foodgrain crops namely, yield uncertainty, price uncertainty, institutional uncertainty, labour uncertainty, technological uncertainty, crop diseases uncertainty etc.

(v) This study has also made an attempt to suggest some measures to either minimize or mitigate gross loss of yield or revenue, arising due to risk and uncertainty. Besides, it has also given emphasis on crop insurance scheme.