Discussion Papers in Economics

Risk Management in Agriculture

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June 2003

Discussion Paper 03-08

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June 2003

*This monograph was written to be part of the series of studies commissioned by the Ministry of Agriculture under the rubric of "State of Indian Farmer – A Millennium Study".

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Acknowledgements

The initiative for this study came from the Ministry of Agriculture, GOI; we are grateful to Shri R.C.A. Jain, Secretary, Ministry of Agriculture, and to Dr. M. K. Srivastava, Director (Millennium Study), Ministry of Agriculture. The Centre for Management in Agriculture at the Indian Institute of Management, Ahmedabad administered this project. For most of its duration, Professor S. M. Datta handled this project. We are grateful to him for his support. For expert referee comments and suggestions, we thank Shri R.C.A. Jain, Ministry of Agriculture and Professor R.S. Parchure, National Insurance Academy. We also received valuable comments from the participants at the review seminar on Millennium Studies held at the Institute of Economic Growth. Dr. G. Srinivasan, Department of Science and Technology provided precious advice on climate and weather risk. Bharat Ramaswami thanks his home institution for granting a leave of absence for the purpose of researching this study. He also thanks Santanu Kar for assistance with tables and figures. The authors alone are responsible for the contents of the study including views, interpretations and errors.

Executive Summary

1. Introduction

The enterprise of agriculture is subject to great many uncertainties. Yet more people in India earn their livelihood from this sector than from all other sectors put together. This includes large number of the poor who have little means of coping with adversities. Understanding agricultural risks and the ways of managing it is therefore a topic that deserves serious attention and research. On the basis of existing literature, this study documents the status of our knowledge on risks of agriculture and their management. Inspite of its manifest importance, risk management in agriculture is an under-researched topic relative to traditional concerns such as land tenure, technology adoption and food policy.

2. Principal Risks

Chapter 2 discusses the evidence on the nature, type and magnitude of agricultural risks. There are very few studies that give us such information because the measurement of risk requires (a) observations over many time periods, i.e., time-series data and also requires (b) observations at the lowest unit, i.e., the farm. In most cases, therefore, the evidence is fragmented and indirect.

Production and price (or market) risks are two major risks that confront farmers. These risks could either be systemic or covariate (i.e., they are common to large groups of producers) or they could be individual-specific or idiosyncratic. The distinction is important because risk pooling and insurance arrangements (whether formal or informal) are more likely to offer protection against idiosyncratic risks rather than systemic risks.

The diversity of climate, growing conditions and market structures means that there is no typical risk environment for a farmer. In the drylands without access to assured irrigation, rainfall is a dominant production risk. There are, however, many attributes of rainfall – the relevance of the onset date of monsoon and the distribution of rainfall through the season varies according to crop and soil type. The spatial spread of rainfall varies too. As a result, rainfall risk could be both covariate (i.e., a systemic risk) and individual specific depending on the year and the region. Similar is the case with pests and disease. Local pest and disease infestations depend on many factors including the crop variety, weather, the use of pesticides and other crop practices. Beyond a threshold level, the infestation can quickly reach epidemic proportions affecting large areas. Unlike rainfall risks, the humid and irrigated regions have no special advantage with respect to pest and disease attacks.

As the demand for agricultural products is inelastic, supply shocks are magnified in price variations. Besides production risks, supply shifts are also because of variability in planned supply, i.e., area planted to a particular crop. Variability in planned supply comes about because of errors in forecasting prices. Often, the biases in these errors are systematic as forecasts are determined by past prices. As a result, prices and planned supply can oscillate creating endogenous variability. Such uncertainty is often seen in seasonal price movements as well. The importance of price risk would depend on the extent of exposure to market forces as well as existing market institutions. International trade can increase or decrease price variability.

3. Risk Management at the Farm Household Level

Chapter 3 discusses farmer strategies to combat risk. This chapter as well as the next relies heavily on the findings from ICRISAT village studies. Uncertainties in income within agriculture can arise from several sources and a farm household adopts different strategies to mitigate this risk, and smooth income and consumption. A distinction is usually made between risk reducing strategies that the farmer adopts ex-ante to lower risk and risk roping strategies that the farmer adopts ex-post.

There are essentially six ex post ways to compensate for shortfalls in farm income: They can sell stored produce, liquidate assets, borrow for consumption, receive transfers from relatives, change jobs and/or increase their labour market participation and migrate in search of work. In their choices, farm households will try to protect their assets so as to minimize the adverse impact on their future livelihoods. If a risk averse household is not able to achieve an entirely smooth consumption path through *ex post* mechanisms such as these, it has an incentive to devote resources in an effort to secure a more stable income stream. Households might farm a diversified portfolio of agricultural activities, adopt technologies, such as inter-cropping or drought- resistant crops, and contractual arrangements such as sharecropping that reduce the variance of income, or diversify their activities through migration or local non-agricultural employment. Any of these *ex ante* actions might be costly, so that the households would be sacrificing income, on average, in order to assure a less risky stream of income.

4. Risk Management at the Community Level

In addition to the mechanisms at the level of the farm household, the need to cope with risk can also affect community interactions and social customs. Gift-based exchange that is based on reciprocity and informal borrowing and lending on implicit and flexible terms are instances of community level mechanisms that can help farm households to cope with adversity.

In developing countries like India, broad-based formal insurance markets are hindered by problems of imperfect information and costly enforcement. However, these problems are limited in small communities. Villagers tend to know a great deal about what their neighbours are up to, and they can fall back on 'informal' enforcement mechanisms like social sanctions when disputes arise. The focus of this chapter is income smoothing attained through mutual insurance between economic agents. The mechanisms involved might be gifts, transfers or borrowing and lending. However, all mutual insurance schemes share the element of reciprocity. At the community level, exchanges and informal credit are the principal traditional risk coping strategies. This chapter discusses their effectiveness and their limitations that arise because of the covariate nature of agricultural risks.

Recent research has shown that rural households in India use a wide variety of instruments to smooth consumption, some through market and some through informal mechanisms. The ICRISAT studies show that village level risk sharing is able to mitigate a large portion of idiosyncratic risk. Nonetheless, some idiosyncratic risk remains and poorer households are considerably more vulnerable than richer households. Furthermore, what is disturbing is that risk pooling at the level of village seems weaker than by caste and kinship groups. Recent academic work on incomplete risk sharing has focused on the role of imperfect enforcement in explaining the lack of full risk sharing. Enforcement problems are key part of the economic environment in the ICRISAT study region, but they are insufficient to explain the patterns in the data. Most important, evidence of incomplete risk sharing may result as well from imperfect information, heterogeneity in desires and ability to save and borrow, specification error, costly contracting, and a host of other factors including discrimination and social isolation. The decline of common property resources, which is an important element of collective sustenance arrangements in village India suggests that traditional arrangements for mutual insurance are, probably much weaker today than what obtained at the time of independence.

5. Production Risks, Technological Change and Government Programmes

In chapter 5, we consider how production risks have been transformed by developments in the agricultural economy in the post-independence period. The first part of this chapter considers the impact of technological change on production risks. The second part of this chapter considers the government response to production risks in the form of crop insurance schemes.

In technology, the momentous event was the introduction of improved seeds in the mid-1960s that marked the "green revolution". Since then, agricultural growth in India has been sustained by technological change. Since the 1960s, the Indian agricultural research system has released many improved varieties some of which have been widely adopted by farmers. The displacement of traditional varieties by improved varieties has changed production practices especially in terms of greater use of nutrients and pesticides. The impact of improved varieties on production risks has been controversial. At issue is the susceptibility of improved varieties, relative to traditional varieties, to moisture stress and pests. Improved varieties do well in assured rainfed or irrigated environments. As they are fertilizer responsive, vegetative growth is greater with improved varieties that in turn might encourage more pest attacks. Does that mean, however, that improved varieties are riskier than traditional varieties? From a review of research there is little conclusive evidence to suggest that these have increased the riskiness of production. On the other hand, the adoption of these technologies does carry some long-term risks in terms of soil depletion and genetic uniformity. The chapter also considered the findings on the impact of new technologies on aggregate instability. It was seen that were no direct implications of the rise in aggregate instability for farm-level production.

On the policy front, the government addresses production risks through crop insurance programs. While recent policy changes have enhanced the relevance of crop insurance as a risk management device, the program is still small in relation to its potential. Further, the program is not yet on a sound actuarial footing and requires considerable government subsidies. This factor may well hamper its rapid expansion in the future.

6. Market Risks, Government Interventions and Futures Markets

In chapter 6, we review the principal developments that have impacted on market risks. The most important development in the agricultural economy to have an impact on market risks have been price support programmes. Price supports have been the principal means by which Indian farmers have received some protection against market risks. The price support policy has its limitations as well. Firstly, for crops other than rice and wheat, price support programmes have been limited or non-existent. Secondly, for the crops that are supported, it has been difficult to balance consumer and producer interests. In some of these crops, the support prices have been consistently fixed higher than the counter-factual market price. As a result, stocks with the government tend to increase. As these policies are not sustainable indefinitely, farmers face a policy risk depending on the way stocks are reduced.

There are also private mechanisms that can potentially help farmers to cope with private risks. In specialty crops and vegetables, contract farming is gaining ground as a mechanism by which private processors obtain supplies from farmers. This system takes its appeal among growers because of the price insurance that it offers. These crops are characterized by substantial market risks and contracting allows the transfer of these market risks from the farmer to the processor. It has been found that price stability is a major benefit of contract farming for producers.

A much older institution is the futures market that can provide insurance against price volatility. Futures trading is a market-based institution for trading price risks. Theoretically, it allows farmers to hedge against market risks. However, transactions costs is a formidable barrier to the participation of farmers in futures markets. Further, futures markets in India suffer from a lack of liquidity. Their performance in insuring spot prices is also suspect because the basis risk from futures trading is high relative to spot price risk. At the moment, therefore, futures contracting is not a useful risk management tool for producers.

7. Sources

The paper is largely drawn from the literature. In keeping with the objectives of this study, we focus entirely on India although there are occasional references to other developing countries. Within the literature on agricultural risk management in India, we exclude papers that are exclusively modelling contributions. Clearly, progress in modelling is essential for better design of risk management programs and policies. However, unless the paper throws light on either existing risks, risk management practices or policy issues, the subject is not appropriate for this study. The study also excludes from its ambit prescriptions for better policies.

Chapter 1: Introduction to Study

1.1 Introduction

The enterprise of agriculture is subject to great many uncertainties. Yet more people in India earn their livelihood from this sector than from all other sectors put together. In rural India, households that depend on income from agriculture (either self-employed or as agricultural labour) accounted for nearly 70% of population (estimates from survey of consumption expenditures, NSS, 1999/00). This includes large number of the poor who have little means of coping with adversities. Poor households that were self-employed in agriculture account for 28% of all rural poverty while poor households that are primarily dependent on agricultural labour account for 47% of all rural poverty.[1] Thus, 75% of all rural poor are in households that are dependent on agriculture, in one way or the other. The same survey shows that 77% of all poverty is rural. Thus 58% of all poor are in households that are dependent on agricultural income in rural areas.

Understanding agricultural risks and the ways of managing it is therefore a topic that deserves serious attention and research. On the basis of existing literature, this study documents the status of our knowledge on risks of agriculture and their management. Inspite of its manifest importance, risk management in agriculture is an under-researched topic relative to traditional concerns such as land tenure, technology adoption and food policy. Indeed, to the best of our knowledge, this is the first study of its kind in India.

The goals of this study are

(a) to document the nature, type and magnitude of risks

(b) to describe the alternative ways in which agricultural producers manage risk

(c) to describe community responses to risk including traditional practices of exchange and credit

(d) to describe the impact of government programmes and policies on producer risk

(e) to describe developments in the agricultural economy that have had an impact on producer risk.

Chapters 2, 3 and 4 focus on objectives (a), (b) and (c). Goals (d) and (e) are pursued in chapters 5 and 6. Chapter 5 deals with policies and agricultural developments that have affected production risk. Chapter 6 considers the impacts of the same on price or market risks. The following is a brief guide to the contents of each of these chapters.

1.2 Principal Risks

This chapter discusses the evidence on the type and magnitude of risks. The chapter is organized around production risks and price or market risks. Because of the paucity of risk studies at the farm level, we consider the sources of production risk in weather and in pests and diseases. In price risks, we show how exogenous and endogenous factors play a role in price variability.

1.3 Risk Management at Farmers' Level

This chapter discusses farmer strategies to combat risk. This chapter as well as the next rely heavily on the findings from ICRISAT village studies. A distinction is usually made between risk reducing strategies that the farmer adopts ex-ante to lower risk and risk coping strategies that the farmer adopts ex-post. Risk reducing strategies include crop diversification, intercropping, farm fragmentation and diversification into non-farm sources of income. Risk –reducing strategies can be effective in many production and market related risks but they are typically costly for those farmers who have to forego their most profitable alternatives. Risk coping strategies are relevant for dealing with catastrophic income losses, once they occur. Under risk coping strategies, farmer may rely on new credit, the sale of assets, temporary off-farm employment. Other strategies might involve contractual relations in land and labour. For instance, sharecropping distributes production risks while contracting with traders and merchants for credit and marketing is another way of coping with market risks. Similarly, interlocked contracts are another mechanism which re-distributes risk between the contracting parties.

1.4 Risk Management at Community Level

At the community level, exchanges and informal credit are the principal traditional risk coping strategies. This section will discuss their effectiveness and their limitations that arises because of the covariate nature of agricultural risks.

1.5. Production Risks, Technological Change and Crop Insurance

The green revolution and the subsequent developments that have led to improved varieties has been a major factor in the transformation of Indian agriculture. The first part of this chapter considers the impact of technological change on production risks. The second part of this chapter considers the government response to production risks in the form of crop insurance programs.

1.6 Market Risks, Government Interventions and Futures Markets

The most important development in the agricultural economy to have an impact on market risks was price support programmes. This chapter considers market intervention operations and their impact on producer risk. The chapter also considers a newer development in the private sector, which is the system of contract farming. This system takes its appeal among growers because of the price insurance that it offers. Another private sector solution to price instability is futures markets. The chapter winds up with a discussion about the value of futures markets in India as a risk management tool.

1.7 Sources

This paper on risk management is a part of the larger study conceived by the Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India called "State of the Indian Farmer – A Millennium Study". The guidelines that have been provided to the authors of the individual components of the millennium study seek to define their scope and content. According to them, the millennium study "seeks to record the impact of the transformation induced by public policy, investments and technological change on the farmers' access to resources and income as well as the well-being of the farm households at the end of five decades of planned economic development." Thus it is expected that the papers "give a historical perspective of developments, changes in policies and programmes and their impact on professional and economic environment of the farmer………The papers are in the nature of comprehensive reviews in which the authors are expected to paint an objective and unbiased image of developments in agriculture during the last five decades keeping in view the farmers' perspective or farmer at focus…. Policy prescriptions are to be avoided."

In keeping with the objectives of this study, we focus entirely on India although there are occasional references to other developing countries. For recent surveys on agricultural risk management in the developed countries, see OECD, 2000 and European Commission, 2001. Within the literature on agricultural risk management in India, we exclude papers that are exclusively modelling contributions. Clearly, progress in modelling is essential for better design of risk management programs and policies. However, unless the paper throws light on either existing risks, risk management practices or policy issues, the subject is not appropriate for this study. The study also excludes from its ambit prescriptions for better policies.

We also note two limitations of this study. First, because of the absence of relevant literature, this study is unable to provide a systematic chronology of developments in agricultural risk management. This lacuna is addressed to some extent by our description and analysis of the impacts on the farmer's risk environment due to major changes in the agricultural economy (in chapters 5 and 6). Second, as documented in Chapter 2, paucity of information at farm level has meant that the goal of viewing risk from the perspective of farmer is difficult to achieve by a direct description of the farmer's risk environment. To circumvent this problem, this study supplements the limited number of farm-level studies by information assembled from diverse sources on farm-level risk factors.

Chapter 2: Principal Risks

2.1 The Risk Environment: Conceptual Considerations

At a descriptive level, the income risks borne by producers can be classified into three kinds: production risks, price risks and input risks. Production or yield risks arise because of two principal factors. Random uncontrolled inputs (e.g., moisture, temperatures) due to weather is the first factor. Pests and diseases constitute the second factor. Risks from variable prices is the second kind of risk. Because of substantial production lags in agriculture, production decisions are made far in advance of the date when output is realized. As a result, farmers need to forecast the prices that will prevail at the time of sale. The loss to farmers occur when realized prices are lower than the expected price. Although production risks have consequences for price risks, the latter is not just because of production risks alone. Prices can vary also because of demand shocks as well as instability in expectations formation. Finally, there are input risks that occur when either there is a shortage of inputs or when their prices vary. Besides these agricultural risks, farm households are also subject to non-agricultural risks such as illness and disease. Although analysis of such risks is beyond the scope of this study, there is sometimes significant overlap between the mechanisms that farmers use to cope against agricultural and non-agricultural risks. Figure 2.1 summarises our discussion about the schematic classification of risks.

From an analytical point of view, a very important distinction is between risks that affect and are common to all farm households (such as possibly price and weather shocks) and risks that are specific to a particular farmer such as possibly a pest or disease. The former risks are called systemic risks or covariate risks while the latter are called idiosyncratic risks. The distinction is important because economic theory predicts that risk pooling and insurance arrangements (whether formal or informal) are more likely to offer protection against idiosyncratic risks rather than systemic risks.

Another distinction that is worth making is between risk and variability. Too often variability is used interchangeably with risk. However, they are not the same because variability does not always imply risk although the reverse is true. To understand this, consider for instance price risk. It is well known that agricultural prices vary from month to month and year to year. However, if the variation is predictable, farmers would face no price risk. Thus, for instance, even if output price in year 2002 is different from that in year 2001, output prices are not risky if at the time of planting, the farmer knows for certain the output price at time of sale. The farmer would then pick an appropriate production plan. For variability to translate into risk, it must be that when production decisions are made, the producer does not know or does not forecast the relevant variable accurately.

2.2 The Risk Environment: Magnitudes

Information about the magnitude of risks at the farm-level is meager. The difficulty is principally of data. The measurement of risk requires (a) observations over many time periods, i.e., time-series data and also requires (b) observations at the lowest unit, i.e., the farm. Thus we need a combination of time series and farm-level cross-section data, which in current econometric parlance would be known as farm level panel data.

The first requirement is evident as variability in output, prices and farm returns cannot be ascertained from observations at one point. The second requirement is a little subtler. Time-series data on relevant variables such as output, prices or even farm returns is relatively easy to obtain for the country as a whole or for a state as a whole. With a little more difficulty, such data can also be obtained at the level of a district for most crops. However, such aggregate data do not accurately convey the magnitude of risks facing a producer as aggregation inevitably results in dampening variability.

2.3 Relative Importance of Production and Price Risks

Input risks have not traditionally received much attention. Although timely availability of inputs is sometimes an issue especially with inputs supplied by the public sector such as fertilizers and seeds, input risks are in most circumstances not important because production decisions are usually made after the variability in input use and prices is resolved.

Barah and Binswanger (1982) considered the relative importance of production and price risks in crop income risk.[2] They used time series data (1956/57 to 1974/75) from 91 districts covering Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu. In terms of agro-climatic regions, these districts spanned three zones: (1) the unirrigated semi-arid tropics with less than 25% of gross cropped area irrigated, (2) the irrigated semi-arid tropics with annual rainfall between 500 to 1500 mm and with more than 25% of gross cropped area irrigated and (3) the humid tropics with annual rainfall exceeding 1500 mm. Although this study used district level yield data and not farm level yield data, this study is still worth reporting because it is the only one of its kind.

Barah and Binswanger decomposed gross revenue variability into price, yield and price-yield interaction components. If *p* is price, *q* is yield and *R* is gross revenue, then $R = qp$ and the variance of gross revenue can be approximated as

$$Var(R) = \bar{q}^2 Var(p) + \bar{p}^2 Var(q) + 2\bar{q}\bar{p}Cov(p,q)$$

where *Var* is the variance operator, $\bar{q}$ and $\bar{p}$ are the means of yield and price respectively and *Cov* is the covariance operator. Thus, the above identity splits the variance of gross revenue into a price component (the first term), an yield component (the second term) and a price-yield interaction component (the third term). The above identity can be used to compute the proportion of variability in gross revenue that is due to its individual components by rewriting it as

$$1 = \frac{\bar{q}^2 Var(p)}{Var(R)} + \frac{\bar{p}^2 Var(q)}{Var(R)} + \frac{2\bar{q}\bar{p}Cov(p,q)}{Var(R)}$$

where the first term is the contribution of price (CP), the second term is the contribution of yield (CY) and the third term is the contribution of the interaction term to revenue variability. By multiplying both sides of the above equation by 100, the contribution of the price, yield and interaction terms can be expressed in terms of percentages. Note that if the sum of the price and yield terms exceeds 100%, then it means that the price-yield interaction is negative because of negative correlation.

The results of this study are summarized graphically in Figure 2.2. The horizontal axis plots the price component CP in percentage terms while the vertical axis plots the yield component CY in percentage terms for each of the 91 districts in the sample. The line from the origin is the 45-degree line. If a district lies on this line, then it means that the price and yield risk contribute equally to crop revenue risk in this district. If a district lies above and to the left of the 45-degree line, then it means that yield risk is more important than price risk for this district. If a district lies below and to the right of the 45-degree line, price risk contributes more to revenue fluctuations than yield risk in this district. The figure also contains a diagonal line intersecting the 100-

100 points on the price and yield component axes. If a district lies above this diagonal line, the price-yield interaction component is negative while if it lies below the diagonal line, the price-yield interaction component is positive.

49 of the 59 unirrigated districts in semi-arid tropics are located above and to the left of the 45-degree line indicating the greater importance of yield variability in revenue risk. On the other hand, 22 of the 27 irrigated districts in semi-arid tropics and all the 5 districts in humid tropics lie below and to the right of the 45-degree line indicating the greater importance of price variability in revenue risk. The majority of districts lie above the diagonal line connecting the 100-100 points on the price and yield component axes. This means that for most districts, prices and yields are negatively covariate.

The negative correlation between prices and yields reduces crop revenue fluctuations and provides a natural hedge to farmers. This suggests the possibility that perfect price stabilization could destabilise incomes in some districts. This would happen if the yield component is greater than the sum of price component and the price-yield interaction component. The chances of this are higher larger is the negative correlation between price and yield. Indeed, it is found that when the price term and the price-yield interaction term is set to zero (as would be the case with perfect price stabilization), the variability of crop revenues increases in 21 districts that lie above the 100-100 diagonal line. Of these 17 districts are from the poorer unirrigated districts of semi-arid tropics. The major beneficiaries of reduced price variability are the agriculturally richer irrigated districts of the semi-arid tropics and the humid tropical districts. Barah and Binswanger show that stabilizing the yield of the dominant crop in each region would be much more effective in stabilizing revenues in the unirrigated districts of semi-arid tropics. Stabilizing price, on the other hand, is an effective strategy to reduce revenue risk in the irrigated districts.

Note that because of the use of district level data, the importance of yield risk is likely to be more important at the farm-level than indicated by the Barah and Binswanger analysis. This is clear from an analysis of farmers' price and yield expectations collected from an experiment (Walker and Ryan, 1990). The experiment consisted of offering farmers bets with real payoffs (and not hypothetical payoffs). Farmers were given money that they assigned to ten discrete outcomes representing yield, price and gross revenue intervals. Farmers were rewarded the amount placed in the interval that contained the actual realization of price, yield or gross revenue. The yield realization was measured by crop cuts taken in each farmer's field at harvest. The price realization referred to the peak harvest price in the most frequented market. Risk was defined as the difference between actual and expected values in mean absolute percentage errors.

Thirty farmers from villages in Andhra Pradesh participated in the experiment. The villages were in the semi-arid tropics but with access to irrigation. The farmers' expectations were elicited for paddy and groundnut grown in irrigated conditions. Figure 2.3 graphically represents the empirical distribution of mean absolute percentage errors across the thirty farmers. The forecasting errors are much smaller in the price distribution with the average errors around 10% for paddy and a little less than 20% for groundnuts. However, the yield forecast errors are larger than 20% for both these crops. Furthermore, the empirical distributions of price are more tightly clustered than are the yield distributions indicating that more farmers forecast price correctly than they are able to forecast yield.

2.4 The ICRISAT Village Studies

Inspite of such evidence documenting the importance of yield risks especially in harsh dryland production conditions, there is a remarkable paucity of information on the magnitude of farm level yield risks. This is no doubt due to the difficulty that has been alluded to earlier – of collecting a time series of farm level yield data for a cross-section of growers. Perhaps the most well known instance of a time series farm level data set is the data from the ICRISAT village studies that has spawned many papers especially focusing on risk and insurance arrangements in these village economies. These papers have been invaluable in furthering our understanding of how households and communities cope with risk and will therefore be repeatedly cited in this study. For that reason, it is convenient to acquaint ourselves with the villages selected in the ICRISAT study.

In the ICRISAT Village Level Studies (VLS), data was gathered from six villages located in three contrasting agro-climatic and soil tracts in India's semi-arid tropics. Mahbubnagar in the Telengana region of Andhra Pradesh, Sholapur in the Bombay Deccan and Akola in the Vidharba region of Maharashtra were the three regions. Akola is rainfall-assured but has little irrigation. Mahbubnagar is drought prone but has access to irrigation while Sholapur is rainfall-unassured and has no irrigation either. Within each region, two villages were selected. A sample of thirty cultivator households and ten landless households was randomly picked in each village. The households were surveyed with respect to their agricultural operations, investments, consumption expenditures, and asset transactions during the period 1975/76 to 1984/85. The regions and the villages differ with respect to rainfall, soil, crop and other socio-economic characteristics. The names of the villages, regions and their key distinguishing features are summarized in Table 2.1 (Walker and Ryan, 1990).

2.5 Determinants of Crop Failure

Crop failure is an extreme outcome of yield risk when the loss is total. Using the ICRISAT village level data set, Singh and Walker (1984) throw light on the phenomenon of crop failure and its determinants in the dryland agriculture of the semi-arid tropics. They analyze plot-level data over three cropping years from 1975-76 to 1977-78. Crop failure is identified with a plot that is not harvested.

While a plot may not be harvested for a number of reasons, the overwhelming majority of non-harvested plots were due to crop failure. Note that because of the low opportunity costs of labour, crop failure must be extreme for households not to harvest the plot. Because plots are often intercropped and because plots are sometimes harvested for fodder and not for the main product, the definition of crop failure is not straightforward. Singh and Walker consider three possible definitions. Partial crop failure is said to occur when the main product from the dominant crop is not harvested. A more stringent criteria is to consider the crop to have failed when no main product is harvested. This is case (a) of a complete crop failure. The most stringent case is when no main product, by product or fodder is harvested. This is case (b) of a complete crop failure. Table 2.2 displays these definitions and their incidence in the ICRISAT study regions. Note that the incidence of crop failure is the highest for the first definition (the least stringent) and least by the third definition (the most stringent). For all regions, the average incidence of crop failures varies between 9 to 17% during the sample period from 1975/76 to 1977/78. Over these years, rainfall across the 6 villages was close to normal. However, rainfall was erratically distributed across the three years in each village.

Crop failure was highest in drought-prone Sholapur and least in rainfall-assured Akola. From a statistical exercise, Singh and Walker find that the risk of crop failure is much less for deeper soils (which have greater capacity for water retention) and for irrigated plots. Thus, while a change from a deep to a poor soil increases the probability of crop failure by 140%, access to irrigation reduces the probability of crop failure by 64%.

2.6 Components of Production Risk: Weather

As noted earlier, much of output variability is either due to weather or due to pests and disease. Weather is significant in every phase of agricultural activity from the prepatory tillage to harvesting and storage. Weather in its many attributes – rainfall, temperature, and sunlight – is an input into the production process. However, this is an input that is not controlled by the farmer. The farmer can at best employ strategies that could maximise the favourable consequences of weather and minimise its adverse consequences. These strategies, however, do not render the weather input controllable. As a result, fluctuations in weather are a major cause of unplanned fluctuations in agricultural output and yield.

Crop-weather relationships are the subject of research by agro-meteorologists. For the purpose of this study, note that our interest lies only in certain aspects of the crop-weather relationship. In particular, we would like to know the role of the weather elements in production risk. This is a much narrower question than the role of weather in crop production. To illustrate the difference, the duration of sunlight is an important determinant of crop yields. However, in India, this component of weather shows little variation from year to year and is therefore not regarded as a major determinant of variability in crop yields.

The effects of weather on crop yields are specific to the crop, soil type, region and other factors such as whether the land is irrigated or not. It is therefore hazardous to generalize. However, if there is a robust finding it is that rainfall is the pre-eminent weather variable that causes yield fluctuations. According to the report of the National Commission of Agriculture (Government of India, 1976), rainfall fluctuations could be responsible for 50% of variability in yields. Often the focus of crop weather studies is to discover what parameter of rainfall is critical for growth of a particular crop. In the case of rice, the distribution of rainfall during the crop-growing season is found to be the most crucial weather parameter; temperature plays only a minor role. For wheat, pre-season precipitation and distribution of temperature during the crop-growing season are important. The role of weather factors in crop growth often means that short duration varieties have lower climate induced variability than long duration varieties. This was demonstrated in the case of wheat cultivars by Kalra and Aggarwal (1996).

Temperature and sunlight do not vary much from year to year. So although they are important determinants of yield growth, they are not major causes of production risk. Strong winds can damage crops and reduce yields. However, surface winds in the country are generally weak with mean daily wind speeds being less than 10 to 15 km per hour (Government of India, 1976). Strong winds occur mainly in association with cyclonic storms, depressions, thunder or dust storms. Cyclonic storms where wind speeds can reach upto 250 kms per hour are a danger in coastal areas. In sum, rainfall or moisture deficit comes out as the most important weather factor affecting crop growth consistently in all studies at all locations.

Factors other than rainfall are important especially for horticultural crops. This was shown in a study of apple yields in Himachal Pradesh over the period 1968-88 (Tewari, 1991). The study showed that yields were better explained by a composite weather index comprising rainfall, temperature and humidity rather than rainfall alone. Variation in composite weather index was responsible for about one fourth of variation in apple yield in Shimla, Kullu and Kangra, while in Chamba it explained about 50% of the variation in apple yield.

2.7 Rainfall Risk

Except for the south-east peninsula and Kashmir, the country receives between 70-95% of annual rainfall during June to September. Because of the disproportionate importance of the monsoon rains, variability in monsoon is a significant factor in governing farming practice and variability in yields. The intensity and degree of monsoon rainfall vary from year to year. The monsoon may set in late with large delays in rainfall, have long breaks in July and August or withdraw earlier.

The onset of monsoon date is variable. Table 2.3 reproduced from the report of the National Commission on Agriculture (Government of India, 1976) documents the variation in this variable over the 70 years from 1901-70. It shows that the range of variation in dates of onset in Kerala extends over 6 weeks from May 11 to June 25. The median date of onset is June 1 (the mean is May 30) and the standard deviation is 9 days.

Even within the monsoon period, it is only a few heavy falls that account for most of the annual rainfall in many parts of the country. For example, in Saurashtra and Kutch, only 10% of rainy days account for 50% of annual rainfall. As a result, outcomes over a very short period determine the success of monsoon. The coefficient of variation of monthly rainfall is high in most parts of the country and at most times of the year. Table 2.4 tabulates the coefficients of variation of monthly rainfall in different parts of the country. Monthly rainfall variability even in the rainiest months (July and August) and areas, is as high as 40 to 50% over most of central, northern and eastern India. In the south excluding the west coast, the coefficient of variation is 60 to 100%. In September, the coefficient is even higher and in October, the uncertainty reaches 80 to 100% in the southern portions of the peninsula. In the winter months, the rainfall amounts are small and the coefficient of variation is very high. The variability of weekly or fortnightly rainfall is many times greater. Deficient rainfall during any month of the monsoon season is just as likely to be followed in succeeding months by abundant as well as deficient rainfall and vice versa. Hence rainfall is not very predictable.

In general, the variability of rainfall over short time horizons is much greater than over the long horizons. This is illustrated by Table 2.5 from Biswas (1996). Thus while it might seem that seasonal variability is of order less than 50%, it understates the rainfall uncertainty that is faced by the farmer. Crop management is a continuous process and is contingent on expected rainfall not over the entire season but over short periods like the next week or next 10 days. But as Table 2.5 shows rainfall is much less predictable over short periods than over the entire season. Observe that monthly variability is much greater than seasonal variability and variability of rainfall in a week is usually in excess of 100%.

Breaks are periods during the southwest monsoon when there is considerable diminution of rainfall over large parts of the country. During the 80 year period 1888 to

1967, there were 53 breaks in July and 55 in August. Therefore, breaks occurred in bulk of the years. However, the duration of breaks varies from 3 to 21 days and the average duration of break was about 4 days in July and 4.5 days in August. Breaks of more than 9 days occurred about 15% of the time in these months.

A region is regarded as arid if its annual rainfall is less than 500 mm and rainfall exceeds potential evapotranspiration in not more than 2 months of the year. Semi-arid tropics have annual rainfall between 500 mm and 1500 mm and rainfall exceeds potential evapotranspiration for periods between 2.5 and 7 months in a year (Jodha, 1981) that limits the growing season to these periods. For varying definitions, see Gadgil et. al (1988), (Gulati and Kelley (1999) and Walker and Ryan (1990). The noncoastal regions of AP, Karnataka, Maharashtra, Tamil Nadu, much of Gujarat and western and central MP form India's semi-arid tropics. The arid and semi-arid tropics together account 62% of the country's gross cropped area and 54% of the value of the crop output (Gulati and Kelley, 1999). Their contribution is particularly high for coarse cereals, pulses, oilseeds and cotton.[3]

2.8 Droughts and Climate Change

When rainfall deficiency is widespread, the afflicted area is declared to be suffering from drought. However, there is no universally accepted definition of drought that is employed in all situations. The National Commission of Agriculture defined a meteorological drought as an occasion when the rainfall for a week is half of the normal or less when the normal weekly rainfall is 5mm or more. However, from the point of view of farming, what is relevant is agricultural drought, which refers to drought during the growing season. An agricultural drought is defined as a period of 4 consecutive weeks of (meteorological) drought in the period from middle of May to middle of October or 6 such consecutive weeks during the rest of the year.

On the other hand, the Indian Meteorological Department (IMD) defines drought as a situation when the deficiency of rainfall in an area is 25% or more of the normal. When the deficiency of rainfall is more than 50% of the normal, it is termed as severe drought. Areas where the probability of drought is at least 20% of the time period are classified as drought areas while areas where probability of drought is at least 40% are chronic drought areas. Table 2.6 lays out the drought areas and chronic drought areas of the country. It can be seen that these are the areas that form the arid and semi-arid regions of India. Recall these are the regions where yield risk is the important risk (section 2.3).

The quantitative significance of the areas that are drought-prone is brought out by Table 2.7 (from Gadgil, et.al, 1988). The table is based on annual rainfall data for 60 or more years for 31 meteorological subdivisions covering all India. This table shows that drought occurs once in 2-3 years in about 13% of the country's geographical area and 19% of its dry tropical regions (where mean annual rainfall lies between 350mm and 1500mm). More than half of the area of dry tropics (and about 37% of all-India) experiences drought once in every 4 years. When rainfall deficiency is analysed by the time of occurrence during the crop season, Jodha (1981) shows that the mid-season drought is the most common type relative to early and late season drought.

At the national level, systematic records on droughts and rainfall are available since 1875. Table 2.8 from Sivasami (2000) lists the years when widespread droughts occurred and the departure of south-west monsoon rainfall from the normal in such years. Widespread drought is defined as when more than 20% of the geographical area of the country is affected. Since 1877, there has been drought in 25 years i.e., about once in 5 years. In terms of spread, the year 1918 is the most severe, affecting more than 70% of area, followed by 1899 (68%), 1877 (59%), 1972 (53%) and 1987 (48%). These are not necessarily the years when the maximum departure from normal rainfall occurred because the latter refers to all India averages while the former relates to spatial spread (which is more relevant). However, the two are correlated. This is shown in Figure 2.4. There is clearly a positive relation between the extent of departure of rainfall from the average (negative) and the severity of drought in terms of spatial spread.

Given this picture one can expect the following. Long periods of no drought are rare. There have been three periods excluding the most recent from 1987 to 2001 where there was no drought. Further, every such long period is likely to be followed by at least couple of droughts in close succession. These statistical regularities suggest that the drought of 2002 was overdue and that another drought is likely in next few years. The persistence of statistical regularities is, however, in question because of fears about climate change due to man-made factors.

Scientists have documented the increase in the concentration of greenhouse gases especially CO_2 in the atmosphere. This is believed to be the principal cause of the increase in global mean temperatures by about 0.3 degrees C over the last century – a phenomenon which has been referred to as global warming. The impact of this climate change on agriculture is the subject of recent research. This is not easy to establish because while higher temperatures are expected to have a negative effect on crop yields, there are positive effects as well from higher CO_2 concentration and higher precipitation. Moreover, scientific uncertainties still persist regarding the climate change predictions for the Indian monsoon and in crop growth models that simulate the impact of climate on crop yields (Gadgil, 1996).

2.9 Pests and Disease

A crop is usually attacked by a number of pests that are often selective in the sense that they appear at different stages of growth of crop but their virulence varies widely. The loss sustained by a crop depends on the extent and virulence of pest attack. If the attack is of epidemic nature, the crop loss may be total inspite of all other inputs being optimal. Table 2.9 (from National Commission of Agriculture, GoI, 1976) lists some of the serious pests and diseases of some of the important crops.

Loss estimates reported by various state authorities vary under usual conditions from 8 to 45% (National Commission of Agriculture, GoI, 1976). But these estimates are of doubtful quality. Reliable all-India estimates are not available. Trade figures report the average crop loss due to pests and diseases to be 30% of output. Estimates of crop loss vary according to crop and method of estimation. Furthermore, the figures are in the nature of averages or for a particular year and do not regard the loss due to pest and disease itself as a random variable. The averages vary anywhere from 5% to 50%. Table 2.10 (from National Commission of Agriculture, GoI, 1976) provides some indication of the variability in output because of insect pests and disease as it has data on crop loss for two consecutive years. For instance, between 1967 and 1968, the losses in kharif jowar varied from 13% to 27% while for rabi jowar they varied from 11 to 42%. Table 2.11 is also revealing. Data from AP, Orissa and TN reveal the standard errors of the percentage loss from pest and disease to be between 0.33 and 6.32%. Cotton is a crop that is subject to serious pest problems. Sucking pests and bollworms are the principal pests. If untreated with pesticides, losses due to these pests ranged between 28% to 58% in Madhya Pradesh, 27-52% in Haryana, 40-52% in Maharashtra and 54% in Delhi (Gupta, Gupta and Shrivastava, 1998). Unlike weather risks, irrigated regions have no advantages with respect to pest and disease. In fact, they are more prone to crop loss from pests and disease.

Weather plays a big role in the development of diseases and growth of pests. Usually, the pest and disease organisms are always present at a low level of intensity and can multiply rapidly when the weather conditions are favourable and the plant susceptible to attack (Gadgil, Rao, Joshi and Sridhar, 1996). In particular, disease epidemics are almost always due to favourable weather conditions (Mayee, 1996). The causative relationship between weather parameters (such as rainfall, temperature, humidity) and pest build up is however very complex and is specific to the pest, crop, soil and management practices (Rao and Rao, 1996).

An example of the complexity of weather induced disease infestation is the case of rainfed groundnut in Karnataka (Gadgil, Rao, Joshi and Sridhar, 1996). The crop is generally sown in July and harvested towards the end of about 120 days. Although this is the monsoon period, rainfall is variable and so dry spells alternative with wet spells. The dry spells promote the incidence of leafminder attacks (in the middle of the growing season) while wet spells promotes crown rot in seedling stage and also the Late Tikka disease at the pod-filling stage before harvest which causes black pustules on leaves and stem, reduces the leaf area and affects pod-filling.

The groundnut example also points to the dependence of pest infestation on individual farms on cropping choices of others. In the groundnut case, the crop is sowed at about the same time in the entire region (Chitradurga district) that leads to uniform crop growth stages over large areas and promotes the growth of certain epidemic pests and diseases.[4] In addition, groundnut is cultivated in irrigated lands during the summer, which implies the presence of host plants throughout the year. The productivity of the rainfed groundnut in this region is therefore critically dependent on the incidence of pests and diseases.

2.10 Market (Price) Risks: Exogenous Shocks

In subsistence agriculture where farm household's production is barely sufficient for own consumption, market risks are clearly not important. As farmers start producing for the market, price volatility becomes a significant risk. For farmers, the principal difficulty is to anticipate, at the time of planting, the prices that will prevail at the time of sale. This is not an easy task. The consequences of incorrect anticipation can be potentially ruinous.

The balance of supply and demand determines crop prices. Variability in prices is therefore either due to variability in supply or demand or both. Note that if the variability in either supply or demand is anticipated, so can be the resulting variability in prices. As a result, even if prices are variable, they are not risky for farmers as they are anticipated at the time of planting. Unanticipated variability in demand, i.e., demand shocks are usually not large for food crops and vegetables. The demand for these commodities usually changes in a predictable manner with respect to growth of income and population. However, demand shocks can be sizeable for farmers growing industrial crops like cotton and jute as their demand is derived from the industrial sector and is therefore subject to business cycles in industry.

With regard to supply shocks, it is useful to distinguish between exogenous and endogenous shocks. Exogenous shocks are because of yield or production risks that have been discussed earlier. The impact of yield risks on prices depends on the elasticity of demand, which measures the response of demand to a change in price. If because of an increase in price, demand does not fall much then the demand for this crop is regarded as inelastic. On the other hand, demand is regarded as elastic when an increase in price reduces demand substantially. Elasticities are expressed in percentage terms. Thus, if the elasticity of demand for a crop is 2, it means that a 10% change in price leads to a 20% (i.e., twice the proportional change in price) change in demand. It is well known that demand for agricultural commodities and especially food crops and vegetables is characterized by low price elasticities that are typically less than 1. Low price elasticities magnify the impact of supply shocks on prices. For instance, if the price elasticity is 0.3, which is a fairly typical figure for agricultural commodities, a 5% increase in supply will result in a nearly 16% drop in price. On the other hand, if the price elasticity is 0.7, a similar increase in supply will decrease price only by 7%. Under some assumptions, it can be shown that the relationship between supply variability and price variability is given by[5]

$$CV(p) = CV(q)/(\text{Demand Elasticity})$$

where CV denotes coefficient of variation, p denotes price and q denotes output supply. Therefore, smaller is the demand elasticity, greater is the price variability for the same variability in supply. If demand elasticity is highly inelastic, say 0.1, the coefficient of variation of price is ten times the coefficient of variation of supply. It is the inelasticity in demand that transforms a small excess into a glut and a minor shortfall into a scarcity. Table 2.12 displays the demand elasticities for some major crops.

Not all price variability is bad for farmers. Indeed, if price fluctuations are only due to exogenous production risks, prices and a farmer's output will be negatively correlated through the demand curve. The negative correlation automatically stabilises crop revenue as discussed in section 2.3. The strength of this correlation depends on two factors: (a) the extent to which production risks are systemic risks and (b) the importance of demand shocks in price variability. Greater is the extent to which production risks are systemic risks, larger is the correlation between an individual farmer's output and market price. If demand shocks are independent of production risks, then greater is the importance of demand shocks in price variability, smaller is the correlation between an individual farmer's output and price.

It follows that if demand shocks are absent and if the systemic risk component dominates production risk, then an individual farmer's output will be strongly and negatively correlated with market price. Such a scenario is likely in remote regions with poor transport links. In such places, a small increase in output can trigger off a large decrease in prices. As a result, farmers can actually be better off when there is partial crop failure. Thakur et. al (1988) found that in the hill regions of Himachal Pradesh, total net returns of farmers are higher when crop output is half of normal crop output as prices under this situation are doubled. This extreme outcome is because of underdeveloped markets as a result of which the Himachal hill regions are poorly linked to major consuming markets (Thakur et.al, 1997).

2.11 Price Risks: Endogenous shocks and International Trade

Endogenous shocks arise because of instability in expectations formation that in turn leads to fluctuations in planned supply i.e., the area that is planted to a particular crop. The most famous instance of this is the so called cobweb cycle of prices and planned supply. Suppose farmers formulate production plans on the basis of current prices. So if current prices are low, planned supply is restricted in the marketing season. On the other hand, if current prices are high, all farmers expand supply. In the first case, realized prices in the marketing season will be high but in the second case, realized prices will be low. As a result, in the next production cycle, farmers will expand supply in the first case and contract supply in the second case. Thus, planned supply and prices oscillate from glut to shortage. It should be noted that not all area variability is because of variable price expectations. In some contexts, area variability is also a farmer's response to information about rainfall such as delayed onset of monsoons. This phenomenon will be discussed in the next chapter.

In the Indian context, cobweb cycles have been suspected for commercial crops like rubber, jute and sugarcane. Figure 2.5 illustrates the area variability in the case of jute in West Bengal over the period 1985/86 to 1998/99. The large swings in area are indicative of endogenous shocks as farmers adjust their planned supply in light of their expectations of jute prices relative to the prices of competing crops (often paddy). The area variability generates price variability that in turn induces further variability in area. Figure 2.6 plots the September jute price and jute area (in West Bengal) over the period. Both variables are expressed as deviations from their trend. In addition, area variable is scaled downwards so that it can be represented in the same picture as price and the price variable is deflated with respect to the wholesale price index of all commodities.[6] From the figure, the cycles in both variables can be seen. Consistent with a cobweb, the peaks and troughs in planned supply follow the peaks and troughs in prices.

International trade can accentuate or dampen price variability. To the extent that domestic supply shocks are negatively correlated with supply shocks in other supplying countries, international trade stabilizes prices. However, international trade also makes endogenous shocks more likely as in a global setting it is hard to coordinate supplies as a result of which price cycles are very likely. Consider for instance the contrasting experience of coffee and cardamom growers. As table 2.13 shows, average unit values of coffee have more than halved between 1997/98 and 2001/02 while over the same period average unit values of cardamom have doubled. The good fortune for Indian cardamom growers is because of supply shortages from other countries, particularly, Guatemala. On the other hand, the coffee bust is because of additional capacity created in Vietnam, which was encouraged to do so by the coffee boom in the early 1990s. Neither the good fortune of the cardamom growers nor the misery of the coffee producers will last for ever. In the case of coffee, supplies will eventually contract while in the case of cardamom, prices will shrink as supplies expand.[7] However, these adjustments are costly and the burden of it is borne by farmers. Price and supply cycles are not confined to export crops. Arecanut, which is largely used domestically, is another crop that has experienced dramatic fluctuations in prices. From levels of Rs. 130-140 per kg in 1999/2000, prices crashed to Rs. 40 per kg in 2001/02. Like in another instances, the principal problem is excess supply not because of yield risks but because of expansion in planned supplies as measured by the area under the crop.

Left to themselves, markets will tend to produce outcomes that will be regarded by farmers as either excessive production or severe scarcity. The markets for most major crops therefore end up being regulated in some fashion in an effort to match supply and demand in an orderly way. Whether these have been effective is an issue that will be addressed in later chapters.

2.12 Price Risks: Seasonality

A feature of agricultural prices is its seasonality. This comes about because within a crop year, harvests occur at limited number of discrete time points, often not more than once and rarely more than twice while the commodity is consumed throughout the year. As a result, the commodity is stored and carried from the production points to the consumption points. Storage causes prices within a crop year to have a well-defined pattern. For instance, if there is only harvest in a year, prices will typically be minimum at the beginning of the marketing year and will move upwards to peak just before the beginning of the new marketing year. Price variability must therefore distinguish between variability across years (annual) and variability within a crop year (seasonal).

For farmers who sell most of their crop at harvest, it is the annual variability in harvest price that is of most concern. Variability in the seasonal margin (i.e., the price difference between the harvest low and the off-season peaks) matters most to those agents who store the crop. It has often been claimed that farmers and especially the smaller ones lack credit and storage capacity to be able to sell their crop at a point later than harvest. It might then seem that seasonal uncertainty does not matter to farmers and is more of a concern to traders and speculators rather than to farmers. However, this is not entirely true. Storage agents are also risk-averse. When seasonal prices are highly variable, storage is a risky enterprise and the agents who undertake will demand a risk premium. As a result, the seasonal margin needs to be larger which would depress the harvest price.

Fuglie and Ramaswami (2001) compared average seasonal margins in potato between India and the United States. Both markets are characterized by sharply seasonal production and year-round demand. In both countries, cold storage is the principal means of keeping potatoes for year-round supply. Table 2.14 shows the average seasonal price trend and the variation around trend for major potato markets in the two countries. The average seasonal trend shows only the relative change in prices over a storage season because it is computed after removing annual shocks. On average, prices during the storage season rose by 43% above harvest prices in the United States. In India, the average seasonal price increase was 113%. Note also that in both countries, price variation around the seasonal trend rose steadily during the storage season. However, uncertainty in seasonal prices was nearly twice as high in India compared with the United States. After comparing the physical costs of storage, wastage and the costs of credit, Fuglie and Ramaswami conclude that much of the difference in the seasonal margin was due to the risk premium demanded by storage agents in India because of the higher uncertainty in seasonal prices in India. The implication is that if policies and institutions could reduce seasonal price uncertainty, it would also reduce the costs of storage and thereby increase the potato prices at harvest.[8]

The importance of risk costs in the Indian case is reflective of the limited ability of Indian trading firms to bear market risks and of the lack of effective market mechanisms to guide the allocation of supplies such as timely production estimates, stock reports and price discovery mechanisms. In the U.S., on the other hand, marketing institutions have resulted in low seasonal price variability. These institutions include forward contracting, futures trading and dissemination of market information by government agencies.

2.13 Income Fluctuations: Magnitude

The ICRISAT village studies collected information on household income and consumption. Recall that out of the sample of 40 households in each village, 30 households were cultivator households and 10 were landless labour households. Hence the major components of household income were crop revenue and labour income (Walker and Ryan, 1990). Except for the large farm households, cultivator households also received substantial labour market earnings. Labour market income was primarily from agriculture as nonfarm income did not exceed 30% of total income in any of the villages. Therefore, the income fluctuations may be taken to reflect variability in incomes derived from agriculture whether from crop revenue or from the labour market. The income fluctuations were calculated after deflating incomes and removing linear trends.

The analysis reported in Walker and Ryan draws on data from more than 100 households in 3 villages across the three study regions (see table 2.1). The median coefficient of variation of the per capita household income was about 30%. The low figure in the sample was about 10% while the high figure was about 80%. For the majority of households, the coefficients of variation were in the range of 20 to 40%. Thus, income risks are considerable in the rural households of the semi-arid tropics. Surprisingly, income variability does not differ that much by farm-size class. Similarly, while the correlation coefficient between per capita income levels and household income coefficient of variation is negative, it is not large indicating perhaps the ability of richer households to bear income shocks. About one-third of households in the sample suffered income losses that reduced income in a particular year to less than 50% of their median income over the period 1975/76 to 1984/85. Shortfall households were more numerous in drought-prone villages than in the rainfall-assured village.

2.14 Conclusions

The diversity of climate, growing conditions and market structures means that there is no typical risk environment for a farmer. In the drylands without access to assured irrigation, rainfall is a dominant production risk. There are, however, many attributes of rainfall – the relevance of the onset date of monsoon and the distribution of rainfall through the season varies according to crop and soil type. The spatial spread of rainfall varies too. As a result, rainfall risk could be both covariate (i.e., a systemic risk) and individual specific depending on the year and the region. Similar is the case with pests and disease. Local pest and disease infestations depend on many factors including the crop variety, weather, the use of pesticides and other crop practices. Beyond a threshold level, the infestation can quickly reach epidemic proportions affecting large areas. Unlike rainfall risks, the humid and irrigated regions have no special advantage with respect to pest and disease attacks.

As the demand for agricultural products is inelastic, supply shocks are magnified in price variations. Besides production risks, supply shifts are also because of variability in planned supply, i.e., area planted to a particular crop. Variability in planned supply comes about because of errors in forecasting prices. Often, the biases in these errors are systematic as forecasts are determined by past prices. As a result, prices and planned supply can oscillate creating endogenous variability. Such uncertainty is often seen in seasonal price movements as well. The importance of price risk would depend on the extent of exposure to market forces as well as existing market institutions. International trade can increase or decrease price variability.

In later chapters, we consider individual farmer and societal responses to risk. We also consider government programs and policies that have shaped the risk environment.

Figure 2.1: Classification of Risks

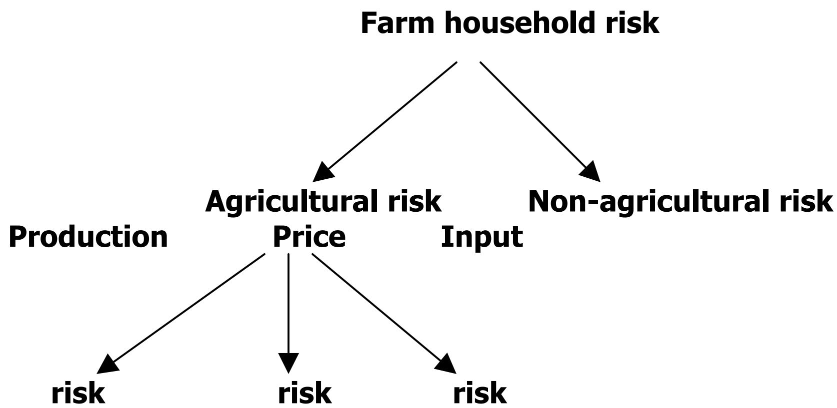
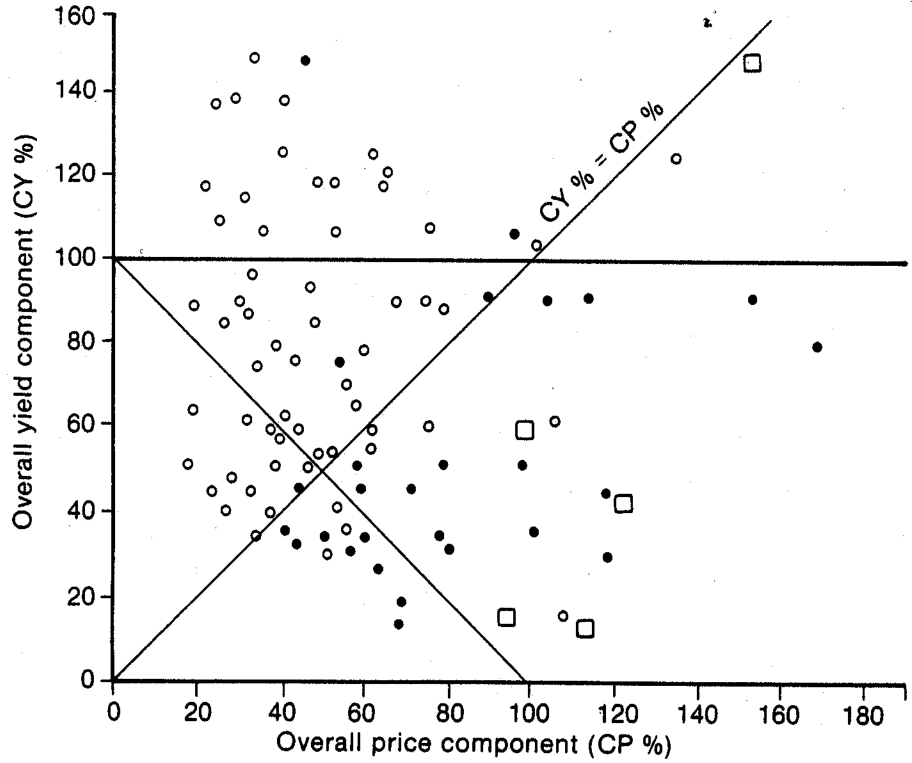
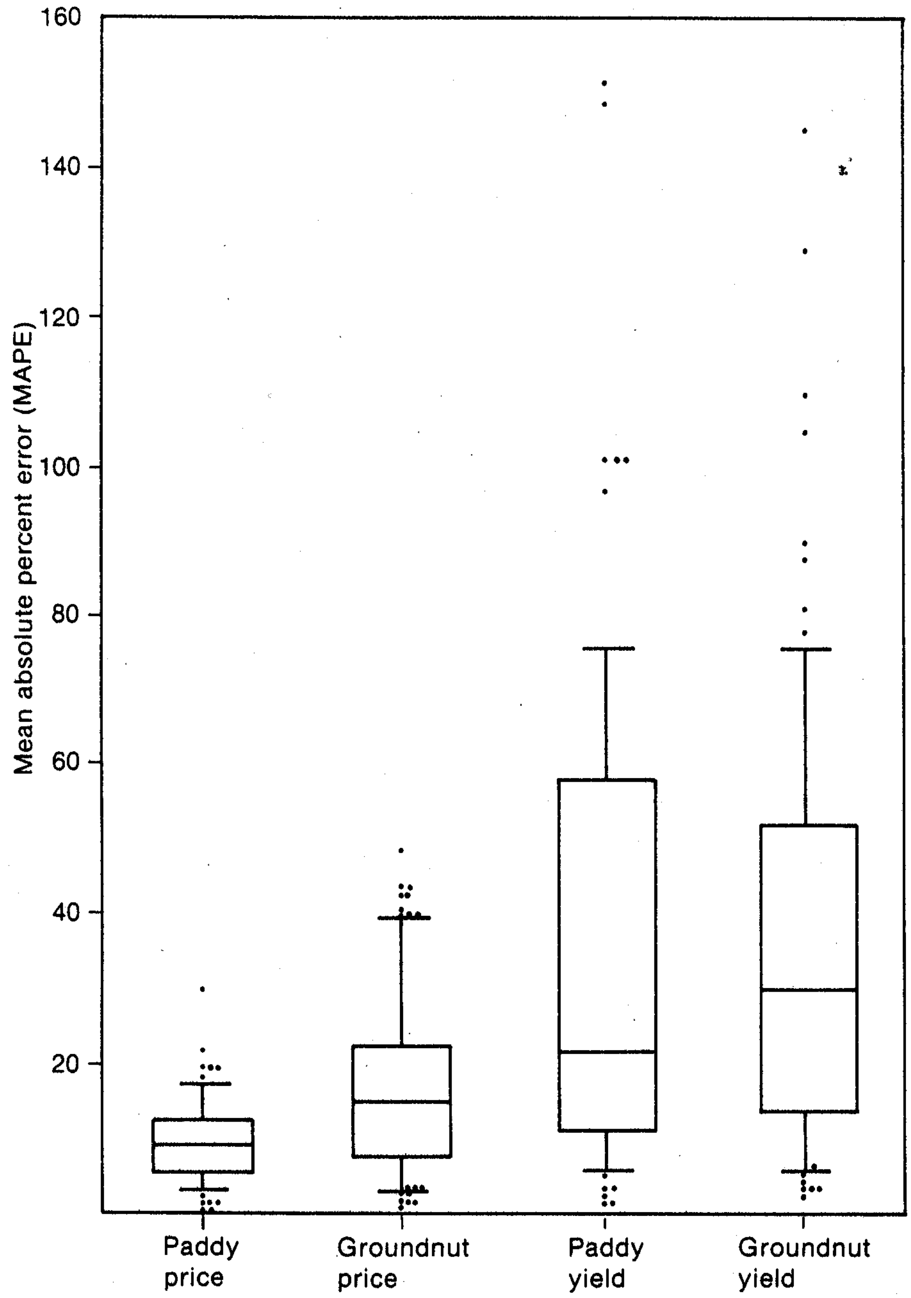


Figure 2.2: Yield Versus Price Risk in Semi-Arid Districts of AP, Karnataka, Maharashtra and TN, 1956/57-1974/75.



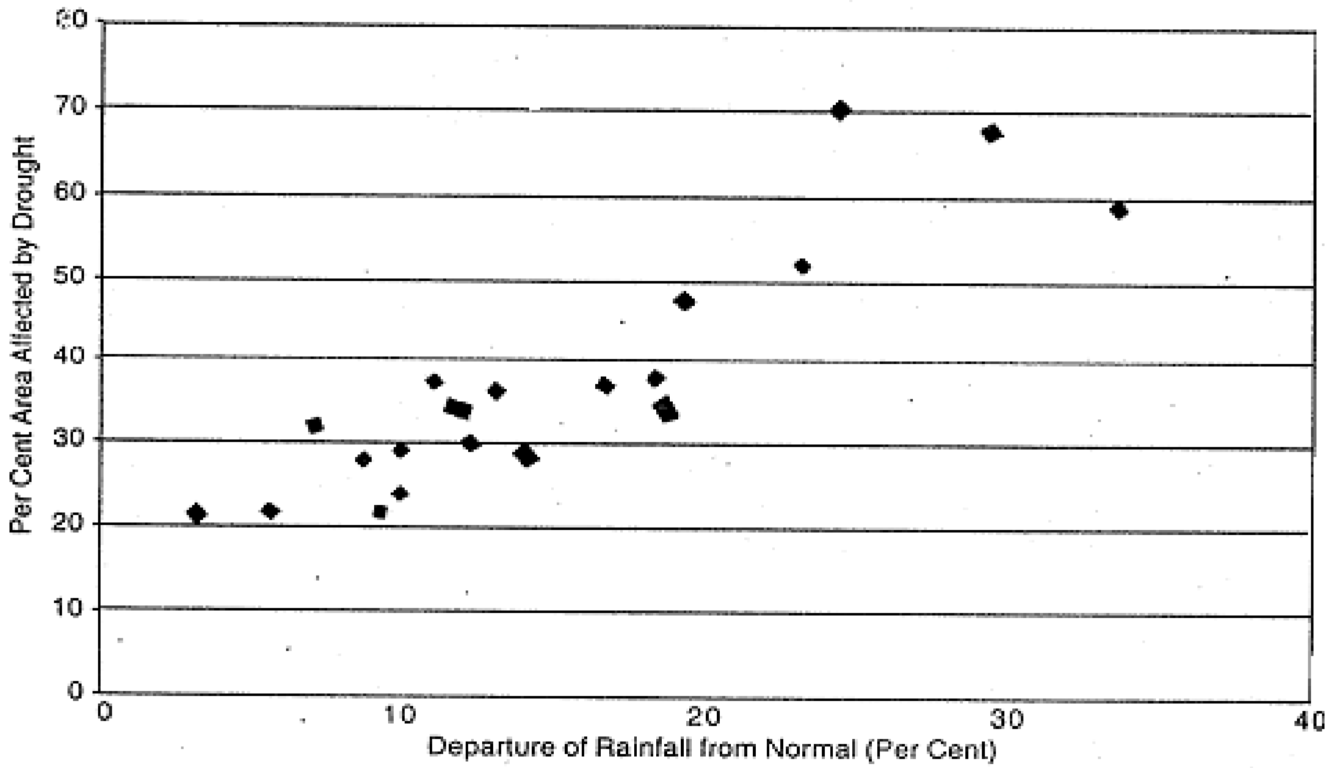
Notes: This figure is from Barah and Binswanger (1982) and reproduced in Walker and Ryan (1990: figure 8.2).

Figure 2.3: Price and Yield Perceptions of groundnut and paddy producers in Dokur, 1982/83 – 1985/86.



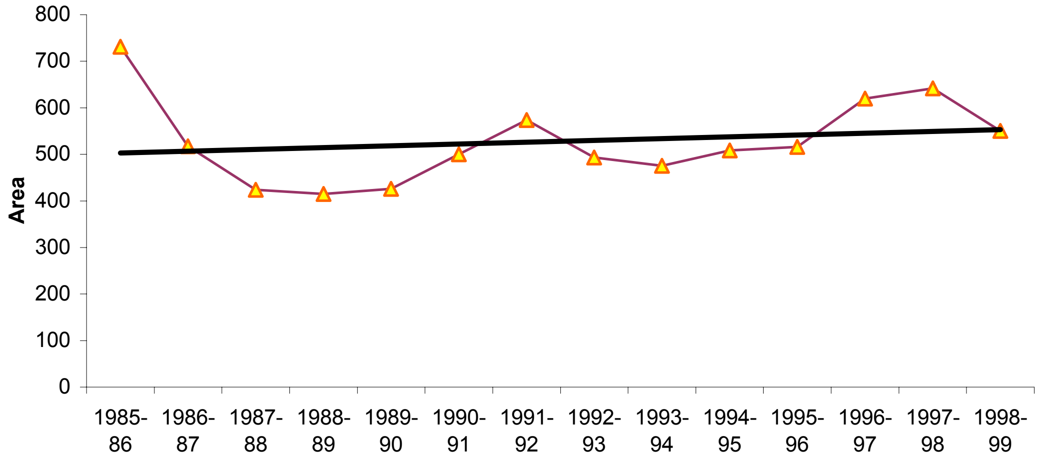
Notes: Figure is reproduced from Walker and Ryan (1990: figure 8.3).

Figure 2.4: Rainfall Deficiency and Extent of Drought



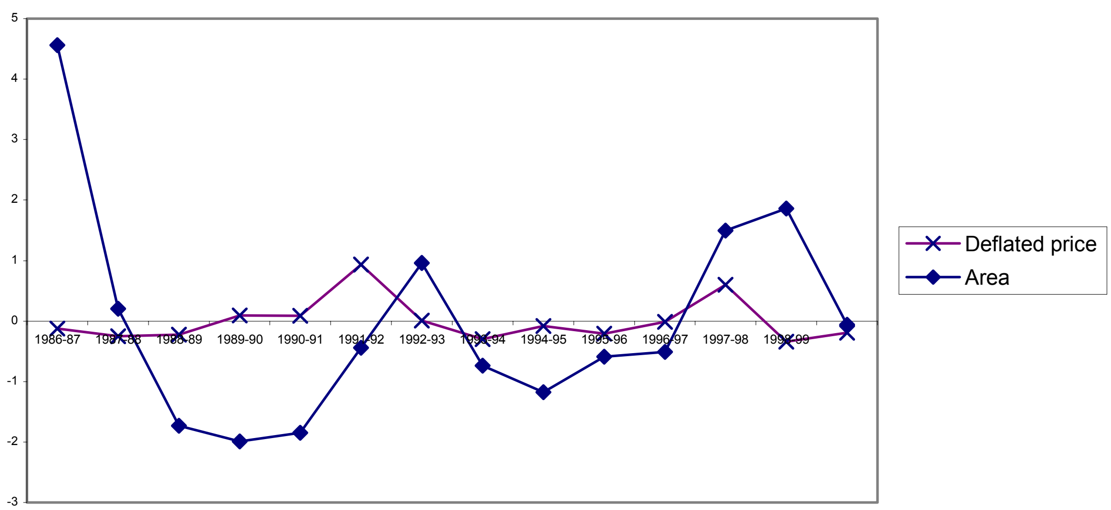
Source: Sivasami (2000)

Figure 2.5 Area Cycles in Jute (West Bengal)



Source: Data is from the report of the Commission on Agricultural Costs and Prices (2001a)

Figure 2.6: Area and Price Cycles (Detrended/Deflated) for Jute



Source: Our calculations based on area and price data for jute from the report of the Commission on Agricultural Costs and Prices (2001a) and from the Economic Survey.

Table 2.1. Soil, rainfall & crop characteristics of the ICRISAT study regions

Characteristics	Regions & villages		
	Mahbubnagar	Sholapur	Akola
	Aurepalle Dokur	Shirapur Kalman	Kanzara Kinkheda
Soils	Red soils (alfisols); marked soil heterogeneity	Deep black heavy clay soils (vertisols) in lowlands; shallower lighter soils in uplands	Medium deep black clay soils (inceptisols)[a]; Fairly homogeneous
	Low water retention capacity	High water retention capacity	Medium water retention capacity
Rainfall[b]	Unassured; pronounced rainfall uncertainty at sowing 630 mm, 31%CV	Unassured; Frequent crop failure 630 mm, 35%CV	Assured; 890 mm, 22%CV
Pattern of cropping	Kharif, or rainy season cropping	Rabi, or post-rainy season cropping	Kharif cropping
Major crops	Kharif or rainy season sorghum, castor, pearl millet, paddy (rice), pigeon pea, groundnut	Rabi or post rainy season sorghum, pigeon pea ,minor pulses	Cotton,sorghum, mungbean, pigeon pea, wheat
Irrigation	Agricultural intensification around dug wells & tanks	Some dug wells	Limited irrigation sources in 1970s & early 80s
Technology	Neglect of dry land agriculture	Technologically stagnant	Sustained technical change in dry land agriculture
Socioeconomic Condition of cultivators	Harijans & caste rigidities; inequitable distribution of land	Tenancy; dearth of bullocks; more equitable distribution of land	More educated

[a] loosely called medium-deep Vertisols
[b] the main rainfall estimates & their coefficients of variation (CVs) in percent refer to ten annual observations collected in one study village in each region from 1975/76-1984/85

Source: Walker and Ryan (1990), Tables 1.1 and 3.4

Table 2.2. Definitions & incidence of crop failure from 1975-76 to 1977-78

Definitions		Regions			All regions
		Mahbubnagar	Sholapur	Aloka	
		Percentage of non-harvested plots to total			
1.Complete crop failure	a) main product output	6.1	17.4	3.7	11.6
	b)main & byproduct output	4.6	13.3	3.6	9.1
2.partial crop failure*	a) main product from dominant crop	8.9	24.2	6.9	16.7
Average rainfall**		736	659	806	737
Total no. of plots		826	2058	921	3805

* Includes sole crops as well as intercrops
**Simple average of daily recordings from rain gauges in the two villages in each region for the three cropping years

Source: Singh and Walker (1984)

Table 2.3. Frequency distribution of dates of onset of southwest monsoon over Kerala & Bombay-1901-70

Dates		Number of years	
		Kerala	Bombay
May	11-15	5	0
	15-20	8	0
	21-25	7	1
	26-31	12	3
June	1-5	20	12
	6-10	14	22
	11-15	3	25
	16-20	0	4
	21-25	1	3
Mean date		May 30	June9
Median date		June 1	June9
Range		May11 to June 25	May 20 to June 25
Standard deviation (days)		9	6

Source: Government of India, Ministry of Agriculture and Irrigation, (1976), Report of the National Commission on Agriculture, Chapter 13

Table 2.4. Coefficient of Variation of Rainfall by Season and Region

Period	Region	Constant of variation (CV)
January-February	Kashmir & North East Assam	40-50%
	Elsewhere	80-100%
March-May	Assam	30-40%
	West Bengal, South Kerala	40-50%
	Elsewhere	80-100%
June	West Coast, N.E. Assam	30-40%
	Elsewhere	60-100%
July-August	East of longitude 80^0 E(Chennai-Jabalpur-Bareilly) & along west coast	40% or less
	North east India	50-100%
	Peninsula or leeside of ghats-MP, Karnataka, Rayalseema & Tamil Nadu	80-100%
September	Peninsula including coast	60% or more
October-December	Southern peninsula & Assam	60%
	Elsewhere	80-100%
November	Tamil Nadu & Kerala	60-80%
	Elsewhere	80-100%
December	South east Tamil Nadu	80-100%
	Elsewhere	>100%

Source: Government of India, Ministry of Agriculture and Irrigation, (1976), Report of the National Commission on Agriculture, Chapter 13

Table 2.5. Coefficient of Variation of Rainfall Across Different Time Periods

Station	Annual	Seasonal Jun-Jul-Aug-Sept	Monthly				Weekly			
			Jun	July	Aug	Sept	25th (18-24 Jun)	29th (16-22 July)	34th (20-26 Aug)	38th (17-23 Sept)
Hissar	45	47	94	71	83	141	174	118	156	261
Indore	18	26	81	52	76	69	117	91	109	129
Rajkot	29	34	58	66	65	59	103	109	140	103
Solapur	28	30	59	43	43	58	104	96	119	109
Hyderabad	28	30	59	43	43	58	104	96	119	109
Bangalore	20	30	50	59	63	56	101	106	110	97

Source: Biswas (1996), p 191

Table 2.6. Drought Prone Areas and Rainfall Deficiency

Drought areas	Rainfall deficiency
Gujarat, Rajasthan & adjoining parts of Punjab, Haryana, west Uttar Pradesh & west Madhya Pradesh. Madhya Maharashtra, interior Mysore, Rayalaseema, south Telengana and parts of Tamilnadu. A small portion of northwest Bihar and adjoining east Uttar Pradesh. A small portion of north-east Bihar and adjoining portion of West Bengal	20% probability of rainfall deficiency of more than 25 % of normal
West Rajastan & Kutch	40% probability of rainfall deficiency of more than 25 % of normal

Source: Government of India, Ministry of Agriculture and Irrigation, Report of the National Commission on Agriculture (1976), Chapter 13

Table 2.7. Distribution (in percentages) of geographical area, rural population and cropped area in India, according to degree of recurrence of drought.

Frequency of droughts	Whole India			Dry Tropical Regions		
	Geographical Area	Rural Population	Cropped Area	Geographical Area	Rural Population	Cropped Area
2-3 years	13.2	5.8	11.2	18.6	9.4	14.7
3 years	11.6	12.6	14.5	15.6	18.9	18.4
4 years	36.5	39	42.4	51.4	62.9	55.7
5 years	30.9	38.2	30.4	14.4	8.7	11.2
> 5 years	7.8	4.4	1.4	-	-	-
Total	100	100	100	100	100	100

Source: Gadgil, et. al (1988)

Table 2.8. South-west monsoon rainfall, negative departure from normal & area affected by drought

Year	% departure (-) from normal rainfall	% area affected by drought
1877	33.3	59.4
1891	6.3	22.7
1899	29.4	68.4
1901	12.1	30.0
1904	11.8	34.4
1905	11.4	37.2
1907	10.0	29.1
1911	14.7	28.4
1913	10.0	24.5
1915	9.4	22.2
1918	24.9	70.0
1920	16.7	38.0
1925	3.3	21.1
1939	8.7	28.5
1941	13.3	35.5
1951	18.7	35.1
1965	18.2	38.2
1966	13.2	35.4
1972	23.9	52.6
1974	12.0	34.0
1979	18.9	34.6
1982	14.5	29.1
1985	7.1	32.3
1986	12.7	19.7
1987	19.4	47.7

Source: The Drought of 1987,Response and Management, Volume 1(1989), Ministry of Agriculture, Government of India, reproduced in Sivasami (2000).

Table 2.9. Serious insect pests & diseases of some of the important crops

Crops	Insects	Diseases
Paddy	Gundhy bugs, green leafhoppers, White leaf hoppers, swarming caterpillar, caseworm, gallmidge, Hispa, grasshoppers, stemborer, Mealy bug, army worms, ear cutting caterpillar	Blast, stem rot, root rot, Bacterial leaf blight, foot rot, helminthosporium
Jowar, maize, bajra & lesser millets	Stem borer, earhead webbing caterpillar, black hairy caterpillar, Midge, decan wingless grasshopper, grasshopper (maize) Hairy caterpillar (jowar)	Grain smut, loose smut downy mildew (jowar), smut (millet). Downy mildew (maize), grain earthed disease (bajra)
Wheat barley & oats	Catworms(wheat), bluebeetle(wheat) Termites, earcockle	Yellow rust, covered smut (barley, oats), black rust, stripe disease (barley)
Cotton	White fly, pink bollworm, spotted bollworms, stem borer, jassids, semiloopers, aphids, field cricket, grey weevil, gram weevil, leaf roller	Wilt, black arm, anthracnose, grey mildew
Jute	Semilooper, mealybugs, stem weevil Cricket, mites	Foot rot
Sugarcane	Pyrilla, Top borer, stem borer	Red rot, smut

Source: Government of India, Ministry of Agriculture and Irrigation,(1976), Report of the National Commission on Agriculture, Chapter 49

Table 2.10. Cropwise all India percentage losses due to insect pests & diseases of high yielding varieties during Kharif, 1967 & 1968 & Rabi, 1967-68 & 1968-69*

Crop	Percentage loss during kharif		Percentage loss during Rabi	
	1967	1968	1967-68	1968-69
Paddy	17.80	19.28	6.77	20.73
Wheat	-	-	3.36	3.58
Maize	6.57	6.58	-	-
Bajra	11.91	-	-	-
Jowar	12.90	26.92	11.26	41.84

*Evaluation Study of the High Yielding Varieties Programme, Planning Commission quoted in Government of India, Ministry of Agriculture and Irrigation (1976), Report of National Commission on Agriculture, Chapter 49.

Table 2.11. Average percentage loss in yield of paddy, due to incidence of all major diseases & insect pests[1]

District	Crop season & duration of variety	Percentage loss*	
		Estimate	S.E.
Cuttack	Sarad LDV**	13.00	2.63
	Dalua SDV**	7.13	6.32
	Samba LDV**	11.38	5.72
Thanjavur	Kuruvai SDV	4.39	1003
	Kuruvai MDV	3.25	0.33
	Samba LDV	10.46	1.65
	Thaladi LDV	3.96	4,15
West Godavari	Kharif LDV	10.57	2.06
	Rabi MDV	14.43	2.95

* For district
**Stand respectively for short (less than 100 days) medium (100-300) & long (over 130 days) duration varieties
[1]Singh,D. et al 1971. Estimates of incidence of diseases & consequent field losses in yield of paddy crop, Indian Phytopath, 24, 446-456, quoted in Government of India, Ministry of Agriculture and Irrigation, (1976), Report of the National Commission on Agriculture Chapter 49

Table 2.12. Range of price elasticities of demand (all India)

Crop	Rural			Urban		
	Low	Medium	High	Low	Medium	High
Rice	-0.23	-1.07	-1.90	-0.26	-1.08	-1.90
Wheat	-0.19	-0.95	-1.70	-0.19	-0.98	-1.76
Coarse cereals	-0.24	-0.53	-0.82	-0.07	-0.18	-0.43
Pulses	-0.51	-0.89	-1.27	-0.5	-0.51	-0.52
Edible oils	-0.50	-0.51	-0.52	-0.36	-0.43	-0.50
Sugar	-0.39	-0.48	-0.57	-0.33	-0.36	-0.39
Cotton (cloth)	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38

Notes: Table is reproduced from Gulati and Kelley, (1999). They selected the elasticities from a survey of the literature.

Table 2.13. Average unit value of coffee and cardamom

Year	Coffee	Cardamom
	Average Unit value (Rs/Kg)	Average Unit Value (Rs/Kg)
1997-98	99.13	273.3
1998-99	92.15	566.65
1999-2000	67.58	488.19
2000-01	53.87	570.41
2001-02	43.31	-

Source: Economic Times, 8 February, 2002

Table 2.14. Trend and variation of producer prices during potato storage season

Location			Month following harvest of the potato crop					
		Harvest	1	2	3	4	5	6
India (Meerut)	Seasonal price trend	1.00	1.33	1.71	2.01	2.21	2.14	2.13
	Coefficient of variation	--	9%	17%	32%	26%	33%	37%
United States (Minnesota)	Seasonal price trend	1.00	1.20	1.17	1.21	1.32	1.40	1.42
	Coefficient of variation	--	7%	7%	13%	12%	17%	18%

Source: Fuglie and Ramaswami (2001)

Chapter 3: Risk Management at the Farm Household Level

3.1 Introduction

In the previous chapter, we saw how Indian farm households must often cope not only with poverty but also with extremely variable incomes. Weather variation, fluctuations in wages, the incidence of disease, pests and a host of other less obvious factors cause farm incomes to fluctuate unpredictably. Variations in the price of marketed output can also cause farm revenues to vary.

This chapter examines the impact of farm income risk on farmer behaviour and welfare. The existing literature on idiosyncratic income uncertainty examines its effects on farm households in India, investigating in particular their vulnerability to crop and agricultural income shocks. Research has found that crop income shock reduces household wealth not only directly, but also indirectly as a result of the costly measures adopted by households to protect consumption from such shocks. These include choosing safer but also less profitable agricultural investments, and either the *ex ante* diversion of productive capital toward more liquid assets or the *ex post* sale of such assets for consumption smoothing.

In understanding farmer responses to risk, a useful distinction can be made between risk reducing strategies that the farmer adopts *ex ante* and risk coping strategies that the farmer adopts *ex post* the shock. If a risk averse household is not able to achieve an entirely smooth consumption path through *ex post* mechanisms such as insurance, savings, and credit transactions, it has an incentive to devote resources *ex-ante* in an effort to secure a more stable income stream. In an agricultural economy, households might adopt technologies such as inter-cropping or drought- resistant crops, farm a diversified portfolio of land, and enter contractual arrangements such as sharecropping that reduce the variance of income, or diversify their activities through migration or local non-agricultural employment. Any of these *ex ante* actions might be costly, in that the households would be sacrificing income, on average, in order to assure a more stable stream of income.

It is also likely that community mechanisms exist in some villages to allocate risk efficiently. Within a community risk pooling can be achieved through formal insurance markets, or through a variety of informal transfer mechanisms as well as drawing upon communal resources. Risk management at the community level is discussed in the next chapter.

Our main goal in this chapter is to discuss farmer strategies to combat risk. We have divided these strategies into five broad categories that are the following.

a) Self-insurance where households use own wealth to protect themselves against uncertainties that they cannot control. Self-insurance can work through several channels. Stocks of cash or savings in banks can be run down (or added to) for the purpose. The same can be done with grain stocks, although holding such stocks can be costly because grain is not perfectly durable. However this may be preferred form of savings if rural banks are few and far between or if there are restrictions on the rapid liquidation of savings. Other assets may be run down or accumulated as well. Livestock and jewelry are two such assets.

b) The second major form of smoothing is taking recourse to credit. There are formal or institutional lenders: government banks, co-operative societies, commercial banks, credit bureaus etc as well as informal lenders: moneylenders, traders, employers etc. Institutional credit agencies often insist on collateral before advancing a loan. For poor peasants, however, this usually makes formal credit an infeasible option. This is not because they lack collateral but because their collateral is often of a very specific kind e.g. labour, house or small landholding that might not be acceptable to the lenders. This makes informal credit more popular among the poor.

c) The third strategy for mitigating risk is tenancy contract, particularly sharecropping which is the most popular form of tenancy contract. Sharecropping is an arrangement that has particular value when the tenant is small and averse to risk: if a given fraction of output is paid as rent, then the tenant is, to some extent, insulated against output fluctuations, because he can share some of these fluctuations with his landlord. The lack of perfect credit and insurance markets make land contracts solve the problem of insurance, however it must also provide adequate incentive at the same time.

d) Labour markets provide alternative mechanisms to deal with risk by allowing households subject to idiosyncratic shocks to shift from own-farm cultivation to the labour market and to avoid uncertainties of the slack season; many landless workers enter 'permanent' labour contracts.

e) Crop management where risk is diversified through the choice of technology as well as the choice of investment portfolio and its composition of productive and non-productive assets, choice of inputs, choice of cropping pattern including crop diversification and intercropping. As we shall see, there exists a positive association between the average returns to individual production decision and their sensitivity to risk.

Tenancy, permanent labour contracts and specific crop management strategies such as diversified farming and intercropping are ex-ante risk adjustment devices. Self-insurance, credit, migration and many crop management strategies are ex-post risk coping devices. As Jodha (1981) points out, the ex-ante strategies are often identified as permanent features of the farming system and therefore their role in risk management is sometimes overlooked.

3.2 Self Insurance

The most important mechanism for consumption smoothing, other than market credit and intra- or interfamily lending, is the sale and purchase of assets. Agricultural households hold many different forms of wealth including land, capital goods such as pump sets and tractors, animals, jewelry, currency, and stocks of food grain. Self-insurance relates to using such assets as buffer stocks; that is, farmers accumulate stocks in periods of relative affluence and deplete these reserves to finance consumption expenditures during tough times.

There are several studies based on the ICRISAT villages (described in section 2.4 and summarized in table 2.1) that explain various self-insurance mechanisms adopted by villagers to smooth shocks. Rosenzweig and Wolpin (1993), is one such study that concludes that rural households engage in substantial buying and selling of certain forms of assets for self-insurance. In this study, immobile capital such as land and buildings constitute a major part of farmers' wealth, accounting for approximately 85% of total wealth. A common observation of most studies based on ICRISAT data is that the asset market for land is curiously inactive although the market for land rentals is very active in these regions. This observation is corroborated by findings of a survey by NCAER in 1970-71 where only 1.5% of all rural households surveyed undertook any kind of land sale, so this is a rarely used mechanism to finance consumption. Among the non-land wealth category, financial assets such as stocks, bonds etc have a very small share - less than 5% even for large farmers. Average crop inventories held over the year accounts for about a quarter of this wealth; however, it varies a lot across harvest and non-harvest seasons, and is probably used more to smooth consumption over the year rather than across years. A sizeable portion of about 19% on average of non-land wealth is held in the form of jewelry, but the data indicate that buying and selling of jewelry too is minimal. The largest component of non-land wealth is bullocks - about 50% of the wealth for small farmers, over 33% for midsize ones, and about 27% for the large farmers. Their work finds strong evidence that farmers vary their ownership of bullocks as a primary instrument to smooth consumption. In another study, Jodha (1981) looked at data from many parts of India and finds that the most common asset sale during droughts is that of livestock followed by jewelry.

There is an extremely well organized, regionally integrated market for bullocks, however, short-term bullock leases are extremely uncommon. The absence of rental market for bullocks implies that there can be substantial productivity gains of ownership of a few bullocks to farmers; therefore, turnover in bullock ownership should be expected to be low. A ten-year survey, however, revealed that 86% of households were involved in at least one transaction in bullocks, indicating that many of these were perhaps motivated to meet consumption requirements. The data indicates that this is indeed the case. The presence of well-integrated market for bullock makes bullock prices immune to village specific production shocks, the evidence for this being that over 60% of bullock sales were made to buyers outside the village, with 10% going to buyers located more than 20 kilometers away. The data indicates that sales of bullocks increase significantly where weather outcomes are poor, and hence incomes are low, and purchases of bullocks increase when rainfall is ample and incomes are above average, in contrast to all other productive assets, inclusive of land. The results also show that the likelihood of a bullock purchase increases significantly when income is high, and the probability of a sale decreases. It is also seen that a farmer holding larger stocks of bullocks is less likely to make a purchase in the future, which suggests that farmers try to maintain a target level of the asset on an average. In data, while this hypothesis holds strongly for medium and small farmers, the fit is much weaker for large farmers, implying that they have much better access to credit and other instruments and therefore do not have to rely heavily on asset sales as a means to achieve consumption smoothing.

Rosenzweig and Wolpin (1993) also suggest that the widespread incidence of "distress sales" together with the absence of rental markets for animals hamper efficiency and lower average agricultural output. The statistical results show that the optimal number of bullocks owned by mid-sized farmers is about two. However the average size of the bullock stock is 0.94, which implies a sizeable under-investment in bullocks. Thus, risk aversion of a farmer together with borrowing constraints and low incomes not only results in output losses but also worsens the fluctuations in incomes. Simulations of their econometric model, which provides a reasonable fit to the life-cycle data on bullock accumulations for low income and middle income farmers suggest that (1) despite farmer's aversion to risk the provision of actuarially fair weather insurance would have no to little effect on farmer welfare, consistent with the almost universal resistance of farmers to unsubsidized insurance schemes. This is in part due to farmers' evident ability to insure a minimum level of consumption via informal arrangements and because of the importance of other risk factors. (2) Increases in opportunities for farm households to receive assured streams of income, say through a rural job creation policy, raises bullock stocks closer to optima levels and have a substantial positive effect on agricultural production efficiency and output.

The role of crop inventories is investigated by Lim and Townsend (1994), who construct measures of changes in farm inventory, real assets, currency and financial assets from the household data of the ICRISAT village studies. They find that crop inventory plays a relatively large role as a mechanism in the monthly and annual data to smooth shocks. Currency also plays a role, especially in annual data. These results are consistent with the results of Paxson and Chaudhuri (1994), who conclude that buffer stocks are responsible for the observed degree of smoothing. They also find patterns, by land class – relatively large landholders tend to use crop inventory while relatively small and landless holders tend to use currency. This fact, as explained by Walker and Ryan (1990) is due to difference in storage capability. Larger farmers are better equipped to store grains across seasons than poor farmers who find it easier to sell the grains upon harvest and use currency as smoothing mechanism. The unimportance of crop inventories in farmer's loss management strategies is also endorsed by Jodha's

(1975) evidence from droughts in Rajasthan in the early 60s. Home produced stocks are important but in the form of fuelwood, dung, dried vegetables and other goods.

Besides these, there might be another interesting mechanism adopted by rural households aimed at mitigating income risk and facilitating consumption smoothing in an environment characterized by information costs and spatially covariant risks, as claimed by Rosenzweig and Stark (1989). A significant part of migration in India, particularly in rural areas, is composed of moves by women for the purpose of marriage. This study explains these mobility patterns by examining marital arrangements among Indian households. In particular, they hypothesize that the marriage of daughters to locationally distant, dispersed yet kinship-related households is a manifestation of implicit inter-household contractual arrangements aimed at mitigating income risk and facilitating consumption smoothing in an environment characterized by information costs and spatially covariant risks. Analysis of ICRISAT data lends support to the hypothesis. Marriage cum migration contributes significantly to a reduction in the variability of household food consumption. Farm households afflicted with more variable profits tend to engage in longer distance marriage cum migration.

3.3. Insurance through Credit

The principal sources of rural credit are institutional sources (banks, cooperatives), professional moneylenders, traders, and friends and relatives. The *All India Rural Credit Survey*, published by the RBI, reveals that in 1951 only 7.2% of all borrowings were from government sources, banks and co-operatives. By 1981, this number had jumped to 61.2% (Bell, 1993) due mainly to the Indian government's substantial drive to extend rural credit through official channels. Individual moneylenders however, did not vanish; 24.3% of all debt was still owed to them.

Formal or institutional credit is mostly for working capital or for investment. Consumption loans to tide over bad times are not officially offered by institutional lenders. At best, institutions can reschedule loans in the event of generalized crop failure. NABARD, which is a government owned development bank specialized in rural finance, provides refinance to banks and other lending institutions in rural areas. This facility also extends to rescheduling of loans against crop failure but does not apply to loan rescheduling against price risk.

A common observation of most studies is that the institutional credit sector is marred by lack of financial discipline. As against the social consequences of defaulting on a loan in the informal market, failure to repay loans from official sources does not carry any stigma. In comparison to the informal sector, the recovery rate of institutional loans and in particular of cooperative credit, is extremely low. Only 40% of loans were recovered by the co-operative societies in Maharashtra in 1980 (Walker and Ryan, 1990). Co-operative Bank of Kannauj claimed to have recovered 50% of loans extended in 1998 (Ravi, 2002). The poor performance arises even though there is a comprehensive legal framework for recovery of loans.

Walker and Ryan (1990) report that almost all institutional loans have a collateral requirement in the form of land or third party guarantees. Third party surety is especially common in Akola villages of ICRISAT. Loan rescheduling and subsequent term conversions are almost always preferred to recovering collateral. Gold still has a considerable value as collateral in the formal sector. 43% of institutional loan taken by respondents in a survey of rural residents in Kerala (Ravi, 2002) are 'gold loans' from co-operative banks. Even though credit institutions attempt to ensure the productive use of funds, a loan is fungible and often diverted to alternative uses. For example, in the Akola villages only about two fifths of the initial loans were destined exclusively for agricultural productive purposes for which they were taken.[9] There were some leakages associated with another two fifths , although the bulk of the loans were spent on productive investments. About one-tenth of the borrowers used their first loans entirely to repay moneylenders. Institutional sources, however still finance proportionally more investment for agricultural production that informal sources.[10]

Well-developed traditional money-lending system still exists in most rural areas of the country and the number of moneylenders would have been much higher if it wasn't for the competition from subsidized institutional credit. As Walker and Ryan [1990] explain from the ICRISAT villages and as is observed by Ravi (2002) in U.P., farmers are associated in a personalized long term relationship extending over several years with a single moneylender. Switching from one moneylender to another is feasible but not common. In the ICISAT regions, transactions are mostly held in secrecy. However, if there are delays in loan recovery then details about client's borrowing can be made public. Most moneylenders, however, exchange information regarding clients.

As noted by several studies based on the ICRISAT data, moneylenders, unlike formal creditors, explicitly lend for consumption and production. This observation also holds in villages of Uttar Pradesh and Kerala as noted in the rural household survey of Ravi (2002). There is very low level of financial intermediation among and between informal lenders in the ICRISAT villages. Informal lenders do not accept time deposits and lend solely out of equity because of seasonality and covariate risk.

Villagers face sharply different borrowing opportunities, depending on their wealth, social status and reputation. Ryan and Walker (1990) observe that the landless are effectively excluded from the informal credit market except for borrowing very small amounts. Farmers are segmented into two loan classes, medium term and seasonal, varying markedly in term structure and interest rate as well as the monitoring activity by the moneylender. There is no long term lending in any of the ICRISAT villages. A precise repayment schedule is often not fixed in advance. The rates of interest charged vary from 18% in Andhra Pradesh villages to 40% in Maharashtra villages of ICRISAT. In Uttar Pradesh, however, Ravi (2002) finds that there is a fixed repayment schedule on loans from moneylenders as well as from cold- storages, both within the village as well as outside. Cold storages extend credit to the farmers but are not a very common source. The rate of interest charged varies from 2% to 6% per month by moneylenders but is more uniform from cold-storages.

Majority of medium term loans in the ICRISAT villages are given without security; collateral is only demanded of relatively unreliable clients. Collateral for most seasonal short-term loans is the standing crop as reported in Ryan and Walker. This is consistent with Ravi (2002), for loans offered by traders and cold storages and among moneylenders within the village. Collateral value of land has sharply declined because several state governments no longer honour promissory notes issued to moneylenders. Collateral substitutes have assumed primary importance in conditioning repayment incentives. The threat of loss of future borrowing opportunities is perhaps the most important.

One of the popular forms of borrowing and lending that is almost exclusively used by women is chit-funds, which are essentially revolving credit and savings societies. In Palaghat, all the 9 villages that Ravi (2002) surveyed had a chit-fund scheme called 'Kudumbashree', with active participation from women and landless labourers. In the

ICRISAT villages women have a hard time borrowing in their own right. As Ryan and Walker (1990) point out, the only women who are not completely rationed out of the credit market are widows who are the heads of households. Furthermore, they are not offered long term labour contracts therefore they cannot obtain loans via labour-credit linkages.

While we have so far reviewed credit arrangements in informal as well as formal credit markets, let us now turn to the performance of the credit market as an *ex post* mechanism for smoothing income fluctuations to that of transfers and quantify the extent to which inter-household transfers substitute for credit arrangements. Rosenzweig (1988) studied the ICRISAT villages of Aurepalle, Shirapur and Kanzara. He looked at the response of net household borrowing to exogenous income movements. The results indicate that credit behaves similarly to transfers in responding to income changes. Credit appears on average to play a greater role in smoothing income – at the sample means credit compensates for 11.3% of shortfalls in normal income as compared to the mean 2% transfer rate. Another important difference between credit and transfers as income 'insurance' is the greater extent to which own wealth influences the contribution of credit to income smoothing. Households with little endowed wealth rely much more heavily in credit relative to transfers than do wealthy households. The estimation results in Rosenzweig suggest that for an otherwise average household with no accumulated assets, the rate at which credit is used to smooth consumption would be almost seven times that at which transfers are used. For households with a net inherited wealth of Rs.100,000 (1983 Rupees), less than one standard deviation above the mean, however, the transfer rate is almost a third of the rate at which credit contributes to income smoothing. The estimated wealth-transfer rate and wealth debt rates also suggest that credit market insurance is viewed as inferior to transfers by the ICRISAT households.

3.4 Land Tenure and Risk

"Tenancy contracts allow farmers to make better use of individual endowments and to arrive at combinations of income, effort and risk that reflect their endowments and tastes", noted Binswanger and Rosenzweig (1984). The overall findings from various studies are consistent with this view and although the data from ICRISAT villages suggest several reasons why farmers lease in and lease out land, the most common explanation for most transactions center on resource adjustment. A careful evaluation of the terms and conditions of land transactions implies that one impetus for tenancy is risk sharing.

Agricultural tenancy is common but not predominant in the ICRISAT villages. Table 3.1 provides details of tenancy contracts in the ICRISAT villages. Whereas about 20% of all households sharecrop, far less, below 5%, are fixed rent tenants. It is also interesting that 80% of all tenants cultivate some land that they own (Shaban, 1987). The land-lease market is quite active and overall, sharecropping is dominant as a mode of tenancy. Reverse-leasing – the leasing of land from relatively small to relatively large farmers is also observed. Shaban (1987) notes from the ICRISAT data that on average, in tenancy relationships, 47% of the partners come from the same farm size group, 32% of leasing was reverse and 22% of land was leased by large farmers to smaller ones. In one of the villages, Dokur, reverse tenancy accounted for 55%.

Shaban (1987) covered leases that are predominantly of brief duration, mostly not exceeding one year. Nearly to 60% of the contracts in the region were for only one cropping season. Another common feature of the ICRISAT region, noted in several studies is that landlords rotate their tenants frequently. The long term tenancy relation is almost non-existent in these villages. In a survey of twelve villages of Kannauj district in Uttar Pradesh, however, Ravi (2002) observes cases of long term tenancy relation called *rehan*. These might be due to widespread existence of absentee landlords in the region. However, even here, these are few and far between. The reduction in long term tenancy across several states can be ascribed largely to land reform legislation that makes it easy for long standing tenants to acquire ownership of the plot. The detrimental impact of this legislation being that with limited tenure, the tenant has little incentive to apply proper amounts of inputs such as manure, fertilizer etc that are known to have residual and lasting effects on crop yields.

Jodha (1978) who evaluates the terms and conditions of sharecropping transactions in the ICRISAT villages, makes the following generalizations: 1) There is large variety in leasing conditions to reflect individual landowner and tenant circumstances. The sharing rules vary across villages. In Dokur, where the use of purchased inputs is fairly high, more than 90% of the contracts stipulate 50-50 output as well as input cost sharing, while in Shirapur, where use of purchased inputs is much less intensive, the tenant is responsible for supplying all inputs and receives a share of 50-75% of the output. 2) Tenancy contracts are flexible and renegotiations based on midseason production contingencies are common. In cases of failure to supply for inputs, there are renegotiations and readjustments. 3) Tenancy contracts can be interlinked across other factors and product markets and though not prevalent, interlinked contracts comprised of 12 percent of tenancy transactions. 4) Tenants decide what crop to plant unless the owner provided a considerable quantity of purchased input. Fixed rental, sharecropping and owner operation also coexist in the same locality as explained by Eswaran and Kotwal (1985). 5) Many tenancy arrangements improved the risk-bearing capacity of the landowner as risk was transferred to or shared by the tenant. Table 3.2 shows the risk implications of several tenancy arrangements. Walker and Jodha (1986) explain that about 60 percent of the tenancy transactions in the Sholapur villages from 1975/76 to 1978/79 had implications for intertemporal adjustment to risk. These transactions represented continuing attempts by farmers to adjust to resource losses.

It has been argued by many economists that sharecropping is essentially an inferior system to that of fixed-rent tenancy. The basic idea behind it – if the effort of the tenant cannot be monitored and controlled by the landlord, the tenant has an incentive to undersupply his effort, because under sharecropping a part of the output produced by him gets siphoned off to the landlord. Shaban (1987) compared the efficiency on share cropped land with efficiency on owned land after carefully controlling for other factors that affect yields. The main result being that output and input intensities per acre are higher on the owned plots. The average difference is 33% for output and 19-55% for inputs. Why then does sharecropping still exist? It is the dominant form of tenancy in the ICRISAT villages. It exists and is rampant because sharecropping emerges as a way to share, not just the output, but also the risk that is associated with the production. When a tenant pays a fixed rent, he is forced to bear the entire uncertainty of production. While under sharecropping, he is able to pass on some of this uncertainty to the landlord by varying the rent payable with the size of the output. As tenants are risk averse and they do not have perfect access to credit or insurance markets, therefore, landlords can make money by attempting to insure them from agricultural uncertainty.[11] But in doing so, the landlord must offer contracts that induce the right incentives. Besides, these contractual relationships may have implications for other kinds of landlord-tenant behavior, such as the provision of credit to the tenant, the tendency to evict tenants and the incentives to make long run improvements on the land.

Another potential strategy that agricultural households can adopt to smooth production shocks is to hold spatially scattered plots. Land fragmentation is synonymous with a spatially dispersed farm holding in which land held by an individual is scattered in plots separated by land in the possession of others (Royal Commission on Agriculture 1928, as cited by Roy 1983). In the Walker and Ryan study of the ICRISAT villages, risk reduction was indeed alluded to as a beneficial consequence of land fragmentation. They explain that holding several spatially dispersed parcels was often associated with greater opportunities to exploit soil variation within the village. They further write that, farmers believed that some crops could be profitably grown only on some soils in the village; hence access to soil variation through fragmentation encourages crop diversification, which in turn facilitates resource adjustment as seasonal input demands vary by crop. Nevertheless, more than 40 percent of the households in their study felt no benefits were derived from spatially dispersed holdings. In general, farmers who owned more than one parcel felt that the costs of land fragmentation outweighed the benefits. Among the several potential costs attached to owning and cultivating fragmented plots that Walker and Ryan (1990) discuss in detail, increased travel time and greater troubles in supervision of cropping operations were the prominent ones. This is not a surprising result because the premise on which benefits from fragmentation are expected is of spatial variation in the quality of land and topography. Such variation is usually lacking in India's dry semi arid tropics and most likely explain why many farmers feel that spatial diversity is not highly conducive to risk reduction. Land fragmentation, therefore is not a prominent strategy adopted *ex ante* to smooth income variation.

3.6 Insurance through Labour Market

Rural households can protect themselves from idiosyncratic income shocks in the labour market using both *ex post* strategies like shifting from own farm cultivation to the labour market or by increasing hours of work as well as *ex ante* measures like entering 'permanent' labour contracts to avoid seasonal fluctuations in wages and employment opportunities. The ability to smooth income directly reduces the need to resort to the depletion of assets or to costly *ex ante* measures. The importance of labour income for Indian farm households increases the likelihood of the above responses. In the ICRISAT village studies, the majority of farm households (70%) report labour earnings in the daily wage labour market, with total labour income amounting to 25% of total crop profits. While almost all small farms (87.5%) report such income, so do a significant number of large farms (46.4%).

To gauge the extent of (ex-post) smoothing that is done via labour market, we look at the regression results of Kochar (1995), which indicate that small negative crop shocks evoke significant increases in wage income – increased wage income allows small, medium and large farm households to compensate for 45%, 62% and 41% of small crop income shocks respectively. Households are more vulnerable to large negative crop shocks, which are uncompensated through either wage income or informal borrowing. The incidence of large crop shock is, however, relatively small. Though households are able to compensate for episodes of illness suffered during slack season, there is a significant loss of wage income associated with illness in the peak season, particularly illness of males. Such shocks increase informal borrowing, and the fact that borrowing is resorted to only when increases in wage incomes are not feasible indicates the relative costliness of this strategy. Constrained access to credit by small farmers in conjunction with their greater vulnerability to illness suggests that such shocks link income uncertainty to poverty to a greater degree than crop income shocks.

Kochar's (1995) analysis of household vulnerability to idiosyncratic income shocks reports two implications of the use of labour as insurance. The first is that wage income will be ineffective as a source of insurance against shocks that affect the household's valuation of labour, since it pools risk at the level of the household. Therefore demographic shocks and the dissolution of the family will require alternative and possibly costlier methods of insurance. Such shocks can then affect the economic condition of farm households to a greater extent than crop shocks. Demographic shocks, in fact, contribute significantly to the variability of full income. Rosenzweig's (1988) estimates of full income, defined as the sum of crop profits and the income that would be earned by adult household males if each worked 312 days at the going wage rate, suggest that in the ICRISAT villages, variability in the household's male labour endowment respectively contributed to 38%. These figures understate the importance of demographic shocks, since no allowance is made to illness. These episodes appear to be frequent, with 39% households reporting loss of working days due to illness in a given year. The study also indicated that the poor appear more vulnerable; while 28% of large farm households recorded an episode of illness, 43% of small farm households recorded such an episode.

Another implication noted by Kochar is that the segmentation of labour markets by gender may make a household's vulnerability to crop income shocks a function of its demographic composition, in particular the number of able-bodied males relative to females. As consequence of such a segmentation, it is easier for males to obtain employment on the daily-wage labour market than it is females.[12]

Kochar also looks at the extent to which a household's vulnerability to crop shocks depends on its demographic composition. Ability of a household to smooth crop shocks depends on its male labour endowment, with female members, in fact, detracting from this ability. It is also seen that households that are relatively disadvantaged in the labour market are not able to compensate through the credit market. An analysis of the demographic composition of households shows that small farms have fewer male workers than other farms, which makes them more vulnerable to crop income shocks. Not much is known about the methods used by households to reduce their exposure to demographic shocks and the costs of the methods used. While the short–run costs of using labour as insurance may be low relative to the use of credit, there may be substantial long-run costs. Thus, in addition to possible effects on fertility, the household may maintain excess stocks of family labour at the cost of income-increasing migration. The use of labour as insurance may also lower educational attainment.[13]

Let's now turn to the *ex ante* strategies that households adopt to avoid seasonal fluctuations in wages and employment opportunities. Table 3.3 has data on seasonal fluctuations in employment in the ICRISAT village for 1975-76. The data indicates huge fluctuations in employment rates between the peak and slack seasons. This fluctuation is especially acute for women. Households in such a situation would then like to enter into contracts that guarantee a stable income across the year. Perhaps the most extreme case of income smoothing through labour market activity is given by Bardhan's (1983) analysis of 'tied labour'. His study takes on the notion that permanent labour contracts are inefficient relics of an age when slavery was condoned. Such contracts involve long term relationships between employers and employees at steady but low wages. Tied labour contracts account for roughly one-third of agricultural labour relationships in surveys of rural India and have been employed in a diverse set of agricultural economies. The labour markets in India are by no means homogeneous or uniform; there are vastly different kinds of arrangements that can be seen. As noted there are two kinds of hired labour- casual labour, hired on a daily basis sometimes weekly basis, and permanent workers or 'tied' labourers, who are on long term contracts that extend for months or even years. Bardhan [1983] has proposed an explanation for the existence of permanent labour, based on the following idea. Risk averse workers faced with an uncertain spot wage can engage in long term contracts with risk-neutral landlords for a pre-negotiated wage, albeit at a rate lower than the expected spot rate. The main comparative static result of this model explains the well-acknowledged empirical findings that the proportion of permanent workers is higher in tighter labour markets. In addition, Bardhan [1979] makes the observation that permanent workers in Indian agriculture typically enjoy a significantly higher annual income, despite a lower daily wage, then casual workers.[14] Permanent workers get consumption loans as well as other patronage benefits while casual workers face a great deal of uncertainty on the labour market.

3.7 Crop Management and Choice of Agricultural Investments

So far we have considered ex-post strategies (asset sales, credit, participation in casual labour market) and ex-ante strategies (tenancy, "permanent" labour contracts) that farmers use to cope with risk. Now we consider strategies that farmers can employ to directly modify the risks that they have to manage. These are necessarily ex-ante strategies and work through the many choices that comprise crop management.

3.7a Risk Attitudes and Perceptions

Although it is often asserted that farmers are risk averse, rigorous evidence on this issue is hard to come by. In a pioneering study that has since not been replicated in India, Binswanger (1980), conducted experiments with individuals in rural India with real monetary payoffs. 300 individuals were randomly picked from the six villages that formed the field subjects for the ICRISAT study. Three-fourths of households in the ICRISAT sample were cultivator households while the others were landless labourers. In his experiment, Binswanger offered the subjects the choice of lotteries with different payoffs. From the choices made by the subjects, it is possible to infer their risk aversion. While a detailed account of the methodology is beyond the scope of this study. However, the basic idea is the following. Suppose a farmer is offered a choice of Rs. 5 or a bet where the farmer either gets Rs. 0 or Rs. 10 with equal probability. Clearly, a farmer who opts for the former is more risk averse than the farmer who chooses the risky bet. From analyzing the pattern of such choices, Binswanger found that most farmers in the ICRISAT villages were intermediate to moderately risk averse. As is expected, higher the stake, greater is the risk aversion.

Walker and Ryan (1990) emphasize the distinction between risk aversion (determined by innate preference characteristics) and risk perceptions (determined by how farmers process information). They point to the example of in-well boring in the ICRISAT villages. Drilling bores costs money and it pays off if the bores intercept water-bearing fissures. Otherwise, the expenditure is a loss to the farmer. Thus, the decision of whether to drill in-well bores is risky. Walker and Ryan quote an investigation by Engelhardt who found that the only statistical difference between the groups of farmers who planned to drill bore and those who did not plan to bore was the difference in their subjective probability of hitting water-bearing fissures. On average, within the same watershed, the farmers who planned to drill were much more optimistic about the possibility of hitting water fissures than the farmers who did not plan to drill. They conclude that differences in risk perception rather than in risk aversion was what that determined the drilling decision. [15]

3.7b Investments and Technology adoption

To understand whether farmer's risk attitudes are a constraint for undertaking new investments and the adoption of new technologies, Lipton and Longhurst (1989) point out that although poor people often give uncertainty as a reason for delaying or refusing adoption, the effect of risk aversion is not straightforward. In the semi-arid tropics, digging wells and purchasing fertilizer are two most risky cash-intensive decisions (Walker and Ryan (1990). Whereas digging wells is risky because in the semi-arid watersheds, about 30% of dug wells are dry, fertilizer is a costly input that pays off when plants face no moisture stress. Binswanger et. al (1982), found that risk aversion did constrain a farmer's decision to invest in dug wells, however, the direct effects of risk aversion on fertilizer use were found to be modest.

This is mostly because of the divisibility of fertilizer inputs. In the adoption literature, it is well known that risk aversion can constrain adoption of technology only if its fixed costs are substantial (Feder and O'Mara, 1981). Otherwise, even the most risk-averse farmer would be tempted to use a potentially remunerative technology on a small plot. The fixed costs of dug wells are clearly more important than of using fertilizers. However, as the profitability of fertilizer use depends on access to irrigation, the indirect effect of risk aversion on fertilizer (which works through the dampening effect on irrigation investments) is sizeable. This is consistent with Schluter's (1974) findings from Gujarat that risk is a more serious constraint on smallholder's adoption than access to credit for inputs in unirrigated areas but less serious in irrigated areas.

Consistent with the Walker and Ryan emphasis on risk perception, Lipton and Longhurst suggest that much of the risk of adoption of new technologies and varieties comes about because small farmers are likely to know less about them than about traditional varieties and in particular about the resistance of new varieties to pest and disease. Much of the fixed costs of adoption then are related to the fixed costs of learning about new technologies.

3.7c Crop Diversification

World over, crop diversification is regarded as the most common and effective risk management strategy that is employed by farm households. By spreading risks across multiple crops, the idea is that even if a particular crop does not do well, the loss will be compensated by gains in another crop. There are some limitations of this strategy however. First, diversification is clearly a feasible strategy to the extent that crop risks are independent, however, if returns are strongly correlated across crops, the risks facing farmers are similar to covariate risks and crop diversification will not be effective in reducing producer risk.[16] Second, crop diversification calls for spreading resources across crops even when a particular crops offers higher average net returns than other crops. Therefore, the price of diversification is the income foregone, on average, by not growing the must remunerative crop. Third, if there are fixed costs in the cultivation of a particular crop, then there is a minimum efficient scale and that may conflict with the requirements of crop diversification. Farmers with small holdings are likely to run into this constraint.

We look at some quantitative evidence about the prevalence of crop diversification as reported in the 54th round of the National Sample Survey (NSS). Among other things, households were asked to report their principal crops ,up to a maximum of 5, in kharif and rabi. Classification of farm households can then be according to the number of crops they cultivate. In table 3.5, we tabulate, by farm size, the proportion of agricultural households in each category. As expected, the extent of diversification increases with farm size except for the dip in the highest size category.

Crop diversification is, however, not determined by considerations of risk alone. This point comes about in an analysis of crop diversification data in the ICRISAT village studies (Walker and Ryan, 1990). The determinants of crop diversification varied across and within the ICRISAT villages. In Mahbubnagar and Akola regions, draft power availability was an important factor that explained the variation in crop diversification. Larger farms with more gross cropped area were more diversified than small farms. This was not so much because of the greater costs of diversification for small farmers but because of more profitable opportunities for diversification as well as higher costs of specialization for large farms. As large farms hold more fields they can exploit location-specific production opportunities and they also have greater access to credit to finance more input-intensive cropping activities. At the same time, by diversifying crops and the cropping calendar, large farms are able to reduce peak season labour requirements. In the Sholapur regions, resource endowments in the shape of draft power and land size were not important in explaining diversification which was largely due to differences in land quality and cropping-year conditions. Irrigation usually leads to specialization because it enables farmers to grow high value crops. In Mahbubnagar, this led farmers to grow paddy while limited well irrigation in dryland Akola and Sholapur led farmers to grow new crops such as wheat, chickpeas and other pulses.

Although factors other than risk alone drive farm decisions about cropping patterns and diversification, crop diversification in the ICRISAT villages does stabilize crop income (Walker, Singh and Jodha, 1983). Interestingly, crop diversification was three times more effective in stabilizing net returns in rainfall-assured Akola than in drought-prone Sholapur (Walker and Ryan, 1990). Walker and Ryan attribute this to the fact that in Sholapur most crops are vulnerable to the same source of risk, namely drought, while the sources of yield risk are much less covariate in the Akola villages.

3.7d Intercropping

Intercropping systems is another way for farmers to manage yield risks (Bliss, 1976). Intercropping lowers yield risks because of (a) lower disease and insect pest incidence and (b) greater potential for yield compensation (Walker and Ryan, 1990). The first effect operates presumably because intercropping interferes with the spread of pests given that their operation is specific to crop type. However, as Walker and Ryan point out, this effect also is specific to location and cropping system and does not always work. Yield compensation refers to a crop's ability to take advantage of light, nutrients and soil moisture released by the other crops adversely affected by risk (Walker and Ryan, 1990). Clearly, this is not possible in pure stands.

Walker and Ryan are, however, skeptical of the value of the contribution of intercropping as a risk management tool. They report findings from Walker and Jodha (1986) about the covariances in yields between crops in the same field. If intercropping reduces risk, the covariances should be negative or zero but should not be strongly positive. However, they find that correlation between sorghum and pearl millet yields in the sorghum/pearl millet/pigeon pea cropping system in Aurepalle (an ICRISAT study village) was as high as +0.63. Clearly, these crops are affected by the same sources of risk. They report similar findings from other dry-land villages. The assured rain-fed environment of Akola village offered more opportunities for risk reducing inter-cropping.

Because of a longer growing season, farmers could grow short- and long-duration crops within the same field and thereby create a crop portfolio with compensating risks. In general, however, they conclude that inter-cropping in dry-land ICRISAT villages is driven by other factors (principally resource endowments such as family size, livestock etc) rather than risk.

Although the risk reducing potential of inter-cropping in drought-prone areas might be limited, even in those areas, inter-cropping seems to help in avoiding complete crop failure. In section 2.5, we discussed the analysis of Singh and Walker (1983) who examined the incidence of crop failure in 3805 plots in the 6 ICRISAT study villages. From their paper, we reproduce Table 3.6, which shows the incidence of crop failure of one or more of the components of intercrops and mixtures. It shows that the probability that all crops failed was very low – from 0.01 in Akola to 0.03 in Mahbubnagar. However, the probability of failure of any one component in the intercropping system was high – ranging from 0.14 in Akola to 0.39 in Sholapur.

3.7e Production Flexibility and Information

It has been long recognized that in situations of uncertainty, it can pay to delay decisions even when such delay is costly. The idea is that when decisions commit the producer to certain fixed costs, then they cannot be reversed easily. In such cases, it might be better for a producer to wait to receive more information and then depending on the information, the action is undertaken or a revised plan is set in motion.

Jodha (1981) sees production flexibility as integral to the practice of dryland farming. When crop failure is foreseen, households begin salvaging byproducts and other low value operations that would not be worthwhile in normal years. Typically, it also results in changes in cropping patterns as farmers focus their efforts on crops that have a greater chance in adverse weather circumstances. Such flexibility is demonstrated by the farmers in the semi-arid tropics of India (Walker and Ryan, 1990). In the drought prone Sholapur region, post-rainy season cropping in October is more assured (in terms of yield risks) than rainy season cropping. Farmer's plans for rainy season are contingent on rainfall. As a result, the relative importance of rainy and post-rainy season cropping fluctuates from season to season. In a "normal" rainfall years, rainy season crops account for about 40% of gross cropped area. If rainfall is deficient, the share of rainy season crops can drop to less than 10%. As a result, the area of kharif season crops is very variable. However, while this is a source of output and price variability, the area variability is itself not a risk but a response to weather risk.[17]

Another example of area variability given by Walker and Ryan is the substitution of sorghum by castor that is induced by the late arrival of monsoon in Aurepalle. Late planted sorghum is susceptible to pests and so farmers prefer to plant castor. The response to agro-climatic events is even stronger in Mahbubnagar because of the short window of about 2-4 days after the onset of monsoon that is available for planting. Figure 3.1 reproduced from Walker and Ryan compares the variation in planting date in drought-prone Aurepalle to the rainfall-assured village of Kanzara. The sample standard deviation in planting date across the 10 years of the ICRISAT sample was about 15 days in Kanzara and only 6 days in Kanzara where the early season monsoon rainfall was usually sufficient.

Comparing the cropping decisions across low and high soil moisture years in the ICRISAT villages, Gadgil et. al (1988) find that low soil moisture leads farmers to reduce cropped area, increase inter-cropping, increase area to short-duration and low water-requiring crops. Thus, production flexibility is a key feature of farmers' adjustments to weather risks.

3.7f Risk Reducing Inputs

As discussed in the earlier chapter, the principal causes in yield risk in India are rainfall uncertainty and damage from pests and insects. The two inputs that directly affect these variables are irrigation and pesticides and related chemicals.

The absence of moisture stress substantially reduces yield risk. We saw this earlier in the discussion of the relative importance of yield and price risks (section 2.3). It was also seen in the analysis of the effect of resource endowments on crop failures (section 2.5). Irrigation fundamentally alters the production possibility set of the producer. New opportunities become available as a result of which irrigation usually alters the cropping pattern even in semi-arid tropics from subsistence dryland crops like jowar and bajra to high yielding varieties of paddy and wheat that thrive on assured water (Gulati and Kelley, 1999). Thus, the dynamic impact of irrigation on farm household risk might well be that as production risk declines; farmers take on more market risk.

The risk reducing potential of pesticides is documented in studies that are quoted in the National Commission of Agriculture (1976). The picture of pesticide users by crop is provided in Table 3.7. Pesticide and weedicide is most prevalent among growers of "other cash crops". This category includes cotton that is well known to be particularly susceptible to pests. Vegetables and paddy are other crops that lead in the extent of pesticide use. This picture is consistent with the evidence on the crop destination of pesticides that is tabulated in Table 3.8. As can be seen the major markets for pesticides are cotton, paddy and vegetables. About half of the pesticides demand comes from cotton even though it is grown on only 4-5% of cultivable area. On the other hand, the pesticides market for coarse cereals is small even though more than 50% of cultivable area is under these crops. The reason is that these crops are primarily grown in dry lands. In these conditions, with the forever threat of drought and rainfall deficiency, the application of costly pesticides is risky. As such information is not available for earlier years, it is hard to know how the pesticide use has changed over years although from the growing market for pesticides (from 7000 metric tonnes in the early 1960s to more than 100,000 metric tonnes by the mid-1990s), one would surmise that pesticide use has increased.

Besides using risk-reducing inputs, risk averse farmers could also curtail the use of inputs that increase risk. Bliss and Stern (1982) take up this issue in investigating production choices in the village of Palanpur, in Uttar Pradesh. They find that fertilizer is a highly productive input in wheat cultivation, but the marginal product of fertilizer remains 3.5 times its price. Farmers could substantially raise expected profits by increasing applications of fertilizer, but by using less fertilizer, investment losses are reduced in bad times. The authors' calculations suggest that the foregone expected profits are most plausibly explained by high levels of risk and risk aversion. In Antle's (1987) investigation of paddy producers in the ICRISAT village of Aurepalle, fertilizer was once again found to be a risk increasing input.

3.7g Investment Portfolio

A study by Rosenzweig and Binswanger [1993] based on the ICRISAT data shows that the agricultural investments portfolio behaviour of farmers reflects risk aversion. This study is concerned with the role of assets in mitigating risk *ex ante*. They examine how the composition of productive and non-productive asset holdings varies across farmers with different levels of wealth and across farmers facing different degrees of weather risk. They find that large farmers typically hold riskier investment portfolios than small farmers. This feature arising from the evident willingness of wealthier farmers to absorb significantly more risk while reaping the higher average returns than less wealthy farmers, is evidence against the common supposition that smaller farms are always more efficient than larger farms, a presumption that ignores the returns to agricultural investment holdings. Thus, uninsured weather risk is a significant cause of lower efficiency and lower average income for small farmers – a one standard deviation decrease in weather risk would raise average profits by 35% among farmers in the lowest wealth quartile as lower risk enables them to shift their portfolio to high-return investments. These results suggest that improvements in the abilities of farmers to smooth consumption, perhaps via increased consumption credit, would increase the overall profitability of agricultural investments; similarly the availability of rain insurance would both raise overall profits in high risk areas and decrease earnings inequality within such areas. However, the study by Rosenzweig and Binswanger finds that demand for rainfall insurance might be quite weak. First, a substantial proportion of profit risk is idiosyncratic and well diffused. Second, demand for weather insurance would come primarily, if not exclusively, from poor farmers. Wealthy farmers are evidently unwilling to pay a premium, via reduced average profits, to reduce their exposure to *ex ante* weather risks.

3.8 Hierarchy of Responses

Of the ex-post strategies available to combat risk, the household does not treat them all equally. Rather it has been seen that options such as the sale of assets are used only when the crisis is grave and when other options are ineffective. There is thus a hierarchy of risk management strategies and the farm household usually begins with strategies at the bottom of the hierarchy. A description of the hierarchy is provided by

Jodha (1975) who examined the response of farm households in Western Rajasthan to famine. The sequence of household responses to risk proceeds as follows.

(a) When crop failure is foreseen, the household undertakes supplementary operations such as collection of normally wasted products such as bushes and rough fodder for fodder and fuel. In addition, the households undertake additional effort to minimize waste such as processing of stalk for animal feed, collecting every piece of dung and other low value activities that would not be worthwhile in normal years.

(b) Households curtail current consumption. Examples of such strategies are non-milking of wet animals to permit adequate milk for young calves, higher priority for feed and fodder in purchases, inclusion of items like gur and oil (which disappear from human diet) in the feed for needy animals.

(c) Households dispose off inventories of stored items such as fuelwood, dung cakes, ghee, pickles and dried vegetables, and timber.

(d) Households mortgage and sometimes sell their assets. Farmers prefer the mortgage of unproductive assets. With respect to livestock, sale is preferred to mortgage because of the need to take care of the mortgaged animal.

(e) The final option is to migrate to other areas. Jodha distinguishes four kinds of migration: (i) farmers move out to irrigated areas or areas unaffected by drought to work with their own bullocks and labour as share-croppers (ii) farmers with their bullocks go to towns to engage in transport activity (iii) youngsters move to irrigated areas as gang labour during the seasons of peak labour demand and (iv) farmers migrate with their animals to other states where pasture is available. During the time of Jodha's analysis (1963-64), the fourth migration was most important. With the decline of common property resources, it is doubtful if that would continue to be the case.

Jodha's analysis points to the fact that farmer behavior in the face of severe adversity is primarily to protect their assets and their means of livelihood. His analysis also shows that farmer responses are dictated by the nature of their integrated enterprises containing field crop cultivation as well as animal husbandry. This leads farmers to be concerned not merely about grain production but overall biomass and stability (Jodha, 1991). Hence the importance in traditional risk-coping of perennial vegetation – of grass, shrub and trees. They are less sensitive to rainfall fluctuations than field crops and their output is non-covariate with that of annual crops. The livestock component of traditional farming systems is used to convert biomass availability into economic gain. These traditional strategies are endangered because of new crops and technologies, which neglect fodder requirements, and also because of decline in fodder-fuel producing resources such as common property resources. Jodha (1991) also points out that the mobility of livestock endows it with a greater capacity (compared to immobile field crops) to respond to spatial variability of rainfall. But as noted earlier, the decline of common property resources has severely compromised the role of livestock migrations in buffering the shock of crop failure.

3.9 Conclusions

Uncertainties in income within agriculture can arise from several sources and a farm household adopts different strategies to mitigate this risk, and smooth income and consumption. There are essentially six ex post ways to compensate for shortfalls in farm income: They can sell stored produce, liquidate assets, borrow for consumption, receive transfers from relatives, change jobs and/or increase their labour market participation and migrate in search of work. In their choices, farm households will try to protect their assets so as to minimize the adverse impact on their future livelihoods. If a risk averse household is not able to achieve an entirely smooth consumption path through *ex post* mechanisms such as these, it has an incentive to devote resources in an effort to secure a more stable income stream. Households might farm a diversified portfolio of land, adopt technologies such as inter-cropping or drought- resistant crops and contractual arrangements such as sharecropping that reduce the variance of income, or diversify their activities through migration or local non-agricultural employment. Any of these *ex ante* actions might be costly, so that the households would be sacrificing income, on average, in order to assure a less risky stream of income. We have analyzed all likely strategies that a farm household adopts to cope with variations in income by classifying them as responses in different factor markets.

Figure 3.1: Mean and Standard Deviation of Planting Dates

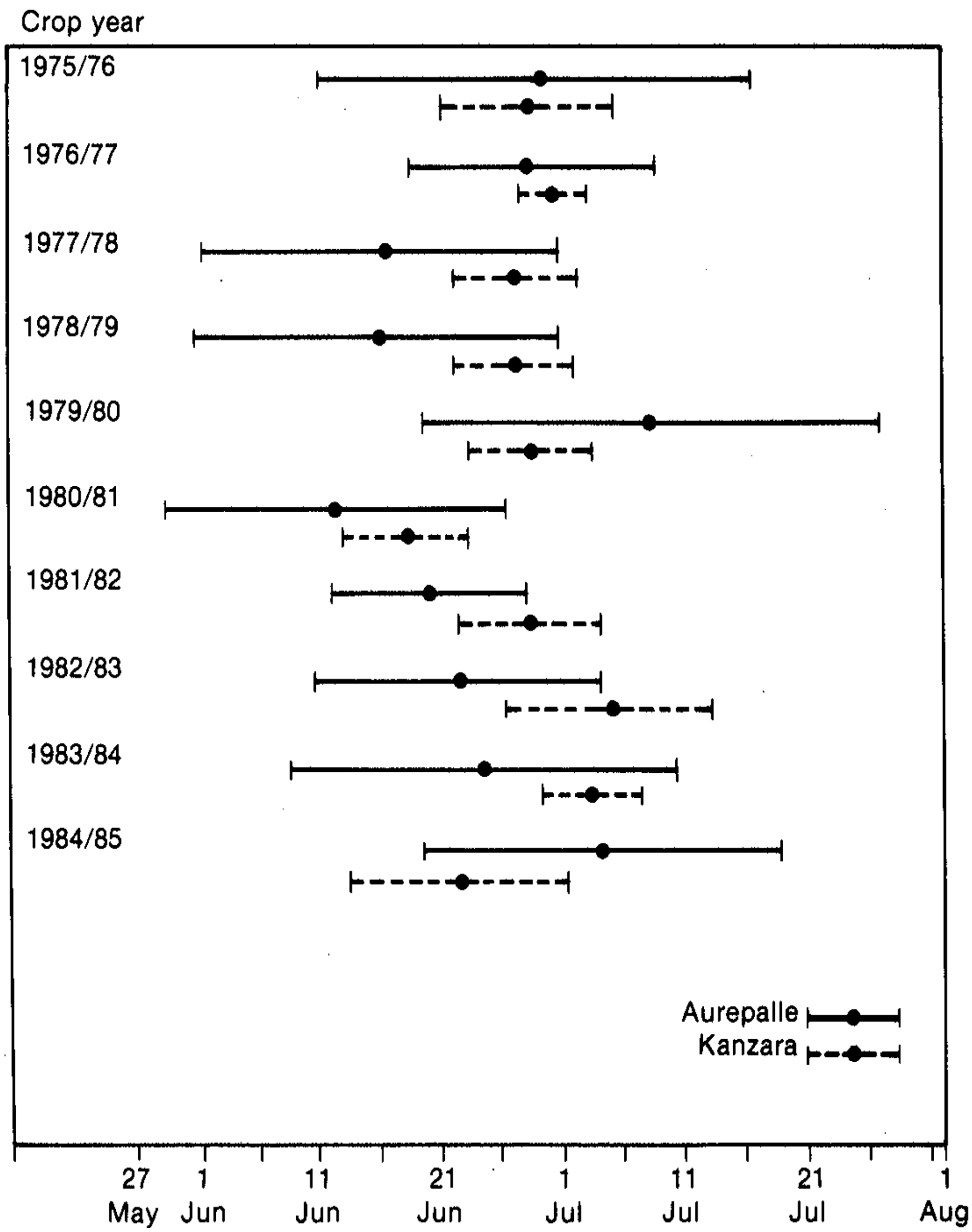


Table 3.1. Tenancy in ICRISAT villages by household

Villages	Households	Owners	Sharecropping tenants (%)	Fixed-rent tenants(%)	Mixed tenants(%)
Aurapalle	406	90.7	1.2	8.1	0.0
Dokur	220	82.3	15.9	0.9	0.9
Shirapur	437	69.1	30.4	0.5	0.0
Kalman	296	68.6	30.7	0.7	0.0
Kanzara	320	80.6	11.0	5.3	3.1
Kinkheda	187	85.0	14.5	0.0	0.5
Boriya	186	56.5	29.0	12.9	1.6
Rampura	216	76.4	14.8	5.6	3.2
All	2,268	76.8	18.2	4.1	1.0

Source: Shaban [1987, Table 1]

Table 3.2. Risk implications of tenancy arrangements in the Sholapur villages, 1975 to 1978

Tenancy Arrangement (N farms)	Risk Implications
Rent essentially fixed but subject to harvest (1)	Implicit risk sharing
Rent fixed, independent of harvest (2)	Risk transfer to tenant
Advance loan, rent subject to harvest (2)	Implicit risk sharing; risk/loss management
Input and output sharing (14)	Explicit risk sharing
Input (excluding bullock) and output sharing (29)	Explicit risk sharing; risk/loss management
Input and output sharing with adjustable advance loan (30)	Explicit risk sharing; risk/loss management
Net output sharing (19)	Risk transfer to tenant
Net output sharing with adjustable advance loan (17)	Risk transfer to tenant; risk/loss management
Risky plot tenancy with no fixed rental, no advance loan, meager crop share (19)	Implicit risk sharing
Mid-season leasing with share in output(9)	Risk transfer to tenant
Land lease linked to labour and credit contracts (22)	Explicit risk sharing; risk/loss management

Source: Walker and Jodha [1986, Table 2.6]

Table 3.3. Unemployment rates, ICRISAT villages, 1975-76

	Unemployment rate (%)		
	Peak	Slack	Total
Men	12	39	19
Women	11	50	23

Source: Walker and Ryan [1990]

Table 3.4. Proportions of tied labourers in ICRISAT villages

Village	Type of farm	(%) Farms employing farm servants
Aurepalle	Small/medium Large	13 47
Shirapur	Small/medium Large	6 7
Kanzara	Small/medium Large	0 7

Source: Pal [1993]

Table 3.5. Crop Diversification in Kharif and Rabi in 1999/00

Farm Type	Farm size (hectares)	Average no. of crops in portfolio (Kharif)	Average no. of crops in portfolio (Rabi)
Marginal farms	>0 but <=1	1.230522	1.581382
Small farms	>1 but<=2	1.540505	1.824489
Small-Medium Farms	>2 but <=4	1.732585	1.916738
Medium farms	>4 but<=10	1.885877	2.039622
Large farms	>10	1.688423	1.807482

Source: Our calculations from the 54th round of the NSS

Table 3.6. Incidence of crop failure of main components in intercrops & mixtures from 1975-76 to 1977-78

Component*	Percentage of non harvested plots to total		
	Regions		
	Mahbubnagar	Sholapur	Aloka
First crop only	1.2	5.1	1.8
Second crop only	6.5	15.0	3.9
Third crop only	7.1	3.9	4.9
First & second crops	1.2	8.8	1.4
Second & third crop	8.9	2.8	1.1
First & third crops	0.6	0.8	0.0
All three crops	3.0	2.6	1.1

*Ranking of the components in intercrops & mixtures is based on relative area occupied by each species

Source: Singh and Walker (1983)

Table 3.7. Pesticide and Weedicide Use in Indian Agriculture, 1999/2000

Crop	Percentage of Agricultural Households using pesticide	Percentage of agricultural households using weedicide
Paddy	46.82	20.35
Wheat	32.99	17.51
Other cereal	29.17	11.14
Pulses	29.81	9.44
Oil seeds	36.30	14.39
Mixed crop	29.00	9.21
Sugar cane	38.67	20.47
Vegetables	45.31	14.33
Fodder	23.92	12.74
Fruits & nuts	30.47	10.16
Other cash crops	61.65	17.54

Source: Our calculations using the 54th round survey of the NSS

Table 3.8 Composition of Pesticides Market

Crop	Percentage of Pesticides Market
Cotton	50%
Paddy	25%
Vegetables	14%
Plantation Crops	5%
Coarse Grains	5%

Source: Interview with S. Jeyaraj, Professor of Entomology, Tamil Nadu Agricultural University, Bulletin Board of Centre for Indian Knowledge Systems, www.ciks.org

Chapter 4: Risk Management at Community Level

4.1. Introduction

In the last chapter, we saw how Indian farmers typically manage and cope with risk. The strategies that we discussed were those that are employed by individual households. In addition to these mechanisms, the need to cope with risk can also affect community interactions and social customs. Gift-based exchange that is based on reciprocity and informal borrowing and lending on implicit and flexible terms are instances of community level mechanisms that can help farm households to cope with adversity.

Anthropologists typically stress the value of social customs such as gift giving in securing the social status of the giver within the local social structure. In contrast, economists tend to emphasize the gift-giving social norms as mechanisms for community insurance. In developing countries like India, broad-based formal insurance markets are hindered by problems of imperfect information and costly enforcement.[18] However, these problems are limited in small communities. Villagers tend to know a great deal about what their neighbours are up to, and they can fall back on 'informal' enforcement mechanisms like social sanctions when disputes arise.

The focus of this chapter is income smoothing attained through mutual insurance between economic agents. The mechanisms involved might be gifts, transfers or borrowing and lending. However, all mutual insurance scheme share the element of reciprocity. If household *A* receives a gift or loan when it is in need, then in good times, this household might be called upon to lend or give gifts and transfers (although not necessarily to the same donor agents from which it received transfers). For mutual insurance to work, it must be that if some farmers are worse off in a particular year, then there must be other farmers in the risk pooling group that are better off. In other words, there must be a certain absence of positive correlation between the fortunes of the participating agents. This is the reason why mutual insurance is difficult: agriculture does present large correlations because of the weather. If it is a bad year for all households in the community, then clearly there is no household that can share its good fortune with the less fortunate. On the other hand, there are situations that are idiosyncratic across various agents (illness, festivities, local crop damage), and these can benefit from mutual insurance.

4.2. Mechanisms of Community Insurance: Informal Credit

Reciprocal exchange is subject to many enforcement problems. A household that receives a loan may decline to repay later or may repay only meager amounts. Likewise, households experiencing relative prosperity may refuse to help out their neighbours who are in need. How does the community, then ensure that its members meet the obligations of reciprocal insurance? Very often the obligations are themselves social norms and violating them would invite censure and possibly ostracization. Formal insurance markets are governed by laws rather than social norms. However, even here, often the most effective punishment for default is denial of service for future transactions.

A study of rural credit markets in villages of northern Nigeria by Udry (1993, 1994) provides a rich empirical illustration of institutional adaptation to problems of enforcement or missing information. He shows credit flows between the village members is essentially in the nature of insurance and is contingent on the circumstances and needs of borrowers and lenders. The evidence shows that it is part of the norm that the repayment burden is reduced or excused for those borrowers who run into financial trouble: proof of the insurance aspect of these transactions. Because lending is restricted between closely knit communities, borrowers usually find it impossible to misrepresent their true financial situation or to feign crop damage, illness or any other misfortune quite unlike formal credit contracts where the lender would be reluctant to reschedule payments because of the absence of credible information of the borrower's circumstances. In the few cases of dispute and perceived default, Udry observed that a complaint is made to the community leader or village head by the lender. If, after review of the situation, the leader holds the borrower to be guilty, the punishment imposed is usually a verbal admonition and, in extreme cases, a threat to make the matter public.

However, Udry's analysis also highlights the limitations of community insurance. As will be explained in more detail in the next section, a shock to income can be of two types: an *idiosyncratic* shock, which affects a single household (e.g. an illness in the family, flooding or insect damage to the family's plot etc), and an *aggregate* shock, which can affect an entire village or region (e.g. rainfall shortage, the flooding of a river, etc). Because most borrowing and lending is restricted to small communities and villages, the rural credit market should be efficient in pooling risk and providing insurance against the first kind of shock, but not against the second. Udry estimated that in his sample, about half (58%) of the variation in farm yields was caused by aggregate shocks, so this limitation must be serious.

Ravi's (2002) survey of some Indian villages in Uttar Pradesh and Kerala also reports similar norms as mentioned in Udry's account of northern Nigeria.[19] Lending within the Muslim villages of Kannauj is interest free. There are, however, a wide variety of fixed costs that the lenders impose on the borrower depending on the financial situation of the borrower *and* lender. Though not formally analyzed by economists, we are aware of several social institutions, cultural norms and networks that exist in rural India, which perform the roles of coordination and enforcement to facilitate mutual insurance.

4.3 Mechanisms of Informal Insurance: Patronage

A patron-client relationship such as *jajmani* system in northern India traditionally involves a set of reciprocal but asymmetrical obligations between patrons and clients (Agarwal, 1990). The obligation of the clients was to provide labour, rent or services. In return, the patron was obliged to provide a fixed payment usually in kind and to take care of the client in times of extreme need (illness, marriage etc). Clearly, such patronage systems provided some protection against seasonal and annual shortages. However, patronage systems are on the decline because landlords are able to obtain cheaper labour from the casual labour market. Similarly, the option of migration to urban areas has reduced the supply of clients. Agarwal cites a table from Jodha that compares the prevalence of patron-client support between 1963-64 and in 1982-84. This is reproduced here as Table 4.1. The data unambiguously show a decline in patron-client relationships.

4.4 Mechanisms of Informal Insurance: Kinship and Friendship

We have already seen how social relationships can sustain informal credit markets. Agarwal (1990) draws attention to the role of kinship networks in sharing, lending and borrowing other kinds of economic resources as well such as labour, irrigation water, agricultural implements and machinery. Women's networks exchange small amounts of foodstuffs, fuel and fodder. Traditional support systems draw strength from caste groupings. Aggarwal claims that women's networks established through marriage alliances and complex reciprocal gift-giving play an instrument role in sustaining social relationships.

A recent study by R. Murgai et al (2002), analyzes water transfers data from Punjab, Pakistan where water delivery is subject to idiosyncratic random shocks. They show that households cope with variability by exchanging water bilaterally with neighbours and family members, and also with members of tightly knit clusters. Their work finds the relevance of kinship as an organizing principle for self selected clusters. Risk sharing takes place preferentially in social arenas that facilitate rapid information flows, impose norms of fairness and reciprocity, and apply social sanctions on defaulting parties. These functions of local institutions are non-trivial because they solve inherent problems of coordination, asymmetric information, and contract enforcement that can be prohibitively costly for outsiders to solve.

There is some evidence from work by social scientists that traditional forms of support whether from family or from friends are eroding. These are especially connected with the breakdown of marriage (for women) and old age (Agarwal, 1990).

4.5 Mechanisms of Informal Insurance: Communal Resources

Another mechanism adopted by rural communities to smooth shocks to income is to draw upon common resources. Poor agricultural households typically obtain their incomes from a wide variety of sources. In particular, apart from field crops and vegetables, they also keep livestock, poultry and collect and sell products from common resources such as fruits, honey, fuelwood (Agarwal, 1990; Jodha, 1975). Agarwal points out that "access to village common property resources (CPRs) and state forest plays a critical role in enabling poor rural households to obtain essential items for daily use, to diversify income sources, and to increase the viability and stability of traditional farming systems by allowing a more integrated and diversified production strategy involving crops, trees, livestock etc."

Jodha's (1986) study covering semi-arid regions in seven states of India (Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Andhra Pradesh, Karnataka and Tamil Nadu) shows that while all rural households use CPRs in some degree, CPRs play a bigger role in the life of the poor. In most districts, the poor derive more than 20% of their income from CPRs. In other districts, the contribution of CPRs ranges between 9-12%. The poor depend on CPRs especially for fodder and fuelwood. The latter is still the primary source of fuel for cooking in rural India. In semi-arid regions, CPRs provide 90-100 percent of firewood, 66-84 percent of all domestic fuel, and 69-89 percent of the grazing needs of the landless and small farmers (Agarwal,1990).

CPRs are particularly useful in the slack season. Agarwal (1990) quotes a study which estimates that among tribals in central India, gathered food provides 12% of energy intake during normal pre-harvest seasonal shortages compared with two percent in the post-harvest period. In a survey of arid and semi-arid districts, Jodha (1986) found the employment from CPRs to be more important than own farm employment. What is more CPR collections reduced the person days of unemployment by 30%.

Jodha's study also shows that CPRs have declined since the early 1950s. The area of CPR lands declined by 26-52% (depending on region) between 1950-52 and 1982-84. Correspondingly their role in supporting the livelihood of poor rural households and in cushioning the risks from dryland farming must have reduced as well. The main reason for the loss of CPRs is the privatization of these lands either because of illegal appropriation or because they were distributed to individual households under various welfare programmes. Jodha (1991) believes that the deterioration in CPRs is one element in a general erosion of social sanctions and norms that governed collective sharing arrangements. He attributes this to several factors: introduction of formal institutions & the legal and administrative framework which often took no account of traditional customary arrangements, individualism stemming from market forces and population pressures that led to encroachment of CPRs. The dissolving of collective risk adjustment devices means that farmers today are more dependent on their individual efforts and on public relief measures for support in times of adversity.

Common resources are not always physical but can also be financial resources, which are mostly micro-finance projects. They are schemes like 'Kudumbashree'[20] in several districts of Kerala, which are essentially revolving credit and savings societies, which comprise of groups of participants, particularly landless labourers and women, who periodically contribute to a fund, which is earmarked to each member by lot or by auction. Loans are also advanced to members from the fund if need arises. There is a novel project known as 'Gram Vikas Kosh' run by Seva Mandir, a Non Government Organization in Udaipur, Rajasthan. This is a project aimed at building corpus funds at the village level. It is also a platform, which a village can gather around and use for deliberation and action towards self-managed development. These are also projects aimed at building social capital within the communities, which will then lead to better coordination and enforcement of mutual insurance mechanisms. The role of outside agents to help build community social capital beyond local descent groups has been explored by the World Bank [1997], Durston [1999], and Abraham and Platteau [2001]. While there is no single solution, and the time dimension can be substantial, key elements of this undertaking include the rediscovery of ancestral norms of reciprocity in the community, the training of community members in basic principles of governance of local organizations, and the provision of new opportunities to derive short-term material benefits from the use of social capital.

4.6. Risk Pooling and Perfect Mutual Insurance

As discussed in section 2.1, a farmer's risk can be considered to consist of two components: a systemic or common risk that affects all members of the community and an individual or idiosyncratic risk that is particular to that farmer. Examples of the former are weather risks. Examples of the latter are local pest infestations and illness. The maximum insurance that can be achieved by risk pooling is to completely insure the idiosyncratic component of a farmer's income. This situation is known as perfect insurance. This makes sense because common shocks affect all members of the community and therefore risk pooling within the community is not capable of achieving insurance against the common systemic risks.

Note that perfect insurance does not imply that a farmer's income is completely stable. What it implies is that all fluctuations in a farmer's income is entirely because of the common systemic risks and not because of individual specific idiosyncratic risks. It follows that one can examine the existence and effectiveness of mutual insurance by looking at how the consumption of households varies with idiosyncratic shocks. If the risk pooling within the community is at its maximum, then the consumption of households within the community should be invariant to idiosyncratic shocks and move only with common systemic shocks. In practical terms, perfect insurance means while consumption of households will vary with common misfortunes such as drought (and also good fortunes), it will be invariant to individual misfortune. Thus, community risk pooling should lead individual consumption to be more closely related to aggregate village consumption than to individual income.

Researchers have used this idea to examine the extent of risk pooling within the ICRISAT villages. Townsend (1994) followed by Ravallion and Chaudhuri (1997) found that while a household's marginal propensity to consume out of household income is positive (and not zero as would be in a situation of perfect insurance) it was not large (0.14 in Townsend and between 0.12 and 0.46 in Ravallion and Chaudhuri). These results suggest that informal insurance exists, but it is not nearly perfect. By disaggregating villages by agricultural status Morduch (1994) finds that for large scale and medium scale farmers idiosyncratic shocks are better smoothed than for small-scale farmers and landless labourers. On investigating borrowing constraints, he finds that food consumption growth for the latter two groups is affected by idiosyncratic shocks, while such shocks do not affect larger scale farm households.

Among a growing number of empirical studies conducted on this question, ICRISAT villages do relatively well in exhibiting a great deal of consumption smoothing although the ability to smooth may vary significantly across households. Using a somewhat different test for insurance, Morduch (1995) found substantial evidence of consumption smoothing among relatively better-off farmers, but not so for small farmers and landless labourers. This study also made a point that insurance might look good simply because households try to smooth their income streams so that the remaining fluctuations can be absorbed by the available consumption smoothing mechanisms. Some households, for instance, may forego the cultivation of a crop with high expected return simply because the yield is more risky and cannot be smoothed through insurance. Thus the household chooses a 'safer' crop and its income fluctuations are therefore smaller and consequently easier to smooth. The crux of the matter being that there is a hidden cost, therefore, "for less well off households in the ICRISAT villages, production choices will be made with an eye to reducing the likelihood that the shock will happen in the first place."

Subsequent work with more elaborate models and alternative data have mainly rejected the full-risk sharing model. Inspired by Townsend's work, some researchers have turned to identifying constraints that keep the full risk sharing model form holding. There are mainly two such constraints - information asymmetries and enforcement problems. The newer work strengthens arguments for moving away from the village as the "natural" level at which to organize informal insurance. In recent work that draws inspiration from the ICRISAT studies, for example, Genicot and Ray (2003) show that due to imperfect enforceability of contracts, stable insurance groups at levels below or above the village level can exist even when village level arrangements break down. The arguments for this, hinge on the changing benefits of risk pooling under self enforcing insurance arrangements rather than exogenous costs to group formation. There are trade-offs between the benefits of pooling risks with people versus the tendency for larger groups to sub-divide into smaller coalitions; they show that the stability of coalitions is highly non-linear as their size changes. This has prompted research that looks beyond village level arrangements.

A recent work by Morduch (2002) examines whether failure of the village level tests belies substantial risk- sharing within families or within members of a village subgroup such as a caste group. This work considers tests for group where communal insurance seems more likely, relative to mutual insurance of the entire village. The theory described above implies that if complete village-level insurance exists, the finding should be replicated exactly when investigating the behaviour of any sub-group. Morduch's results by caste provide evidence that food consumption, but not total consumption, appeared to be well- insured for some castes, suggesting that the right model may be one where neighbours insure each other against dire events but are left to cope individually in the face of minor shocks. In Aurepalle and Kanzara (ICRISAT villages), the tests suggest that the highest ranked caste appear to be better "insured" than others. The castes classified as being of lower status show signs of weaker "insurance" systems.

As against previous studies, which have considered changes in consumption, Jacoby and Skoufias (1998) consider decisions about the enrollment of children in school. The basic question they pose is whether enrollment decisions respond to idiosyncratic income shocks? To get adequate variation, they consider seasonal data. Their innovation in this paper is to use seasonal data on rainfall to disaggregate shocks both as idiosyncratic vs. aggregate and as anticipated vs. unanticipated. Rainfall data being predictable provides a basis for distinguishing between credit market failure and insurance failure. Insurance failure is detected by seeing responses to idiosyncratic shocks, both anticipated and unanticipated, while self-insurance failure is detected by seeing responses to anticipated shocks, whether idiosyncratic or not. They reject both perfect insurance and perfect credit market, especially for smaller farmers. The main result of their work being that school enrollments respond to risk.

The consensus from all these empirical studies is that although there is mutual insurance within these communities the risk pooling is not perfect. Idiosyncratic shocks that affect household income do have a significant effect on the consumption of that household.

4.7. Conclusions

Rural households in India use a wide variety of instruments to smooth consumption some through market and some through informal mechanisms, as recent research indicate. The ICRISAT studies show that village level risk sharing is able to mitigate a large portion of idiosyncratic risk. Some idiosyncratic risk, however, remains and poorer households are considerably more vulnerable than richer households. Furthermore, what is disturbing is that risk pooling at the level of village seems weaker than by caste and kinship groups. Recent academic work on incomplete risk sharing has focused on the role of imperfect enforcement in explaining the lack of full risk sharing. Enforcement problems are key part of the economic environment in the ICRISAT study region, but they are insufficient to explain the patterns in the data. Most important, evidence of incomplete risk sharing may result as well from imperfect information, heterogeneity in desires and ability to save and borrow, specification error, costly contracting, and a host of other social factors. The decline of patron-client relationships, kinship and friendship relations and of common property resources all which are important elements of collective sustenance arrangements in village India suggests that traditional arrangements for mutual insurance are probably much weaker today than what obtained at the time of independence.

Table 4.1 Decline in Patron-Client Relationships in Rajasthan

Indicators	% of Households: 1963-66	% of Households, 1982-84.
Households with one or more members working as attached/semi-attached labour	37	7
Households residing on patron's land/yard	31	0
Households resorting to off-season borrowing of foodgrains from patrons	77	26
Households taking seed loans from patrons	34	9
Households marketing farm produce only through patrons	86	23
Households taking loans from others besides patrons	13	47

Source: Jodha (1985) reproduced in Agarwal (1990)

Chapter 5: Production Risks, Technological Change and Crop Insurance

5.1 Introduction

In this chapter, we consider how production risks have been transformed by developments in the agricultural economy in the post-independence period. In technology, the momentous events was the introduction of improved seeds in the mid-1960s that marked the "green revolution". Since then, agricultural growth in India has been sustained by technological change. As is well known, the crucial developments were in plant breeding. Since the 1960s, the Indian agricultural research system has released many improved varieties some of which have been widely adopted by farmers. The displacement of traditional varieties by improved varieties has changed production practices especially in terms of greater use of nutrients and pesticides. The impact of improved varieties on production risks has been controversial. At issue is the susceptibility of improved varieties, relative to traditional varieties, to moisture stress and pests. Improved varieties do well in assured rainfed or irrigated environments. As they are fertilizer responsive, vegetative growth is greater with improved varieties that in turn might encourage more pest attacks. Does that mean, however, that improved varieties are riskier than traditional varieties?

In terms of managing risks, the earlier chapters discussed private and community responses. In addition, there are government programs that could also assist farmers in coping with production risk. The second part of this chapter documents the efforts of government in helping farmers manage production risks.

5.2 Improved Varieties and Fertilizer Use

The use of improved varieties is associated with an expanded use of fertilizers. Indeed, the success of the semi-dwarf varieties of wheat and rice is because of their efficiency in converting added nutrients to grain matter in a way not possible with traditional varieties. This has led to suggestions that improved varieties might be riskier than traditional varieties because while they outperform traditional varieties under optimal applications of fertilizers (which in turn is contingent on conducive weather conditions and water availability), they perform worse than traditional varieties under conditions of low fertiliser use. In their comprehensive review, however, Lipton and Longhurst (1989) show that the evidence on fertiliser response does not justify any kind of simple association between the higher yields of improved varieties and higher risk.

From evidence on improved varieties in mostly Asia and including India, they point out that improved varieties often outperform traditional varieties even with zero fertilizer input. The examples are drawn from maize, wheat, rice, sorghum and ragi millet (pp 44-45). This does not mean, however, that farmers would adopt improved varieties when they cannot afford fertilizers. The yield advantage of improved varieties is proportionally greater at higher inputs and so the farmer's choice might very well be to either go with improved varieties with a concomitant use of fertilizers or to use traditional varieties with little or no use of fertilizers. In such a case, the profit or income risk associated with the improved variety might very well be too forbidding for a poor farmer to adopt it. However, in such instances, the non-adoption is due not to the higher risk of the modern variety but because of the absence of credit facilities which cannot support and cushion the risks of scaling up activity from a low-input subsistence to more input intensive cultivation.

Lipton and Longhurst, however, point to an ecological risk that might arise with the continual expansion and adoption of improved varieties. As improved varieties are typically more efficient in extracting soil nutrients than traditional varieties, fertilizers must be used to replenish the soil. As a result, over the long run, the new technologies might lead to greater dependence on fertilizers and thus on the fossil fuels (oil and natural gas) that constitute the feedstock for inorganic fertilizers.

5.3 Improved Varieties and Moisture Stress

Some studies have claimed that improved varieties perform worse than traditional varieties under conditions of water deficiency. If true, this would mean that improved varieties are riskier than traditional varieties in drought-prone areas. Lipton and Longhurst (1989), however, dispute the existence of any kind of a uncomplicated relationship between moisture stress and improved varieties in general. Indeed, the early improved varieties were less sensitive to moisture stress than traditional varieties because they matured earlier and thus were not dependent on late rains. Lipton and Longhurst quote studies that show that given total water availability, the early improved varieties are more sensitive to timing of water application than traditionally varieties. Among more recent varieties, Lipton and Longhurst cite the instance of CSH-I hybrid sorghum that by the late 1970s was successful in pushing up yields in dryland drought-prone parts of India.

Inspite of these successes, traditional varieties still dominate in areas without assured rainfall or irrigation. Lipton and Longhurst point out that moisture stress is itself a broad term and that the interaction between moisture stress and plant response is complicated and is not uniform between crops. As a result, under the current state of technology, improved varieties have been successful in coping with moisture stress in some instances but not all.

Improved varieties might have an indirect impact on a farmer's exposure to moisture stress because improved varieties of specific crops have in some instances become so successful that it has encouraged shifts towards crops that are sensitive to moisture stress. For instance, while the improved varieties of wheat in North India have outperformed traditional varieties even under moisture stress, they have induced poor farmers to shift to them at the cost of more robust but lower yielding non-wheat crops (Lipton and Longhurst, 1989).

5.4 Improved Varieties and Pests

Resistance and tolerance to pests is usually incorporated in improved varieties. However, breeding strategies can fail or overlook some pests and diseases that are important in farmer's fields. In such cases, breeding strategies are revised as scientists look for varieties that confer resistance. So it is not the case that improved varieties are less stable than traditional varieties in the face of a pest attack. IR-20 rice that replaced traditional varieties in South India and Bangladesh was more resistant to all major rice pests and diseases (prior to a rice disease BPH) and lasted for about 15 years in farmer's fields. Similarly, Sonalika, an improved wheat variety had a life span of almost twenty years as it withstood rust attacks well enough to be popular in North India and neighbouring countries (Lipton and Longhurst, 1989).

The continuous adaptation and evolution of pests means, however, that a successful pest resistance variety will have only a finite life. Indeed, if the target pest evolves into a new more virulent pathogen then it poses a greater risk to farmers.

Lipton and Longhurst summarises the paradox as follows. While the improved variety is almost always more stable in face of pest attack than its predecessor variety (either the traditional variety or older improved variety), the set of improved varieties will probably in the long run prove less stable in the face of pest attack than its predecessor set. The reason this happens is that the success of an improved variety leads all farmers to use it only. But that reduces the genetic range in farmers' fields and increases the likelihood of pest epidemics. A single wheat variety, Sonalika, did so well in South Asia partly because of its rust resistance – so that by 1983 its susceptibility to a new race of leaf rust was a serious issue.

These considerations apply equally to genetically engineered varieties that incorporate pest toxins. In 2002, the first approvals for genetically engineered plants were granted by the Indian government. Approvals were given for commercial sales of three hybrid cotton varieties containing the Bt gene. This gene, transferred from a soil bacteria, enables the plant to produce toxin against the American bollworm that is a serious cotton pest. Results from field trials indicate that pest losses are much smaller for Bt cotton and that planting Bt cotton is a more efficacious and cost-effective pest management strategy than spraying pesticides. In the long run, however, pest adaptation means that the pests will overcome the Bt strategy at some point. The evolution of pest adaptation depends on the extent to which Bt cotton replaces non-Bt cotton. For this reason, the use of Bt-cotton is contingent on the farmer planting some part of land (20%) to non-Bt cotton to provide refuge for the bollworm pests and to delay the evolution of Bt resistance.

5.5 Improved Varieties and Riskiness of Net Returns

In the earlier sections we discussed how improved varieties impact production risks. From the point of view of the farmer, however, what matters is the riskiness of net returns. How does that vary between improved and traditional technologies? This question has been addressed in the ICRISAT village studies (Walker and Ryan, 1990).

As net returns are random and vary according to the state of the world (pests, disease, weather) Walker and Ryan report the outcome of comparing the net returns from improved and traditional techniques for all states of the world captured within the 10 year sample period. Thus, the two techniques are compared for identical states of weather, pests and disease. These outcomes can be classified into the following groups:

1. Group 1: Here the net return from improved techniques is higher than the net return from traditional techniques in every state of the world. As a result, improved techniques are more profitable and less risky than traditional techniques. Such cases pose no barriers to adoption. The comparisons that met this test are:

(a) applying inorganic fertilizer to the cotton/pigeon pea intercrop in Kanzara during the rainy season Vs using no fertilizer

(b) improved fertilizer-responsive, irrigated paddy varieties sown in the rainy season in Aurepalle Vs local varieties.

(c) Inorganic fertilizer application to hybrid sorghum in Kanzara Vs no fertilizer

(d) cotton/mung bean intercrop in Kanzara compared to the traditional more extensive cotton pigeon pea/local sorghum intercropping system.

2. Group 2: Here the net return from traditional techniques is higher than the net return from improved techniques in every state of the world. In this case, farmer's present practices dominate recommended techniques. As a result, empirical instances that fit this case are hard to find because farmers would be irrational to adopt the improved techniques. As an example of this case, Walker and Ryan suggest applying inorganic fertilizer to post-rainy season sorghum in Sholapur Vs no fertilizer. With late planting date, crop yields are not responsive to fertilizers.

3. Group 3: Here the net return from traditional technology is much better than the net return from improved technology in poor growing conditions that are relatively frequent. Examples are

(a) Cash-intensive hybrid cotton in dryland conditions of Kanzara Vs local cotton

(b) hybrid sorghum in Aurepalle Vs traditional sorghum/pearl millet/pulse intercrop

4. Group 4: Here the net return from improved technology is higher than the net return from traditional technology in all states of the world except rare and extremely unfavourable conditions. In such cases, unless farmers are extremely risk averse, they would choose the improved technology. Examples are

(a) improved castor varieties Vs local varieties in Aurepalle.

(b) Planting improved paddy varieties with high fertilizer levels in post rainy season in Dokur or Aurepalle Vs local varieties at lower fertilizer levels.

5. Group 5: Net return from improved technology is higher in favourable states of the world and lower in unfavourable states of the world where both the favourable and unfavourable states occur with about the same probability. Here the choice of technology would depend on farmer's risk aversion. Examples are
(a) Castor Vs traditional cereal/pulse intercrop (Aurepalle)
(b) hybrid sorghum Vs local cotton intercropping systems (Kanzara)

These investigations are inconclusive about the effects of improved technologies on farmer risk. The results are contingent on particular crops, varieties and location.

5.6 The Evidence on Aggregate Instability

Researchers have found that aggregate foodgrains output as well as output of individual foodgrain crops has been more unstable during the period of improved varieties than in earlier periods (Mehra, 1981; Hazell, 1982, Ray, 1983). Such a comparison is contained in Table 5.1 where it can be seen that the only exception is wheat. The instability in aggregate foodgrains output varies by state (see Table 5.2). There is no readily understandable pattern in the variation of state-level instability. In particular, there is no unique relationship between the degree of instability and growth rate of output (Rao, Ray and Subbaro, 1988).

Rao, Ray and Subbarao find that foodgrains output in the post-green revolution period is more sensitive to rainfall than in the earlier period. Their findings for foodgrains output as well as its individual components is summarized in Table 5.3. Note that *rabi* output shows significantly lower variation than *kharif* output. This is attributable to the more water assured production environments in *rabi* because of irrigation. The same factor is reflected in the lower variation of wheat where much of it is grown under irrigated conditions.

The instability in crop output is the outcome of instability in area and in yields. Table 5.4 compares the variation in area and in yields across the pre-green revolution and green revolution periods. As can be seen, both area and yield have become more variable. The variation in area reflects instability in area allocation as farmers react to relative crop advantages whether manifest in prices or production conditions. Using methods similar to the decomposition of crop revenue risk into price and yield risk (section 2.3), Rao, Ray and Subbarao decompose the instability in crop output to variation in area, variation in yields and variation in the area-yield interaction term. Clearly if area and yield are positively correlated, that would magnify output fluctuations compared to the case when they are negatively correlated. The authors find that the relative contribution of correlated changes in area and yield has increased significantly in the post-green revolution period (Table 5.5).

Rao, Ray and Subbarao also point to shifts in cropping patterns towards crops sensitive to rainfall and a shift in crop output regions towards locations vulnerable to rainfall as explanations for the higher rise in aggregate instability. In the green revolution period, the share of rice in irrigated area recorded a significant decline from 45% in 1960-61 to 32% in 1983-84 while the share of wheat rose sharply from 15 to 38%. As for locational shifts, the authors find that the emergence of new centres of growth in the western states (Maharashtra, Gujarat, MP, Rajasthan) that are historically more variable and the correlation between the outputs of western states and northern region to be the major factors in higher instability.

The growing covariance between regions (presumably because of the dominance of similar improved varieties) as a factor in aggregate instability is also emphasized in Walker's (1984) district-wise which showed that 95% of the increase in all-India aggregate production variance for jowar and 92% of the increase for bajra is due to higher covariance among the producing districts. These proportions would be even higher at the farm level.

There are no direct implications of the rise in aggregate instability for farm-level production. First, as we have seen, much of the higher output variability is because of greater covariances among crops and regions. Second, in all analyses, instability is measured by coefficient of variation. However, coefficient of variation can increase even when the output in the worst-scenario rises. The latter is a more meaningful measure of extreme risks. Lipton and Longhurst (1989) point out that even though the coefficient of variation of jowar and bajra output in semi-arid parts of South India rose with the successful adoption of improved varieties, the worst-case output also rose. These factors suggest that aggregate instability is not illuminating about farm-level production risks. Indeed, it seems conceivable that the increase in aggregate instability in India has occurred inspite of a fall in farm-level instability. Nonetheless, the rise in aggregate instability is of concern from a policy perspective and deserves a comprehensive explanation.

5.7 Output Stability and Irrigation

As rainfall is a major source of production risk, irrigation has the potential of substantially reducing output variability. Based on an analysis by Dhawan (1988), Rao, Ray and Subbarao (1988) report the findings from an exercise that compares instability between irrigated and unirrigated farming for 11 major states (Table 5.6). For the group as a whole, irrigation has lowered the standard deviation in annual growth rates from 19 to 7.3% in the case of all crops; from 19.5% to 8.4% in the case of foodgrains output; from 14.5% to 5.9% in respect of overall crop yield and from 5 to 2.4% in respect of overall crop acreage.

Similar trends are observed for individual states except Bihar and Madhya Pradesh. The authors believe that because these are high rainfall states, the stability grains from irrigation are limited. The authors attribute the high gains in Punjab and Haryana to the extensive development of private tubewell irrigation in these states and the small gains in Tamil Nadu, Karnataka and Andhra Pradesh to the dependence in these states on tanks, which is highly sensitive to rainfall variations.

Irrigation also contributes to drought-proofing the agricultural economy. Table 5.7, also from Rao, Ray and Subbarao (1988), displays output reductions (from tend) in selected drought areas across irrigated and unirrigated areas. The table also compares between these areas, the elasticity of output with respect to rainfall. Measured either way, the table highlights the protective role of irrigation.

At a more disaggregated level, the risk reducing role of irrigation is contingent on the prevailing ecosystem. Otherwise, the promotion of irrigation could actually exacerbate the effects of drought. An instance of this is provided by Mehta's (2000) study of Kutch. Historically, Kutch is a drought-prone area. Rainfall is erratic and variable and droughts take place every 2-3 years. Before independence, the Kutch economy was predominantly dependent on livestock. As grass growth is possible with just 112mm of rain, livestock activity was possible when agriculture was hazardous. Kutch also sits on an aquifer and so groundwater was a valuable resource in times of water scarcity. With independence, the government promoted irrigation schemes and agriculture. These have put pressure on groundwater resources as a result of which the water tables have been falling. In Kutch, resource endowments are not conducive to intensive agriculture. Without the buffer of groundwater resources, irrigation cannot succeed in stabilizing production when rainfall is deficient.

5.8 Crop Insurance: Proposals and Pilot Schemes

In earlier chapters, we saw how farmers used various strategies to manage risks. Perhaps, the most direct strategy would be for farmers to obtain insurance against these risks such as in crop insurance that provides insurance against production risks. Crop insurance was considered by the central government as early in 1947-48. However, the state governments did not support the proposal on account of its expense. In 1965, the matter came up again and it met the same fate as on the earlier occasion. The government constituted an expert committee headed by Professor Dharam Narain, the then Chairman, Agricultural Price Commission in 1970, which did not recommend the introduction of crop insurance because it felt the resources could be more productively deployed in increasing agricultural productivity.

The official deliberations, however, threw light on the pros and cons of an `individual approach' versus an `area approach'. The former seeks to indemnify the farmer to the full extent of the losses and the premium to be paid by him is determined with reference to his own past yield and loss experience. The 'individual approach' basis necessitates reliable and accurate data of crop yields of individual farmers for a sufficiently long period, for fixation of premium on actuarially sound basis. In an area approach, farmers are compensated for losses according to an index of yield for a region to which they belong (e.g., village). The latter yield is called the area yield. The idea behind such insurance is that individual yields would be correlated with the area yield provided the area is reasonably homogenous. Further, area yield data is more easily obtainable than individual yield data and is not subject to moral hazard in the same way as individual yields. In an area approach, farmers within the same `homogenous area' pay the same rate of premium and receive the same benefits (as they are determined by the area yield relative to its average), irrespective of their individual fortunes.

A beginning in crop insurance was finally made in 1972 by implementing an experimental scheme for Hybrid-4 cotton in few districts of Gujarat State. This scheme was based on the 'individual approach' and a uniform guaranteed yield was offered to selected farmers. It continued till 1979 when it was concluded that crop insurance schemes based on individual approach are not feasible and economically unviable to implement on large scale. The major difficulty for implementing any scheme based on individual approach was to fix the guaranteed yield and the actuarially fair premium rate for each farmer for each crop and loss adjustment.

Against this background, a new study was commissioned from Professor V. M. Dandekar by GIC. Based on his recommendations, another pilot scheme but this time based on area insurance was introduced in 1979. Participation in the scheme was voluntary but was open only to farmers who had received short term crop loans from financial institutions. The scheme covered cereals, millets, oilseeds, cotton, potato and gram. The premium for small and marginal farmers were subsidised to the extent of 50%. The liabilities were shared between the GIC and the State government in the ratio of 2:1 while the premium subsidy was equally shared by the state and central governments. The pilot crop insurance scheme was implemented in 13 States till 1984-85 and covered 6.27 lakh farmers for a premium of Rs. 196.95 lakhs against claims of 157.05 lakhs.

5.9 Comprehensive Crop Insurance Scheme (CCIS)

The pilot crop insurance scheme was replaced by a Comprehensive Crop Insurance Scheme (CCIS), which was introduced from April, 1985 by the Government of India with active participation of the State Governments. The CCIS largely replicated the principal features of the pilot scheme but on a wider scale. The difference was that CCIS was now mandatory for all farmers (growing the specified crops of cereals, millets and oilseeds). Further, the premiums and claims were now split in the same ratio of 2:1 between the central and state governments. The premium rates were fixed at 2% for Cereals and Millets and 1% for Pulses and Oilseeds and the 50% premium subsidy continued.

The Scheme was implemented by 19 States and 3 Union Territories (Andhra Pradesh, Assam, Bihar, Goa, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Orissa, Rajasthan, Tamil Nadu, Tripura, Uttar Pradesh, West Bengal, Andaman & Nicobar Islands, Delhi and

Pondicherry. Table 5.7 summarizes the coverage under this scheme until kharif 1999. Majority of the claims were paid in the states of Gujarat - Rs. 1086 Crores (47%), Andhra Pradesh - Rs. 482 crores (21%), Maharashtra - Rs. 213 crores (9%) and Orissa - Rs. 181 crores (8%). Among causes, drought was the chief cause, accounting for nearly 75% of claims, followed by floods with 20%.

The CCIS suffered from various problems. Firstly, the scheme was voluntary leaving it to the option of the state governments to identify the crops and areas in which the scheme would operate. This resulted in adverse selection of areas/states. States like Punjab, Haryana and areas of Western Uttar Pradesh did not show any interest. Some states that participated initially, left the scheme in due course of time. Thus, there was absence, of the basic canon of insurance business i.e., principle of cross subsidization with premia income from areas of stable crops paying for the areas having unstable crops in the scheme. Secondly, there was no uniformity in the basic unit area of insurance (district, taluka, block etc.) for determining the threshold yield and assessment of actual yield in the calamity affected areas. In a large unit areas (i.e. block, taluka or district) incidence of calamity is rarely uniform all over the unit area. As a result, the relation of individual crop loss to insurance compensation becomes weak and therefore does not serve the purpose of reducing farm risk. The success of area approach crop insurance depends upon the homogeneity of the unit area of insurance, which was not observed in all cases. Thirdlly, the scheme was non-viable. As against the premium income of Rs. 402.83 crore, indemnities amounting to Rs. 2302.68 crore were paid during the period of 14 years of operation of CCIS resulting in a premia to claim ratio of 1 : 5.72. This was because of unrealistically low premium rates in relation to the high incidence of natural calamities. Fourthly, the scheme did not include many crops and many farmers. The scheme was dominated by rainfed crops like oilseeds, millets and pulses and excluded cash crops. Fifthly, the scheme was limited in its coverage of farmers as it included only farmers who take loans from financial institutions. Lastly, the information base remained weak. In particular, deficiencies in the system of crop cutting experiments were observed as a result of which the determination of area yield was not adequately supervised and monitored.

5.10 National Agricultural Insurance Scheme (NAIS)

A new crop insurance scheme titled National Agricultural Insurance Scheme (NAIS) was introduced in the country w.e.f. Rabi 1999-2000. The NAIS modifies the CCIS in some crucial respects. First, it provides for greater coverage in terms of farmers as non-borrwowing farmers are allowed to purchase insurance. Second, it provides greater coverage in terms of crops as well. Insurance is now extended to commercial and horticultural crops. At present, sugarcane, potato, cotton, onion, chilies, turmeric, ginger, jute, tapioca, annual banana are covered. Thirdly, it permits greater converge of the risk itself because it allows for a higher amount of maximum insurance. Fourthly, the implementing state is required to reduce the unit area of insurance to the Gram Panchayat. These four reforms are aimed to make crop insurance relevant for more farmers and in more circumstances. Fifthly, to ensure financial viability, premiums are to be based on actuarial considerations and the small farmer subsidy is to be gradually phased out in 5 years. Finally, to distribute the financial burden equitably, the financing of claims and premiums is to be equally divided between the central and state governments. Table 5.9, from Parchure (2003), displays and compares the principal features of the NAIS with that of the CCIS.

The NAIS, at present, is implemented by 19 States and 2 Union Territories. Details of farmers, area covered, sum insured and insurance charges under NAIS during first five crop seasons (i.e. from Rabi 1999-2000 to kharif 2002) are summarized in Table 5.10. The ratio between premium to claims works out to 1 : 4.8. Even excluding the drought year of 2002, the premiums to claim ratio is well above 1 at 3.4. In terms of cost, the NAIS (on the basis of performance of five crop seasons) is better placed as compared to CCIS in terms of viability. Under NAIS also, the maximum amount of indemnity claims (about 53%) have gone to State of Gujarat followed by Maharashtra, Andhra Pradesh, Madhya Pradesh and Orissa. Among the perils, drought has remained consistently the main cause for crop-loss. About 770 crore of indemnities received by Gujarat alone in kharif 2000, are on account of drought. Crop-wise analysis of claims paid shows that highest amount of claims have gone to groundnut crop (45%) followed by (14%).

While the NAIS is an improvement over the CCIS in terms of coverage and financial viability, concerns remain on both counts. While the NAIS covers food, oilseeds and annual commercial/horticultural crops, perennial crops such as apple, coconut, orange, mango etc. are not covered. Some states like Himachal Pradesh, J & K, Andhra Pradesh, Maharashtra where these crops are important wish that these crops be covered as well. But reliable yield data of perennial crops is hard to obtain. Regarding financial viability, there are still large gaps between the existing premium rates and actuarial rates. A case in point is groundnut in Gujarat where the actuarial rate for groundnut works out to more than 25% when the premium charged is 3.5% only.

There are also concerns with respect to the administrative complexity of administering this scheme. While the implementing states are required to educe the insurance unit to the level of Gram Panchayat (GP) in a period of three years, resources to conduct the requisite number of crop cutting experiments per unit area of insurance are not forthcoming. Another issue is the use of short time series in calculating yield guarantees. Currently, guaranteed yield is calculated on the basis of a moving average of 3 to 5 years. As a result, in areas, prone to regular calamities, guaranteed yield comes down drastically after a drought. This has led to arguments that yield data of longer duration need to be considered for the calculation of guaranteed/threshold yield. Similarly, for many insurable crops, level of indemnity comes down to 60% due to repeated calamities in the past. Some crops have reached a stage where only a major calamity would entitle claims due to the very low level of guaranteed yields at 60% indemnity level.

5.11 Impact of Crop Insurance on Farmers

The NAIS covers about 12% of farmers and about 10% of area. So at present, crop insurance is not a risk management tool for most farmers. Yet, even at the current levels of coverage, the government has lost more than Rs. 3000 crores in the two and half years (and six seasons) since the NAIS was launched in Rabi, 1999. As the kharif season accounts for the bulk of crop insurance, most of the losses have incurred in kharif. Of the 3 kharif seasons (2000, 2001, 2002) for which the NAIS has been in operation, indemnities paid out were smallest in 2001. But even in this year, the claims were twice the premium income. Expanding the coverage of crop insurance would therefore increase government costs considerably. Unless the programme is restructured carefully to make it viable, the prospects of its future expansion to include and impact more farmers is remote.

On the demand side, most of the farmers who take up crop insurance are the loanee farmers even though participation in the NAIS is now open to all farmers. This suggests that non-loanee farmers are either not aware of crop insurance or do not reckon the benefits of crop insurance to be great enough to justify their participation. As Dandekar (1976) pointed out, the benefits of area insurance is the greatest when the yields of all farmers in the area responds similarly to production risks. This in turn depends on whether the area that has been selected correctly reflects homogenous growing conditions. Walker, Singh and Asokan (1986) note that this condition is most likely to be satisfied in dryland farming where most farmers face the same dominant risk of inadequate rainfall. However, they also contend that such conditions also lead to area variability as farmers decide on sowing and cropping patterns after initial information on rainfall. Through simulations the authors show that area insurance does not reduce producer risk significantly and area variability is the major reason why insurance does not succeed. They are therefore pessimistic about the value of area crop insurance in dryland farming even though the potential for risk reduction benefits is enormous.

This conclusion of Walker, Singh and Asokan can, however, be challenged because their simulations assume farmers are restricted to buying insurance proportional to their sown area. This together with their assumption of a low level of coverage (upto 75% of normal yield) explain the modest impact of crop insurance in their analysis. In his pioneering analysis, Dandekar (1976) pointed out that with area insurance it is unnecessary to restrict the amounts of insurance either in terms of area sown or in terms of benchmark yields. Instead, as long as premiums are actuarially fair, they should be freely chosen by the farmer (or indeed by anybody including nonfarmers since it is not necessary to grow the crop to buy area insurance).[21] In practical terms, however, as premiums are nowhere close to covering their actuarial cost, it is necessary to restrict the amount of insurance – whether by tying to area sown or by reducing coverage. In such cases, the risk benefits from area insurance will be small as predicted by Walker, Singh and Asokan. However, a definitive analysis is still awaited because there has been no systematic study yet of the impact of crop insurance on farmer's welfare.

5.12 Suicides by Farmers

In recent years, suicides by farmers have come to public attention. Failure of technology and fall in prices have been blamed in the media for the suicides. Although the act of suicide is an intensely personal decision that is not always explicable on the basis of known facts and circumstances, it is still important to know whether it was farming risks that drove some growers to this extreme act. As Deshpande (2002) notes, the causes of distress are many such as crop loss, (because of drought, poor quality of inputs, or pests and diseases) and revenue loss because of crash in market prices. Deshpande also notes that traditional institutional arrangements for coping with risk have declined leaving farmers to face risks on their own.

In an analysis of farmers' suicides in Karnataka, Deshpande found that about a quarter were due to family discord and not directly attributable to agriculture. About 17% of the cases were associated with crop failure while another 6% of cases were associated with high debt and commodity price crashes. In terms of cropping pattern, the author found that the farmers who committed suicides were more market oriented in terms of choice of crops than the "control" group that was chosen from the same village and with social and economic characteristics similar to the suicide victim. Cash crops are subject to greater price variability. Also as they are intensive in purchased inputs, their net returns also tend to be riskier than for food crops. The absence of credit forces farmers to depend on input dealers for credit. However, this also ties the farmer to poor quality inputs supplied by the input dealer. Deshpande found that the suicide victims were more dependent on moneylenders than the control group indicating their relative access to formal credit. The failure of extension system to advise farmers about new technology and their use, limited access to formal credit, low quality of pesticides and other inputs and crash in market prices are some of the risk factors that are highlighted in Deshpande's analysis.

5.13 Conclusions

This chapter has reviewed the principal developments in the agricultural economy that have affected agricultural production risks. In the farmer's fields, the most important change has been in the spread and adoption of technologies and inputs associated with improved varieties. There is little conclusive evidence to suggest that these have increased the riskiness of production. On the other hand, if neglected, the adoption of these technologies carry some long-term risks in terms of soil depletion and genetic uniformity. On the policy front, the government addresses production risks through crop insurance programs. While recent policy changes have enhanced the relevance of crop insurance as a risk management device, the program is still small in relation to its potential. Further, the program is not yet on a sound actuarial footing and requires considerable government subsidies. This factor may well hamper its rapid expansion in the future. In view of the resources committed to crop insurance, it is important to have research studies that would examine the effectiveness of crop insurance in managing risks for the farmer.

Table 5.1. Instability in crop production, all India

(Standard deviation in annual output)

Crop & crop groups	1950-65	1966-85	1968-85
Rice	9.99	13.92	14.27
Wheat	11.52	11.15	11.44
Course Cereals	8.01	13.20	13.35
Cereals	7.83	10.81	11.10
Pulses	12.00	16.26	16.07
Kharif food grains	-	-	13.88
Rabi food grains	-	-	9.83
Total food grains	8.10	11.14	11.43
Oilseeds	9.30	16.92	17.36
All crops	6.27	9.19	9.40

Source: Rao, Ray and Subbarao (1988)

Table 5.2. State wise instability in food grains production

(Standard deviation in annual food grains production growth rates)

State	1961-70	1971-85	1961-85
Andhra Pradesh	14.8	13.6	14.0
Assam	10.5	11.3	11.0
Bihar	31.3	17.0	23.4
Gujarat	25.1	35.7	32.2
Haryana	25.6	15.0	19.7
Himachal Pradesh	16.7	11.8	14.3
Jammu Kashmir	18.0	10.0	14.2
Karnataka	12.2	22.4	19.3
Kerala	10.2	4.9	7.4
Madhya Pradesh	21.7	21.6	21.6
Maharashtra	16.4	27.4	23.9
Orissa	14.5	26.0	22.8
Punjab	13.4	4.5	9.1
Rajastan	28.8	29.6	29.4
Tamil Nadu	8.6	24.2	19.2
Uttar Pradesh	15.9	15.8	15.8
West Bengal	11.6	16.8	15.1

Source: Rao, Ray and Subbarao (1988)

Table 5.3. Sensitivity of output to rainfall variations

Crop & crop groups	Percentage deviation in output due to 1% deviation in rainfall from its normal level		
	1950-65	1966-85	1968-85
Rice	0.4657	0.6650	0.6437
Wheat	0.0980	0.1613	0.0279
Course Cereals	0.0407	0.5746	0.5907
Cereals	0.1747	0.5256	0.4431
Pulses	0.2350	0.5172	0.6093
Kharif food grains	-	-	0.7613
Rabi food grains	-	-	0.1130
Total food grains	0.1939	0.5240	0.4643
Oilseeds	0.1912	0.3910	0.3539
All crops	0.1651	0.4052	0.3794

Source: Rao, Ray and Subbarao (1988)

Table 5.4. Stability in cropped areas & yields in pre and post green revolution periods

(standard deviation in annual growth rates)

Crops & crop groups	Area			Yield		
	1950-65	1966-85	1968-85	1950-65	1966-85	1968-85
Rice	1.92	3.10	3.17	9.42	11.36	11.66
Wheat	6.05	5.27	5.41	9.80	7.52	7.70
Course Cereals	3.39	4.01	4.08	5.92	9.98	10.09
Cereals	2.13	2.99	3.07	6.21	8.37	8.60
Pulses	4.64	5.33	5.43	10.85	13.40	13.20
Kharif food grains	-	-	3.70	-	-	10.73
Rabi food grains	-	-	3.94	-	-	7.58
Total food grains	2.43	3.25	3.33	6.37	8.56	8.78
Oilseeds	4.79	4.93	5.04	9.01	13.16	13.51
All crops	1.85	3.19	3.28	5.34	6.54	6.68

Source: Rao, Ray and Subbarao (1988)

Table 5.5. Decomposition of instability in annual crop output growth rates during the pre & post-green revolution periods, all India

Crops & crop groups	1950-65 Percent of variation in output growth rate (g.r) due to			1966-85 Percent of variation in output growth rate (g.r) due to		
	Var. in area g.r	Var. in yield g.r.	Correlated changes in area & yield g.r.	Var. in area g.r	Var. in yield g.r.	Correlated changes in area & yield g.r.
Rice	3.70	88.80	7.50	4.97	66.59	28.44
Wheat	27.56	72.38	0.06	22.40	44.58	32.02
Course Cereals	17.90	54.56	27.54	9.20	57.19	33.61
Cereals	7.37	62.84	29.79	7.63	60.02	32.35
Pulses	14.98	81.75	3.27	10.74	67.91	21.35
Total food grains	9.03	61.87	29.10	8.49	59.01	32.50
Oilseeds	26.49	93.88	-20.37	8.50	60.50	31.00
All crops	8.70	72,50	18.80	12.08	50.60	37.32

Source: Rao, Ray and Subbarao (1988)

Table 5.6 Instability in irrigated & unirrigated farming (1971 to 1984)
(Standard deviation in annual growth rates)

State	Irrigated food grains			Unirrigated food grains			Irrigated segment**			Unirrigated segment**		
	Area	Yield	Output	Area	Yield	Output	Area	Yield	Output	Area	Yield	Output
Andhra Pradesh	8.7	9.2	14.9	5.8	13.2	16.1	8.6	8.4	13.6	5.5	16.4	18.8
Bihar	5.9	18.5	22.6	6.2	14.4	19.4	5.8	18.0	22.0	6.0	13.9	17.9
Gujarat	12.2	18.0	28.1	15.1	41.3	60.8	10.4	18.0	23.8	10.9	67.3	86.3
Haryana	3.1	9.9	10.7	18.1	43.81	59.0	2.2	9.2	9.3	18.0	38.5	54.8
Karnataka	12.2	20.8	27.5	10.7	8.9	29.7	11.3	11.7	16.7	10.6	20.7	31.4
Madhya Pradesh	7.4	21.4	26.5	2.5	23.0	23.3	6.7	20.01	24.5	3.1	22.5	23.0
Maharashtra	11.2	29.6	41.6	10.9	26.9	43.5	10.8	11.9	17.9	9.8	28.8	43.8
Punjab	2.6	4.5	5.4	14.1	13.0	18.2	1.7	4.2	4.9	13.6	12.1	19.3
Rajasthan	10.6	9.4	11.4	10.8	42.8	50.7	10.2	9.4	11.3	10.5	39.7	46.9
Tamil Nadu	15.2	12.7	26.1	14.5	27.1	41.1	14.0	8.8	19.2	13.4	26.6	41.6
Uttar Pradesh	3.2	13.1	14.4	3.8	37.1	41.0	2.4	10.6	12.0	3.5	36.5	40.0
Average*	2.4	6.7	8.4	5.3	14.9	19.5	2.4	5.9	7.3	5.0	14.5	19.0

* Based on aggregate data of the eleven states
** pertains to all crops, food grains & non-food grains

Source: Rao, Ray and Subbarao (1988)

Table 5.7. Percent reduction in output in selected drought areas

Drought year					Elasticity with respect to rain fall			
	Total output		Food grains	Output	Total output		Food grains	Output
	IRR	UIRR	IRR	UIRR	IRR	UIRR	IRR	UIRR
1972-73 (27)	7	20	8	18	0.3	0.7	0.3	0.7
1974-75 (19)	7	13	10	14	0.4	0.7	0.5	0.7
1979-80 (18)	10	20	6	22	0.6	1.1	0.3	1.2

Note (1) figures in parentheses indicate percent deficiency in normal rainfall;
(2) IRR: Irrigated; UIRR: Unirrigated
(3) These estimates are based on the combined position of the eleven states listed in table 5.6

Source: Rao, Ray and Subbarao (1988)

Table 5.8: Coverage under the Comprehensive Crop Area Insurance Scheme: 1985-86 to 1999

Total number of farmers covered	7,61,79,361
Total area covered (Hectares)	12,75,13,668
Total Sum Insured (Rs. Crores)	24922
Total Insurance Charges (Rs. Crores)	403
Total claim (Rs. Crores)	2303
Claims ratio	1:5.72

Table 5.9: Major Features of the National Agricultural Insurance Scheme (NAIS) Compared to the Comprehensive Crop Insurance Scheme (CCIS)

Features	CCIS	NAIS
Farmers Covered	Loanee Farmers	All Farmers
Premium	2% for cereals & millets and 1% for Pulses and Oilseeds	(a) Food Crops & Oilseeds Kharif: Bajra & Oilseeds: 3.5% or actuarial rate whichever is lower. Rabi: Wheat: 1.5% of actuarial rate whichever is lower Other Crops: 2% or actuarial rate whichever is lower. (b) annual commercial/horticultural crops: actuarial rates
Premium subsidy	50% subsidy for small and marginal farmers	50% in the first year, but to be phased out in five years
Limit of sum insured	Rs. 10,000 per annum	Upto the value of 150% of average yield. However, sum insured exceeding value of threshold yield shall attract premium at actuarial rate
Sharing of Risk	2:1 by Central and State Government	Food Crops & Oilseeds: Until complete transition is made to actuarial regime in a period of five years, all claims beyond 100% of premium shall be borne by the GOI and States on 50:50 basis. Thereafter, all claims upto 150% of premium for a period of three years and 200% of premium for an extended period of additional three years, thereafter shall be met by insurance authority. Claims beyond the limits of insurance authority shall be paid out of Corpus fund for a period of three years.

		Annual commercial/horticultural crops: Insurance authority shall bear claims upto 150% of premium in the first three years and 200% of premium thereafter subject to satisfactory claims experience, The claims beyond the limits of Insurance Authority shall be paid out of Corpus Fund.
Participation by Farmers	Compulsory for Loanee Farmers	Compulsory for Loanee farmers and Optional for non-loanee
Participation by States	Voluntary	Available to all States/UTs
Approach by the Scheme	Area approach	Area approach. However, in case of localized calamities, individual assessment will be experimented in limited areas.
Administrative Expenses	The GOI reimburses 50% of expenses to GIC	The GOI/States reimburses 100% expenses in the first year, which will be reduced on sun-set basis. From 6th year onwards, all expenses shall be borne by the implementing agency.

Source: Parchure (2003)

Table 5.10: Coverage, claims and premia under the National Agricultural Insurance Scheme

Season	Farmers Covered (in lakhs)	Area Covered (in lakh ha.)	Sum Insured (Rs. crores)	Insurance Charges (Rs. crore)	Total Claims (Rs. crore)
Rabi 1999-2000	6	7.8	356	5	8
Kharif 2000	84	132	6903	207	1222
Rabi 2000-01	21	31	1603	28	59
Kharif 2001	86	128	7300	257	470
Rabi 2001-02	21	32	1698	35	64
Kharif 2002	97	155	9425	327	1876
Total	315	487	27286	859	4128

Chapter 6: Market Risks, Government Interventions and Futures Markets

6.1 Introduction

In this chapter, we review the principal developments that have impacted on market risks. Government policy has played a big role in moderating price risks. So the major part of this chapter concerns market interventions. There are also private mechanisms that can potentially help farmers to cope with private risks. In recent years, contract farming has become popular in certain cash and specialty crops. A much older institution is the futures market that can provide insurance against price volatility.

6.2 Price support programs

In India, the origins of government intervention lie in the second world war when the government used its powers to promulgate orders on price control, movement and requisition of foodgrains. In 1942, the Department of Food was established to administer these policies. The principal issue was on the best means by which government should procure foodgrains. The British government instituted a foodgrain policy committee to consider the question whether the government should purchase grain from the market in competition with private traders or whether it should have a monopoly of grain trade and obtain the supplies it needs? The committee rejected either of these extremes and instead opted for a dual market consisting of a procurement machinery, fixation of procurement and levy price and a retail network of ration shops. These elements of the foodgrain economy have survived till today. A comprehensive history of government interventions in agricultural markets in India is beyond the scope of this study and the reader is referred to Chopra (1986). Here in this section, we draw on the elements relevant to our purpose.

The initial intervention was motivated by the necessity to procure and supply foodgrains to the cities in times of overall shortage. As shortages persisted after independence, the second world war interventions were continued. However, till the mid 1960s, relative to commercial imports and food aid, domestic procurement was neither an important or reliable source of supply to the public distribution system. Thus, the principal effect on domestic producers was a fall in output price because of foreign supplies. For the same reason, output price variability was also bounded.

In 1965, the government formed the Food Corporation of India, which became the principal central agency responsible for purchase and storage of foodgrains. The other important event was the formation of the Agricultural Prices Commission to advise on price policies for wheat, rice, jowar, bajra, maize, gram and other pulses, sugarcane, oilseeds, cotton and jute. One of the objectives of the commission was the need to provide incentives to producers for technology adoption and maximise production. To protect farmers from downside risk that comes about because of a fall in price, a distinction was made between procurement price and support price. The procurement price is the price at which the government purchases grain. As procurement is discretionary, not all farmers might receive the procurement price. The support price is a floor price below which the market price is not allowed to fall. This is made operational by the commitment of the government to purchase at the support price any amount of grain that is offered to it. Table 6.1 displays the crops for which minimum support price is fixed by the Commission on Agricultural Costs and Prices or CACP (which was earlier called the Agricultural Prices Commission).[22] While FCI is the nodal agency for procuring cereals, the National Agricultural Cooperative Marketing Federation (NAFED) is similarly designed for oilseeds and pulses.

The price support system considerably reduced the market risks of foodgrains producers especially by reducing the phenomenon of distress sales. Through procurement, storage and public distribution, government operations can augment supplies in times of shortfall (and thus reduce price) or subtract supplies in times of abundance (and thus increase price). While there is no study that has quantified the reduction of market risks because of price supports, Ramaswami (2002) provides some evidence on the success of these policies in the case of foodgrains. He finds that during the 20 years between 1972/73 and 1991/92, the government augmented supplies (because procurement was less than public distribution sales) in 9 years while it subtracted supplies (by procuring more than public distribution sales) in the remainder 11 years. As a result the average annual change in stock (which is the difference between procurement and public distribution sales) was negligible amounting to 0.43 million tonnes. Ramaswami argues that in a successful stabilization scheme, the average annual change in stocks is, over a long enough period, close to zero. Thus, the

1972/73 – 1991/92 experience with price supports corresponds well to stabilization and risk reduction.

These trends have not continued as since 1991/92, the government has subtracted supplies in every year. As a result in the 8 years from 1992/93 to 1999/00, the average annual change in stock was 7 million tonnes. This indicates that price supports in this decade have not been merely stabilizing – but rather that they have consistently increased producer prices. This has had a favourable effect on market risk for producers. However, foodgrain producers face a long-term policy risk. A policy that leads to stock accumulation every year is not financially sustainable. When it breaks down, the stocks will come to the market and prices will crash.

For crops other than rice and wheat, there are few studies that systematically evaluate the effect of support prices on market risks. Mundinamani and Mahajanashetti (2001) consider the impact of the market intervention of the Karnataka Co-operative Oilseeds Growers' Federation (KOF) in Karnataka's groundnut markets in Gadag, Bijapur, Hubli, Raichur, Challakere, Chitradurga and Davanagere. The study period was bifurcated into the pre-market intervention period (1985-85 to 1989-90) and market intervention period (1990-91 to 1994-95). As a measure of price variability, they use the range of the observed price (i.e., the difference between the observed maximum and minimum price) during each of the sub-periods. This information is presented in Table 6.2 according to peak season, lean season and the overall period. By this measure of variability, the table shows an unambiguous decline in price variability during the market intervention period. The table also shows that the market intervention was more successful in stabilizing prices during the peak season because that was the period in which the KOF was active. While the study throws light on the reduction in annual price variability, it unfortunately does not throw light on the extent to which the market intervention stabilized prices. Furthermore, the study does not relate the price stabilization to its cost (incurred presumably in holding stocks across years).

In the case of coarse cereals, price support programs have not been extensive and procurement has been falling (CACP, 2001). The limited shelf-life of coarse cereals has discouraged price support operations although price supports could still be feasible at a local/regional level. As regards non-cereals, there was no procurement of barley, gram or pulses in kharif 1999/2000 because market prices were higher than the MSP

(CACP, 2001). This does not necessarily indicate that price support was inadequate. Indeed, if the MSP is to function like a floor price then it should be operative only in times of excess production and not in every year.

For 1999/2000, the CACP reports instances of commodities and markets where market prices were less than the MSP. In these cases, the MSP has clearly been ineffective. One reason for this is the limited presence of procuring agencies that often station themselves only in the major markets. But sometimes, even in the major markets, price support operations are so limited that they fail to prop up the market price to the level of the MSP. This for instance, was the case with soyabeans in 2000, when the MSP was higher than the market price in all the major producing states – Madhya Pradesh, Rajasthan, Maharashtra, AP, Karnataka and UP (CACP, 2001). Similar was the case with sunflower seed in Madhya Pradesh, Karnataka and Maharashtra. The same problem, but for different reasons, was also seen with paddy in the eastern region. As the governments in that region procure rice by the levy system, they have little incentive to support paddy prices although they matter more to the farmer (CACP, 2001). Another way in which price support turns out to be ineffective is when the MSP is announced well after sowing. The CACP report of 2001 documents instances of this for the rabi and kharif crops of 2000. When this happen, the MSP cannot have an effect on production decisions of farmers.

The opposite problem: i.e., a market intervention that is more effective than desired is also seen in India. This happens when the support price is fixed so high that the procuring agencies procure more supplies than they can sell (without severe discounting). We have already seen an instance of this with foodgrains.[23] Among non-foodgrains, the problem is most severe with cotton. In 1999/00, the Maharashtra Cotton Growers Cooperative Marketing Federation (MCGCMF) offered producers in Maharashtra a price even higher than the central MSP. As a result, the MCGCMF procured 32 lakh bales of cotton, sold only 7 lakh bales and accumulated the remainder as stock. As the losses of such policies are not sustainable indefinitely, cotton growers face a policy risk as policy will have to find some way of getting rid of these stocks.

6.3 Contract Farming

In some cash crops especially vegetables, processors contract with growers to obtain supplies. In most cases, the grower supplies tools, land, labour and management while the processor supplies the grower with seed, other inputs such as pesticides and extension service. Usually, the contract specifies that the processor would buy all the produce at a pre-determined price.

From the point of view of the processor, this arrangement ensures raw material supplies (subject to production uncertainty). From the point of view of the grower, such an arrangement provides an assured market and hence reliable income (again subject to production risks). Cash crops such as vegetables are intensive in purchased inputs and subject to significant market risks. Indeed, for some of the vegetables grown on contract there might not be even an assured local market (such as gherkins) as would happen when they are grown for an export market. Without a contract, therefore, few growers would cultivate these crops with substantial market risks.

Contracting therefore provides a way in which producers transfer market risks to processors. In return, the processors receive assured supplies at a cost that might be lower than if they organized production themselves.[24] In this exchange, both parties can in principle be better off. However, whether this actually happens is an empirical issue. Sukhpal Singh (2000) investigated contract farming in Punjab where growers contracted to grow tomatoes, chilies and potatoes with processors. He found that farmers perceived the main benefits of contracting as better and reliable income, new and better farming skills, and better soil management.[25]

Dileep, Grover and Rai (2002) compared the returns from contract farming in tomato in Sirsa district of Haryana with that of non-contract tomato growers. They found that while the total cultivation cost of contract growers was 30% higher than that of non-contract growers (because of higher cost of variable inputs), their gross returns were nearly double that of non-contract growers on account of substantially higher yields. Net returns (over total cultivation cost plus transport cost) of contract farmers were 62% higher than that of non-contract farmers. The gain to contract farmers would have been much higher but for the stiff transportation charges imposed by processors. The contract farmers faced zero price uncertainty while the coefficient of variation for prices received by noncontract farmers ranged from 6% to 27%. Production risks were also lower for contract farmers. The authors attribute this to the better quality of seedlings supplied by the processor.

6.4 Futures Markets

Forward contracts where a seller (or buyer) agrees to deliver (or accept) a commodity in the future at an agreed price is a way for commodity market participants to do away with price uncertainty. However, there are other risks in forward contracts. One of the parties might default at the time when the transaction is to be realized. Further, the forward contract is not easily tradable which the seller or buyer might desire if their circumstances change. Neither of these risks are present in futures contracts traded on futures markets. The clearing house in the futures market guarantees the contract and as the contracts are freely traded in the market, the market participants can exit from the contract at any point. There is, however, a basis risk that arises whenever the relationship of the futures price to the spot price changes. It is generally the case, however, that the basis (the difference between the current spot and futures price) is much more predictable than the spot commodity price. So futures trading involves the exchange of commodity price risk for a much smaller basis risk.

Even in countries with well developed futures markets, very few producers directly participate in futures trading. There are transactions costs of using this market and few producers have the trading skills to know when they should lock or lift a hedge. As a result, futures markets are usually used by commodity merchants and processors. For producers, the major gain from futures markets is that it provides a forecast of the future spot price. Indeed, often the futures price is used to form the price in a forward contract between a producer and the local grain elevator (storage agent).

In India, futures trading is regulated by the Forward Contracts (Regulation) or FC (R) Act of 1952 . Any forward contract of duration more than 11 days falls within the purview of futures regulation. Within this class, the FC(R) Act distinguishes between forward and futures contracts. Forward contracts are further divided into transferable and nontransferable contracts. The FC(R) Act prohibits futures trading as well as forward contracts in all major cereals and pulses. Table 6.3 lists the commodities (and exchanges) in which futures trading is active. Recently, the government has permitted futures trading in sugar and some oilseeds like sesame seed and safflower seed. K. G.

Sahadevan (2002) and Naik and Jain (2002) provide a recent account of the history of futures markets and the evolution of government policy.

According to Naik and Jain (2002), liquidity is a major problem in all futures markets except those of castor seed and pepper. The lack of interest in futures trading has been ascribed to excessive government regulation and the functioning of exchanges (Sahadevan, 2002). To gauge the effectiveness of futures markets in providing price insurance, Naik and Jain compared the basis risk with the spot price risk. As discussed earlier, the basis risk should be less than the spot price risk if futures contracting is to be used as a risk management tool. Naik and Jain found that except in the castor and pepper market, the basis risk was very high in the other markets. For instance, in the December futures *gur* contract traded in Hapur, the basis risk was greater than spot price risk for most of the months of the sample period (1989-97) in which the contract was traded. The authors also find that, except for the Mumbai castor seed market, futures markets in India are not efficient in price discovery either. At the moment, therefore, futures contracting is not a useful risk management tool for producers.

6.5 Conclusions

Price supports have been the principal means by which Indian farmers have received some protection against market risks. The price support policy has its limitations as well. Firstly, for crops other than rice and wheat, price support programmes have been limited or non-existent. Secondly, for the principal crops that are supported, it has been difficult to balance consumer and producer interests. In some of these crops, the support prices have been consistently fixed higher than the counter-factual market price. As a result, and this is especially so in recent years, stocks have ballooned. As these policies are not sustainable indefinitely, farmers face a policy risk depending on the way stocks are reduced.

In specialty crops and vegetables, contract farming is gaining ground as a mechanism by which private processors obtain supplies from farmers. These crops are characterized by substantial market risks and contracting allows the transfer of these market risks from the farmer to the processor. It has been found that price stability is a major benefit of contract farming for producers.

Futures trading is a market based institution for trading price risks. Theoretically, it allows farmers to hedge against market risks. However, transactions costs is a formidable barrier to the participation of farmers in futures markets. Further, futures markets in India suffer from a lack of liquidity. Their performance in insuring spot prices is also suspect because the basis risk from futures trading is high relative to spot price risk.

Table 6.1. Crops for which Minimum Support Price is announced

Rabi	Kharif	Kharif and Rabi	Others
Wheat, Barley, Gram, Rapeseed/Mustard, Safflower	Paddy, Jowar, Bajra, Maize, Ragi, Pulses Groundnut, Soyabean, Sunflower, Sesamum, Nigerseed, Cotton, VFC Tobacco	Groundnut, Sunflower, Paddy	Copra, Jute , Sugarcane

Source: Reports of the Commission on Agricultural Costs and Prices (2001a & 2001b)

Table 6.2. Impact of market intervention operation on groundnut price in selected markets

Market	Range of seasonal indices of prices		
	Period	Pre-MIO period (1984-85 to 1989-90)	Post-MIO period (1990-91 to 1994-95)
1.Gadag	Peak	19.66	10.86
	Lean	15.12	14.13
	Overall	25.78	13.97
2.Bijapur	Peak	16.97	7.66
	Lean	15.78	9.67
	Overall	16.97	14.20
3.Hubli	Peak	7.13	4.24
	Lean	21.81	12.60
	Overall	22.42	16.79
4.Raichur	Peak	17.63	9.14
	Lean	25.22	14.78
	Overall	17.22	14.78
5.Challakere	Peak	13.37	3.43
	Lean	35.08	19.09
	Overall	35.08	22.04
6.Chitrdurga	Peak	15.93	15.94
	Lean	33.63	16.93
	Overall	33.63	16.93
7.Devanagere	Peak	6.35	4.73
	Lean	36.11	21.57
	Overall	36.11	27.50

Source: Mundinamani and Mahajanashetti (2001)

Table 6.3. Commodities traded & exchanges involved in futures trading in India

Commodity	Futures exchange	Year since futures contact is being traded
Pepper (domestic & international)	IPSTA, IPSTA-ICE	Domestic futures trading started in 1952,and by IPSTA in 1957; International trading started in November 1997
Turmeric	SOEL	1957
Gur	VBCL, COC, BOOEL MACECL, ROOEL, (Gwalior)	1982
Potatoes	COC	1985
Castor seed	ACEL, BOAOEL, RSOBMAL	1985
Hessian	EIJAHEL	1992
Sacking		1998
Coffee	CFEIL	1998
Cotton (kapas)	EICAL, RSOBMAL	1999
Castor oil-international	BCEL	1999
Soyaseed, soyaoil and meal	SBT	December 1999
RBD palmolein	BCEL	April 2000
Rapeseed /mustard seed, its oil & cake	KCEL	December 2000
Copra/coconut, its oil & cake	FCEI	October 2001
Groundnut its oil oilcake	BCEL & RSOBMAL	November 2001
Sunflower seed, its oil & oilcake	BCEL	November 2001
Cottonseed. its oil & cake	RSOBMAL,(BCEL, ACE & Surendernagar)	December 2001

Notes:
ACE=The Ahmedabad Commodity Exchange
BCEL=The Bombay Commodity Exchange, Mumbai (erstwhile The Bombay Oilseeds & oils Exchange)
BOOEL=Bhatinda Om & Oil Exchange, Bhatinda
CFEIL= The Coffee Futures Exchange of India
COC= The Chamber of Commerce, Hapur
EICAL= The East India Cotton Association, Mumbai
EIJAHEL= The East India jute & Hessian Exchange, Kolkata
FCEI= First Commodity Exchange in India, Kerala
IPSTA =Indian Pepper & Spice Trade Association, Kochi
KCEL=Kanpur Commodity Exchange, Kanpur
MACECL= The Meerut Agro Commodity Exchange Company, Meerut
ROOEL= Rajdhani Oils & Oilseeds Exchange, Delhi
RSOBMAL= The Rajkot Seed Oil & Bullion Merchants' Association, Rajkot
SBT= SOPA Board of Trade
SOEL= Spices & Oilseeds Exchange, Sangli
VBCL= The Vijay Beopar Chamber, Muzaffarnagar
Exchanges mentioned in parentheses have been permitted to trade in respective commodities

Source: Naik and Jain (2002)

Chapter 7: Concluding Remarks

There is no typical risk environment that obtains for all Indian farmers as it varies by location, weather conditions, soil type, access to irrigation and by the particular commodity market. Rainfall and drought risks dominate agriculture in arid and semi-arid tropics. These risks are substantial and major. As we saw, more than 50% of the arid and semi-arid areas are affected by drought once in four years. The farming systems in these areas is shaped (in terms of cropping pattern, investments, land tenure, labour markets, the relation between crop and livestock agriculture and production flexibility) by the fact that farmers must constantly live with the prospect of weather-induced crop failure. The choices that farmers make to ward off calamities – big and small - often means turning away from profitable opportunities. The trade-off is most acute for small farmers because their opportunities for ex-post management of risk through credit are limited. When all other measures fail, farmers have no option but to sell their assets (principally livestock) or to migrate out to regions with better work opportunities. Use of the first option is known to affect adversely their future livelihoods while distress migration is socially disruptive with the costs often borne by children. Thus, coping with risk whether ex-ante or ex-post inflicts severe costs on poor farmers that often have such long-term consequences as to keep them mired in poverty.

At an aggregate level, irrigated agriculture is found to be more stable than unirrigated agriculture. At the level of the farmer, irrigation not only substantially reduce the risks of moisture stress from uneven rainfall and dry spells but also enables the adoption of high-yielding varieties that thrive in conditions of assured moisture. Further, it extends the growing season and makes possible multiple crops. New varieties and higher cropping intensity increase incomes that in turn substantially enhances the capacity of farmers to bear risk directly and indirectly (through credit markets).

The impact of improved varieties on production risks has been controversial. It has been said that improved varieties do poorly, relative to traditional varieties, because of their greater vulnerability to moisture stress and pests. Yet, the evidence does not support such a generalized statement. Many improved varieties outperform traditional varieties under adverse conditions. Furthermore, by increasing farmer incomes, new technologies have enabled poor farmers to cope better with existing risks. Risks could, however, arise from the success of new varieties. Their widespread adoption leads to the possibility in the long-term of soil depletion and genetic uniformity.

To protect farmers against production risks, the Central Government together with the State governments offer a crop insurance scheme based on the `area approach'. The scheme as yet covers a small minority of farmers. Even so, concerns have already arisen about the cost of this scheme. This is due to the fact that premiums are not yet in line with actuarial cost. Such subsidisation makes it expensive to expand the crop insurance programme.

As farmers start producing for the market, price risks become important. Because of inelastic demand small increases in crop output can crash prices. This is often the case with perishable products and with small remote markets. As a result, except for a few wealthy farmers well connected to urban and international markets, high value crops are very risky. The growth of processing and development of transport and market infrastructure can help in enlarging markets and enhancing the elasticity of demand.

In Indian markets, price oscillations (such as cobweb cycles) due to instability in expectations formation are often seen. Commodities traded in world markets are also subject to such price variability. The problem of matching supply to demand requires coordinated actions among producers. Such coordination can arise from dissemination of market information and price discovery mechanisms.

Price supports have been effective in protecting rice and wheat farmers against market risks. For other crops, central government interventions have been limited. For crops that are important to the regional economy, state governments have often stepped in to offer price supports (e.g., cotton, coconut, apples). Price supports have been expensive and they have tended to accumulate stocks especially of low quality. In some cases, farmers face a serious policy risk because of the immediate necessity to dispose of stocks.

As yet, private mechanisms that offer insurance against price risks are limited. Futures markets have a long history in India. However, crippling government regulations and extensive government intervention in the major commodities have limited the scope to minor commodities. Recent policy changes are more permissive of futures markets. However, world over, farmers rarely participate directly in futures trading. The principal benefits are indirect: from price discovery and lower risks in agricultural trade. Contract farming has more direct impacts on farmers. Market risks are large in specialty crops and vegetables that deters most farmers from investing in them. Through price insurance, credit and technical inputs, contract farming could be an important mechanism by which small farmers can supply high value crops to urban and international markets.

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Endnotes

[1] Estimates based on the Planning Commission poverty lines for urban and rural sectors of different states.

[2] The discussion of Barah and Binswanger's work is substantially drawn from Walker and Ryan (1990). In Walker and Ryan, the Barah and Binswanger paper is cited as a discussion paper circulated in ICRISAT and it is therefore unpublished.

[3] The figures can vary depending on the definition of arid and semi-arid regions. For instance, Gadgil et.al (1988) report the contribution of arid and semi-arid regions to total cropped areas as 54%. No matter what definition is used, more than 50% of the country's cropped area is subject to significant moisture stress.

[4] Similarly, pest management practices in sorrounding farms can affect infestation in a particular field as it serves as a "refuge".

[5] Linear demand and multiplicative production shocks are the assumptions used to derive the expression.

[6] We also deflated the jute price with respect to the paddy procurement price as paddy is a competing crop. The results are virtually identical.

[7] Roy (1968) notes how long gestation lags in supply of about 4-6 years creates cobweb cycles in tea prices and supply.

[8] Much of the seasonal price uncertainty could be because of cobweb type expectations. For evidence on this in the context of the wheat market in India, see Ramaswami (2000).

[9] Binswanger et al [1985]

[10] Walker and Ryan [1990], Ravi [2002]

[11] Of course, when tenants are wealthy and seek high returns from entrepreneurship even if it is risky, then they would prefer fixed-rent leases to sharecropping. Rao (1971) showed that farm lease contracts in West Godavari district were dominated by fixed rent in the case of tobacco but by sharecropping in the case of rice when in fact tobacco returns were far riskier than rice farming. This was because tobacco tenants leased in land to earn profits while rice tenants were small farmers augmenting factor incomes through the fuller use of own resources.

[12] Walker and Ryan [1990]

[13] Jacoby and Skoufias [1998]

[14] In Sanghavi, the data on all states in North India, except Uttar Pradesh, showed a higher annual income for male attached workers by a range of 15-100%. Bardhan found that the average level of consumption for the family members of permanent workers in Bengal was Rs32/month whereas it was Rs24/month for family members of casual workers.

[15] Farmers who had wells were relatively wealthy and a difference in access to credit was not a factor in the decision.

[16] While covariate risks necessarily reduce the value of diversification, this strategy will not be effective even when risks are not covariate but they are such that risks across crops for individual farmers are strongly correlated.

[17] The practice of post-rainy season cropping carries a long-term cost, however. It leads to increased soil erosion as bare lands are exposed during the rainy season (Gadgil et.al., 1988).

[18] For credit and insurance markets to work, creditors and insurers should be able to distinguish between high and low risks, ensure that the insurance or credit does not encourage high risk behaviour, and detect and verify the bad states which demand insurance payout.

[19] Ravi [2002, New York University]: Rural credit survey of 720 households across 21 villages of Kannauj, Uttar Pradesh and Palakkad, Kerala.

[20] Ravi [2002, New York University]: Rural credit survey.

[21] Walker, Singh and Asokan are more positive about rainfall lotteries because it is not tied to area planted. But as noted in the text, such a restriction is not necessary for area insurance as well. Area insurance's advantage over rainfall lotteries is that it would involve more basis risk because of the complicated relationship between rainfalls and yield variability. After all, yields depend not just on the quantity of rain but also on its seasonal distribution and timeliness. Rainfall insurance is probably simpler to administer and this is its sure advantage over area yield insurance.

[22] As the commission is an advisory body, the prices recommended by the commission are not binding on the government. Generally, the departures from the commission's recommendations have been in the upward direction – where the government announces a support price higher than the MSP recommended by the commission.

[23] The problem also arises when quality specifications are relaxed. An instance of this is in 2000, when quality specifications were relaxed to procure cyclone-damaged rice from Orissa. While this provided some compensation for the cyclone-affected farmers of Orissa, the build up of low quality stock ultimately tells on the health of the procuring agency.

[24] In India, with restrictions on corporate ownership of agricultural land, processors have no choice but to employ contract farming. However, even if processors could own land, vertical integration might not be superior to contract farming.

[25] Singh believes that these benefits will wear off in the long run as the dependence of farmers on processors will encourage them to use their superior bargaining clout to extract most of the surplus.