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Efficiency of Risk Management by Small Farmers and Implications for Crop Insurance

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An evaluation of crop insurance would be incomplete without an assessment of risk management alternatives available to farm households. Many cropping strategies and farming practices substitute for crop insurance in stabilizing crop revenue. Moreover, crop income stabilization does not necessarily imply consumption stabilization as many households have access to other income generating opportunities that may compensate for shortfalls in crop revenue. The availability and effectiveness of these risk management alternatives are conditioned by public policy and determine the demand for crop insurance. The beneficial or detrimental effects of public policy on risk management by farm households frequently go unnoticed. Policies that improve access to the land, labor, and credit markets could be more cost effective than crop insurance in strengthening risk management by farm households. Hence, it is important to understand not only how well farm households manage risk without crop insurance but also how competing policies and crop insurance interact with the present stock of risk management measures.

It is not easy to arrive at such an understanding. Few research institutions have the stability, resources, or inclination to gather longitudinal information that is indispensable for a multidimensional evaluation of the microeconomic impact of risk on household welfare. Features of risk adjustment have been extensively treated in the multidisciplinary natural hazard literature (White 1974) founded on retrospective surveys that point us in the right direction but do not provide a detailed rendering of the consequences of alternative risk management strategies.

Like biological scientists screening for drought tolerance in field situations, social scientists investigating risk adjustment are often cast in the hypocritical role of sharing the farmer's hope

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for a good year while knowing full well that a bad or better yet "a disasterous" year will enhance the value of their research. Thus economic research on risk adjustment is itself an inherently uncertain endeavor and its risky nature may lead to an underinvestment in such research. For this reason, we strongly rely on casual empiricism and intuition to complement the available factual evidence.

Two questions are crucial to an assessment of the efficiency of small farmers' adjustment to risk; (1) does the present pool of risk management methods protect household consumption stability and preserve farm productive capacity and (2) does reliance on these options result in sizeable losses in static or dynamic social efficiency? If the answers to these questions are yes and no respectively, then the scope is limited for a public policy such as crop insurance to improve farmer risk adjustment and to contribute to societal welfare. In order to indirectly answer these questions we trace out some of the first and later order effects that could come from the introduction of an effective public sector risk reduction policy such as crop insurance. Throughout the discussion, we refer to efficiency in the broad social sense. We assume that small farmers are rational and can make choices on risk management alternatives that are in their economic self-interest.

While Latin America has richer experience in crop insurance, nature is perhaps harsher in Asia and Africa where adjustment to risk has been analyzed intensively in several case studies. Therefore, we draw on experience on small-farmer risk management across several agroclimatic, socioeconomic, and institutional contexts. Comparative evidence from Central America, India, and East Africa furnishes benchmark or reference points for a descriptive analysis of risk management by small farmers. Such a contrasting description is illustrative and not definitive; it only maps out some general boundaries on what small farmers do to manage risk.

We focus on yield risk as a determinant of income variability. Small farmers, particularly more subsistence-oriented producers, probably perceive that yield risk is a greater source of income variability than price risk, and crop insurance as a public policy is explicitly but not exclusively directed at reducing yield risk. Because of this orientation, the paper applies more to rainfed farming where yield risk is dominant than irrigated agriculture where price risk potentially plays a greater role in conditioning farm income variability (Barah and Binswanger 1982).

Risk management is defined broadly and encompasses both practices routinely taken in seasonal production decisions and loss management strategies employed by households to augment unusually low farm income due to shortfalls in production. Within the set of seasonal risk management measures, spatial diversification, intercropping, and tenancy are singled out for detailed scrutiny. Hypotheses relating to diverse aspects of these risk management strategies are tested with data from the ICRISAT Village Level Studies (VLS) (Binswanger and Ryan 1980).

How prospective crop insurance policies are designed and carried out also has implications for farmer risk management. The positive role of crop insurance as a policy that enhances and not adversely compromises present risk management strategies is underscored. The symbiotic interaction among risk management by farm households, the provision of information, and crop insurance is examined in a concluding section where general implications for crop insurance are summarised.

ALTERNATIVES TO CROP INSURANCE, INCOME PROTECTION, AND COSTS OF INEFFICIENT RISK MANAGEMENT

Substitutes for Crop Insurance

Consumption stability should be the ultimate welfare objective of an income stabilizing policy such as crop insurance (Newbery and Stiglitz 1981). The link between crop income stability and consumption stability is tenuous for many small farm households. Crop income is only one component in farm income which itself is only one source of household income.

A variety of informal measures are available to farm households to stabilize crop income. Enterprise diversification is usually the most effective alternative as net returns across farm enterprises are seldom if ever perfectly correlated. Small farmers also diversify their cropping activities across space, time, and altitude. As weather conditions become known during the cropping year, farmers make within-season adjustments in agronomic practices. When crop income falls shorts of expectations, farm income stability can be preserved through asset adjustment of producer durables and management of on-farm stocks and reserves. The cost effectiveness of these informal risk management measures are discussed later in this section.

Nonfarm income can also be a powerful force to compensate for lower than expected crop revenue. Access to sources of nonfarm income, occupational mobility within a region, geographic mobility, and family remittances can play an role in stabilizing household income and consumption. They decrease the demand for crop insurance and are conditioned by the general level of economic development. How well they substitute for crop insurance depends largely on the covariance in agricultural and nonfarm income within and across regions. In Southeast Asia, many farm households derive a considerable share of total income from nonfarm sources (World Bank 1982). In Mexico and Central America, some small farm households receive remittances from a network of relatives in the United States and thus are protected from highly covariate farm and nonfarm income characterististic of small regions in developing countries. Such covariance greatly reduces the prospect of finding employment in the nonfarm sector within the same region that is afflicted with depressed crop income. Production risks across regions may not be highly correlated; therefore, temporary migration may represent a more rewarding risk adjustment strategy than occupational mobility within a region.

Competing public policies may be more cost effective than crop insurance in smoothing small farm household consumption streams over time. Price support policies could improve crop income stability. But they wil be less effective where yields and prices are inversely correlated. Moreover, price stabilization has a greater impact on larger, more commercial producers than on semi-subsistance small farm households.

In theory, the credit market could insure consumption in the face of income variability; in practice, consumption credit is rarely available where institutional credit markets are fragmented and badly distorted. Moreover, a geographically dispersed and broad-based banking system is needed to absorb the shocks caused by covariate production risk across regions and sectors of the economy.

Public relief is a more direct policy than crop insurance to achieve household consumption stability. Employment programs in particular have been an active force in mitigating scarcity and famine not only for farmers but also for landless laborers (Jodha 1978). Food-for-work schemes may be particularly effective in compensating for entitlement failure (Sen 1981) where scarcity is not induced by total food availability but by inefficient distribution.

Income Protection

In order to assess the efficiency of risk adjustment by small farmers, we compare several dimensions of economic welfare in normal years and in years when a drought occurred. Some summary evidence from different drought areas in India is tabulated in Table 1 to broadly illustrate the size of fluctuations in farm income, the contribution of different adjustment mechanisms, and the multiple consequences of drought on household welfare. Shortfalls in crop and livestock income during the drought year were large by any standard. Despite risk adapting cropping strategies and farming systems, the drought was so severe that crop and livestock income contributed only from 5 to 16% to total sustenance income in the four areas studied. The shortfall in farm income was to some extent compensated by relying on private borrowing and public relief which contributed from 44 to 73% and 22 to 56%, respectively to

Table 1. Consequences of risk-loss management measures adopted by drought -hit farms in different areas of India[a]

Description of measures undergoing change	Number of areas studied	Range of changes in drought year compared to normal year (%)[b]
1. CURRENT COMMITMENTS:		
Per household total consumption expenditure	3	-8 to -12
Per household expenses on socioreligious ceremonies	3	-31 to -64
Per adult unit food grain consumption	3	-12 to -23
Households postponing payment of taxes, other dues	1	27
Households withdrawing children from school	1	42
2. ASSETS AND LIABILITIES:		
Asset depletion (through sale, mortgage, etc)	5	-19 to -60
Outstanding debts	4	64 to 192
3. INCOME POSITION:		
Per household income from crops	3	-58 to -82
Per household income from livestock	3	-37 to -73
4. MIGRATION:		
Households having drought-year out-migration	3	37 to 60
Out-migration of animals	3	32 to 56
Migrating animals lost or dead	3	28 to 53
Non-migrating animals lost or dead	3	59 to 87

a. Table reconstructed from Jodha (1975, 1978) and original data sets of the studies.

b. Normal years in the case of item under categories 1 and 3 refer to post drought years. For category 2, normal years refer to predrought years.

household income during the drought year. Traditional farm management risk-reducing practices were not effective in protecting income in these high risk rainfed regions during years of extreme drought.

In Latin America, such detailed microeconomic inquiries (to our knowledge) are not available. What is available are recall surveys, such as the one carried out in two villages in Northern El Salvador (Walker 1980), on past and future mechanisms of adjustment to crop loss (Table 2). Temporary migration for the harvest of export crops played a leading role in risk adjustment. This type of information furnishes some insight but does not allow us to quantify the effectiveness of risk adjustment by small farmers.

Costs of inefficient risk management

Another way to approach the issue of the efficiency of small farmer risk adjustment is to outline the size and timing of some likely scenarios that could result if small farmers had access to an additional risk management measure such as a public sector crop insurance program. We assume that small farm households perceive that crop yield insurance does enhance crop income stability. We focus on how crop insurance could interact with present risk management by small farmers.[1] Shifts in cropping patterns caused by crop insurance are a central theme in the normative analysis by Hazell et al. (1982) later in this book; therefore, we direct our attention on a positive analysis of how risk aversion influences the choice of technique in the next subsection.

Low input intensities and nonadoption

Perhaps no theme pertaining to risk management by small farmers has received as much empirical attention as the role played by risk aversion in conditioning an underinvestment in new agricultural technologies and a resulting departure in input use from a profit-maximizing norm. Yet the magnitude of supply response generated by technological intensification stimulated by a risk reducing policy like crop insurance is still an unresolved empirical issue.

Evidence from positive analyses on risk and adoption does not paint a rosy picture of the potential for intensification by correcting for risk aversion. Participants in a risk-reducing crop insurance program could capture innovators' rents as early adopters, but they would also be exposed to innovators' losses from unprofitable new technologies (Binswanger and Ryan 1977). A perceived reduction in risk could speed up the adoption cycle, but, unless acceptance by a few precludes adoption by the majority, levels of welfare are determined

1. The relationships between rural financial markets and crop insurance are addressed by Binswanger (1982) in this volume.

Table 2. Risk adjustment by small maize farmers in Northern El Salvador[a]

Adjustment mechanisms	Principal mechanism used to manage crop loss induced by drought in 1977 (% of farmers)	Most important potential source of risk adjustment (% of farmers)
No adjustment[b]	41	-
Sale of livestock	20	36
Increased labor market participation[c]	26	62
Draw on family savings	5	2
Receipt of consumption loans in kind	10	0

Source: Constructed from Walker (1980).

a. Refers to 42 farmers in two villages.

b. Implies that stocks were sufficient or farmers did not have to resort to interseasonal loss management mechanisms.

c. Refers primarily to seasonal migration to harvest cotton, coffee, or sugar cane.

by who ultimately adopts rather than by who first adopts (Gerhart 1975).

Therefore, the more relevant welfare question focuses on reasons for persistent nonadoption of mature innovations when farmers have some information on recommended technologies. Intuitively, the output cost of risk aversion is greater for recommended inputs that are indivisible and/or are characterized by large financial risk. Recommendations are frequently clustered into packages that imply all-or-nothing courses of action when in reality farmers make sequential adoption decisions on each cluster or component in a piecemeal stepwise fashion (Mann 1977). The package approach to the diffusion process greatly accentuates risk and therefore the potential for risk aversion to be an impediment to adoption A perhaps biased sample of positive risk-related research on the adoption of mature innovations in Latin America indicates (1) that when packages are partitioned into their components risk aversion is relegated to the role of a minor accomplice (Gladwin 1977) (2) that the conflict between expected profitability and risk is not as sharp as anticipated (O'Mara 1971), or (3) where risk aversion is pinpointed as the primary reason for nonadoption, moving to a risk netural position yields only a marginal increase in expected income (Walker 1981).[2] Although it is difficult to forge a consensus-witness adoption research on the Puebla project where five investigators (Benito 1976, Díaz 1974, Gladwin 1977, Moscardi 1976, and Villa Issa 1976) arrived at quite dissimiliar conclusions and markedly different policy implications - the overriding importance placed on on-farm profitability by Perrin and Winkelmann (1975) in their summary of the CIMMYT adoption studies in the 1970s rings as true today as it did to Griliches in 1957.

Asset depletion

Reliance on liquidation of productive assets to iron out fluctuations in farm income may have strong implications for economic growth and equity in risk prone areas. Jodha (1975) has argued that farmer risk adjustment is conditioned by repeated weather cycles that translate into asset depletion and replenishment cycles for farmers. If governments wait to base public risk management decisions on changes in consumption levels, asset depletion may have already run its course with a resulting, sometimes permanent, erosion in on-farm productive capacity.

In the longer run, such cycles signify stagnating investment for agriculture in risk prone regions. Restoring farm productive capacity is a slow, painful, accretionary process because farmers face a buyers market in the disaster year and a sellers market in the post disaster

2. Similar results are reported by Ryan (1972) who assessed the effect of risk aversion on optimal use of fertilizer for potatoes in Peru. He found that the marginal cost (supply) curve for potatoes was only marginally affected when one allowed for risk aversion.

year (Jodha 1975). With the exception of Northeast Brazil, and isolated pockets of small farmers cultivating extremely marginal hillside land in many countries, asset depletion and replenishment cycles are probably not nearly as severe in Latin America as they are in West Africa, East Africa, and South Asia. Nonetheless, the growth and equity implications of asset depletion and replenishment are sufficiently compelling to make a good case for not ignoring their dimensions in the assessment of public policies whose intent is risk reduction for farmers.[3]

Shifting the incidence of risk adjustment to landless labor

Increased participation in the casual labor market is an important adjustment mechanism for small farmers particularly in Central America where basic grains are grown from May through November and export crops such as coffee, sugar cane, and cotton are harvested from December through March. Survey results in the preceding Table 2 suggest that crop loss or low nonwage earnings induce small farmers to temporarily migrate to the cortas to work as harvesting laborers.

With increased temporary harvesting migration by small farmers, the incidence of risk adjustment is partially shifted to landless agricultural laborers who represent the segment of society least able to cope with risk. In any year the demand for harvesting labor is highly inelastic and is determined by the size of the crop for harvest. An increased supply of labor, arising from migration of labor areas affected by crop loss, translates into decreased real wages or higher probabilities of involuntary unemployment as jobs may be rationed if legislated minimum wages are effective. An effective crop insurance policy could therefore indirectly contribute to the income stability of landless laborers. This equity impact may be an important consideration in many Latin American countries; however, a well-timed and flexible public works program is a more direct means to achieve the objective of reducing the cost borne by landless agricultural labor of farmer risk adjustment.

Land fragmentation

An efficient risk reducing public policy could also exert a dampening influence on accelerating land fragmentation in minifundia agriculture in Latin America. Rather than retain field integrity, fields are subdivided to each heir in what we suspect is a partial attempt to maintain

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3. Browning (1971) and Durham (1979) contend that low coffee yields and prices forced many small landholders in El Salvador to sell to large haciendas in the 1930s and, therefore directly stimulated increasing land concentration.

a diverse portfolio of holdings.[4] Casual empiricism suggests that this is also the case for parts of the Semi-Arid Tropics of India. An efficient crop insurance policy could reduce the demand for spatial diversification as a risk management strategy and thus create a more favorable environment for consolidation of land holdings in countries where man:land ratios are high. Once again we need more empirical evidence, in this case on the determinants of the intergenerational transfer of wealth and on the social costs of land fragmentation before benefits can be quantified.

Population growth and other effects

An effective public sector risk reducing policy could influence fertility behavior specifically in the valuation of children as production durables which partially represents a life cycle adjustment mechanism. Some empirical evidence (Cain 1981) suggests that ineffective risk management may contribute to persisting high rates of population growth in risk prone environments. There are a number of other potential dynamic costs of traditional methods of handling risk and include overstocking, mismanagement of common property resources, and the extension of cultivation to marginal sloped land.

We do not recommend that scarce resources for research be allocated to quantify these later order effects, but their importance should be kept in one's mind when public sector risk reducing policies are evaluated. Regions where small farmers' risk management appears inefficient and implies higher social costs and adverse equity impacts are also likely to be more marginal areas where supply response would not be forthcoming with the introduction of a crop insurance program. Moreover, it is not enough to say that small farmers management is inefficient and ascribe high potential gains to an additional risk reduction policy. One also has to consider the impact the design of the policy imparts on the choice and effectiveness of risk management measures available to small farmers.

An alternative way to describe the effectiveness of small farmers' risk adjustment is to compare the use of different production strategies and management devices in different environments. In the next section, we assign attributes related to the efficiency of these measures and carry out a comparative analysis on small-farmer risk management in El Salvador, Tanzania, and India.

4. As Roumasset (1976) has pointed out on several occasions, alternative explanations may underlie what looks like risk averse behavior. Presumably, if there were enough plots, an owner could take into account land quality and give each heir equitable shares without fragmenting fields.

COMPARATIVE ANALYSIS OF RISK MANAGEMENT IN EL SALVADOR, TANZANIA AND INDIA

Farmers in agriculturally risky environments have evolved several measures to deal with production risk. These measures have been observed with minor variations tailored to local conditions in several small farming systems in developing countries (Ruthenberg 1976, Collinson 1972, Norman 1974, Haswell 1973, Lagemann 1977, and Navarro 1977).

Traditional methods of handling risk in small farm systems can be partitioned into two groups, routine risk preventing or minimizing practices and risk-loss management mechanisms. The first group largely relate to crop management strategies designed to adjust production and resource use in response to perceived risk before and during a production season. The second group include later actions taken by farmers in response to lower than expected crop income caused by natural hazards such as drought.

Loss Management Actions

A listing of potentially important loss management responses and their relevant efficiency attributes is presented in Table 3 for small farm systems in El Salvador, Tanzania, and India. Space limitations of this paper and paucity of time series data (see Jodha 1978, 1981b, for India) do not permit a detailed country assessment. In general, such mechanisms are not as important in Tanzania where man:land ratios are lower than in India and El Salvador. Absence of a labor market and imperfections in other markets force farmers in Tanzania to rely more heavily on traditional crop management strategies to cope with production risk.

Routine Risk Management Practices

Risk management practices embodied in cropping strategies can be subdivided into those that relate primarily to resource and enterprise diversification and adjustment within cropping systems. (Table 4)[5].

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5. In looking at traditional risk management strategies and practices, one can seldom distinguish between those where risk and expected profitability are in sharp conflict and those that are characterized by a lower variance in net returns and also higher average returns when compared to other alternatives. A good example of a stochastically efficient practice is doubling maize, that is, breaking the stalk below the ear to facilitate field drying. Doubling and field drying is simply so much more profitable than competing alternatives in El Salvador that it is not included in our set of risk management practices. If we had "perfect" information for a decision analysis on the production practices listed in Table 4 and on alternative courses of action, we would not be surprised to find that for many environment by technology sets what seem like risk management strategies and practices are also the most profitable alternatives over time.

Table 3. Traditional loss management actions and their efficiency attributes in El Salvador, Tanzania and India.

Loss management actions	Efficiency attributes					Actions observed in[a,b]		
	Protecting sustenance	Protecting production capacity	Production flexibility	Salvage value	Burden sharing	El Salvador	Tanzania	India
Interlinked consumption and production			x	x			x	x
Informal forms of mutual aid and remittances	x	x			x	x	p	x
Storage and recycling	x			x		x	p	x
Linkages of agricultural factor markets, for example tenancy and credit	x	x			x			x
Asset depletion/replenishment cycle	x	x				p	p	x
Seasonal and temporary migration for wage labor, foraging, etc.	x	x				x	p	x
Public relief	x	x				x	x	x

a. p denotes partially observed or empirical evidence is lacking.

b. Observations refer to rainfed agriculture in Northern El Salvador, Kilosa, Tanzania and the Semi-Arid Tropics of India.

Table 4. Routine risk management practices and their efficiency attributes in El Salvador, Tanzania, and India.

Traditional insurance measures related to cropping strategies	Efficiency attributes				Practices observed in:[a,b]		
	Protecting sustenance	Production Flexibility	Production Stability	Salvage value	El Salvador	Tanzania	India
A. Resource-centered diversification							
1. Toposequential planting		x			x	x	p
2. Spatial scattering		x	x		x	x	x
3. Staggered planting/temporal diversification		x	x		x	x	p
B. Crop-centered diversification							
1. Crop diversification using crop with:							
(a) Multiple uses	x	x	x	x		x	x
(b) Insurance potential	x			x	x	x	x
(c) Insensitivity to temporal variability	x		x		x	x	x
2. Mixed cropping and mixed farming	x	x	x	x	x	x	x
C. Adjustments within cropping systems							
1. Plant spacing-contingency thinning/gap filling		x	x			x	x
2. Multiple seed per hill			x		x	x	
3. Splitting and skipping in input use		x			x	x	x

a. p denotes partially observed or empirical evidence is lacking.

b. Observations refer to rainfed agriculture in Northern El Salvador, Kilosa, Tanzania and the Semi-Arid Tropics of India.

Farmers exploit vertical, horizontal, and temporal dimensions of the natural resource base to reduce production risk. Planting on a toposequence is a mild form of vertical diversification that allows flexibility in production conditional on the timing and quantity of rainfall at planting.[6]

Spatial scattering offers scope for improving crop income stability to the extent that production risks are not perfectly correlated across microenvironments. Likewise, staggered plantings and sequential diversification reduce variability to the extent that production risks are not perfectly covariate across time.

Crop-centered diversification is conditioned through the choice of crops with varying maturity periods, differential sensitivity to environmental fluctuations, and flexible end uses of the main and byproducts. Such diversification is often manifested through intercropping with seed mixing or varying row arrangements.

Flexibility is also introduced by management practices that allow the small farmer to manipulate the plant population in accordance with changing information on soil moisture regimes. Flexible input use dictated by emerging weather conditions also constitutes an important measure to handle production risk.

Examples of Routine Risk Management Measures

In this section, we look at some detailed evidence on the use of common risk management practices for areas of rainfed India, Tanzania, and El Salvador. The reliance on resource and crop-centered diversification conditioned by environmental variability is illustrated in Table 5 for the Semi-Arid Tropics of India. The Sholapur villages are located in a high risk production environment where cropping primarily takes place during the postrainy season on residual moisture. In contrast, the Akola villages are located in a more assured production environment where rainy season cropping is practiced. The data in Table 5 suggest that both spatial and crop-based diversification are more widely employed in the more drought prone villages near Sholapur.[7]

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6. A more abrupt form is practiced by farmers in the mountain communities of the Andes in South America (Guillet 1981).

7. A map giving the geographical distribution of plots would provide a better description of spatial diversification.

Table 5. Indicators of diversification strategies to handle weather risk in two areas of the Semi-Arid Tropics of India.

	Akola villages	Sholapur villages
(A) Characteristics of weather-risk		
Annual average rainfall (mm)	820	690
Probability of favorable soil moisture conditions for rainy season cropping	.66	.33
(B) Indicators of spatial diversification		
Number of scattered land fragments per farm	2.8	5.8
Number of split plots per farm	5.0	11.2
Number of fragments per farm by distance from village		
- Zero distance	0.2	0.0
- Up to 0.5 miles	0.3	1.4
- Up to 1.0 mile	1.1	3.4
- 1 to 2 miles and above	0.1	1.0
(C) Indicators of crop-based diversification		
Number of total sole crops planted	20	34
Number of total combinations of mixed crops planted	43	56

Source: Unpublished data from ICRISAT's Village Level Studies; Binswanger et al. (1980).

The Kilosa area of Tanzania offers an excellent benchmark to compare the influence of production risk on cropping decisions. The region is characterized by short (uncertain) rains during October to early December and long (less uncertain) rains from late January to the end of April. The differences in cropping decisions by farmers clearly reflect the higher extent of insurance-oriented practices during the short rains (Table 6). For example, more valley land is planted during the short rains. The incidence of intercropping, salvage crops (i.e. those which can be used before physiological maturity) and cropping near the compound are greater in the short rains. The share of staggered planting is lower during the short rains because these rains recede much earlier than the long rains.

In El Salvador, several studies have documented the use of risk management practices by small maize farmers. Hybrid maize is more likely to be planted in pure stands in lower lying valley land, while local maize varieties which farmers perceive as more drought tolerant and having a greater potential to escape drought are intercropped with sorghum or field beans on hillsides (Cutie 1975, Walker 1981). If the May maize planting fails, some farmers in Northeastern El Salvador will try to procure land (in a rather desperate attempt to salvage something from the cropping year) to plant a low yielding maize crop later in the rainy season in August (Rodriguez, et al. 1978). Part of the motivation for the rapid expansion in fixed cash renting in El Salvador from 1961-71 could be attributed to the buoyant demand for horizontal diversification (El Salvador 1974). Small farmers have consistently rejected the advice to fertilize at planting and prefer to apply a basal dose or fertilizer eight days after planting when they are assured that the crop has successfully emerged (Alvarado et al. 1979).

Trends in the effectiveness of small farmer risk adjustment

The effectiveness of risk management by small farmers is constantly changing in response to changes in the resource and institutional environments. Whether the change is for the better or for the worse, depends largely on public policy. Some impressionistic evidence follows.

In Tanzania, the change has been for the worse. Public policy interventions have adversely affected traditional risk handling methods. The state-operated new marketing arrangements have helped siphon off strategic farm food reserves that traditionally were retained in the village. Statutory regulations that compel farmers to plant a fixed acreage to cash crops has eroded production flexibility. The resettlement of villagers into compact communities at selected sites has deprived farmers of access to the diversity of

Table 6. Relative differences in farming practices during (uncertain short rains and (more certain) long rains in four villages of Kilosa, Tanzania during 1980-81[a]

Incidence of use of risk management practices	Short rains	Long rains	Total
1. Share of total low lying areas planted in the year	83	17	100
2. Share of uplands planted	26	74	100
3. Share of compound plot areas planted	92	8	100
4. Share of total salvage crops in total crops of season	72	32	-
5. Share of intercropping in season	95	79	-
6. Share of staggered planted area in the season	35	69	-

a. Source: Jodha (1982)

the land and diversified compound farming where tree crops played an important role as a food source (Jodha, 1982). Labor market restrictions prohibiting the hiring of agricultural labor, and block farming have also reduced the degrees of freedom available to the small farmer to make decisions.

In India, many well-intentioned public policies have also generated side effects that have made risk management by small farmers less effective in drought prone areas. Both intrayear reserves and intrayear security stocks of food grains and fodder have practically ceased to be important components in risk adjustment (Jodha 1978 and 1981b). Group-centered measures such as mutual risk sharing arrangemments, seasonal migration, and informal interlocking of agricultural factor markets are less compatible with new village institutions. Legal provisions regulating credit, labor contracts, mortgage of assets, and tenancy are often not sensitive to specific adjustment problems of drought prone areas (Jodha 1978, 1981b). As a result of these and other reasons, formal public relief has assumed greater significance in drought prone areas. The enormous public investment in irrigation during the last decade has probably diminished the incidence of risk for the country as a whole and has at least partially compensated for the deterioration of traditional risk management measures.

In El Salvador, the historical picture on the effectiveness of small farmer risk management is less clear. On the positive side of the ledger, technological innovations such as hybrid maize and small "silos" designed to increase on-farm storage capacity have been accepted by many small farmers. On the negative side, increasing population pressure on land, an inactive land market, and the demise of exploitative but risk adjusting patron client relationships as manifested in the "colono" form of tenancy have eroded the effectiveness and availability of traditional risk management methods.

ANALYSIS OF THREE COMMON RISK MANAGEMENT MEASURES

Spatial Diversification

Spatial diversification of farm plots is a closer substitute for crop insurance than other informal means of risk adjustment available to the small farmer. Access to heterogeneous agroclimates across which production risks are not perfectly correlated endows farmers with greater flexibility to cope with yield risk.

The incidence of heterogeneity or location specificity is not easy to quantify and may not be readily observed. For example, for the last seven years, monthly July rainfall measured in two gauges located at opposite ends of the 1400-hectare main experimental station at ICRISAT is correlated at .61, which is less than what one would expect for such a short distance on flat land. Even in small countries such as El Salvador the incidence of production risk can vary markedly among regions producing subsistence food crops. Figures 1 and 2 show average probabilities of drought stress calculated from historical rainfall data for two subsistence maize growing locations in North-central and Northeastern El Salvador.[8] Although the mean growing season rainfall is about the same for both locations, the incidence of drought stress is much higher in village N where farmers have rejected hybrid maize than in village A where farmers have accepted maize hybrids.[9]

An empirical issue closely linked to the substitutability between crop insurance and spatial diversification is the extent that individual farmers' yields are correlated with average yields in a "homogeneous" production environment. Dandekar (1976) has argued that one way to rescue crop insurance from problems of moral hazard, adverse selection, and high administrative costs of schemes targetted at individual farmers is to use a homogeneous area approach in the design and implementation of such programs. The identification of homogeneous production areas implies that individual farmer yields will be positively and highly covariate with average reported yields; hence, crop insurance based on an area approach would act as a more powerful stabilising influence. By the same token if the designated "homogeneous" areas really turn out to be heterogeneous, than the area approach could cause spurious fluctuations in income and thus figure as a destabilizing force (Roumasset 1979). Moreover, if heterogeneity increases within small geographical regions, area-based crop insurance not only become less effective but spatial diversification becomes a more attractive alternative.

We examine this issue for some common cropping systems in the ICRISAT VLS villages in Figure 3. For most cropping systems, average village and individual farmer's yields are positively correlated. The notable exception is local or desi cotton in the Akola region where 40% of the farmers had yields that varied inversely with average village yield from 1975-76 to 1980-81. The absence of significant positive correlation implies some leakage from a homogeneous area approach. Local cotton is produced in a relatively assured rainfall environment and is not exposed to a dominant source of yield risk. In contrast to the other cropping systems, yields in common cotton intercropping systems did not vary significantly over the six cropping years

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8. Drought is estimated from a daily water balance model and follows procedures outlined in Shaw (1974).

9. Drought stress in location N is accentuated by an erratic within-season distribution of rainfall and shallow, stoney soils with low moisture holding capacity.

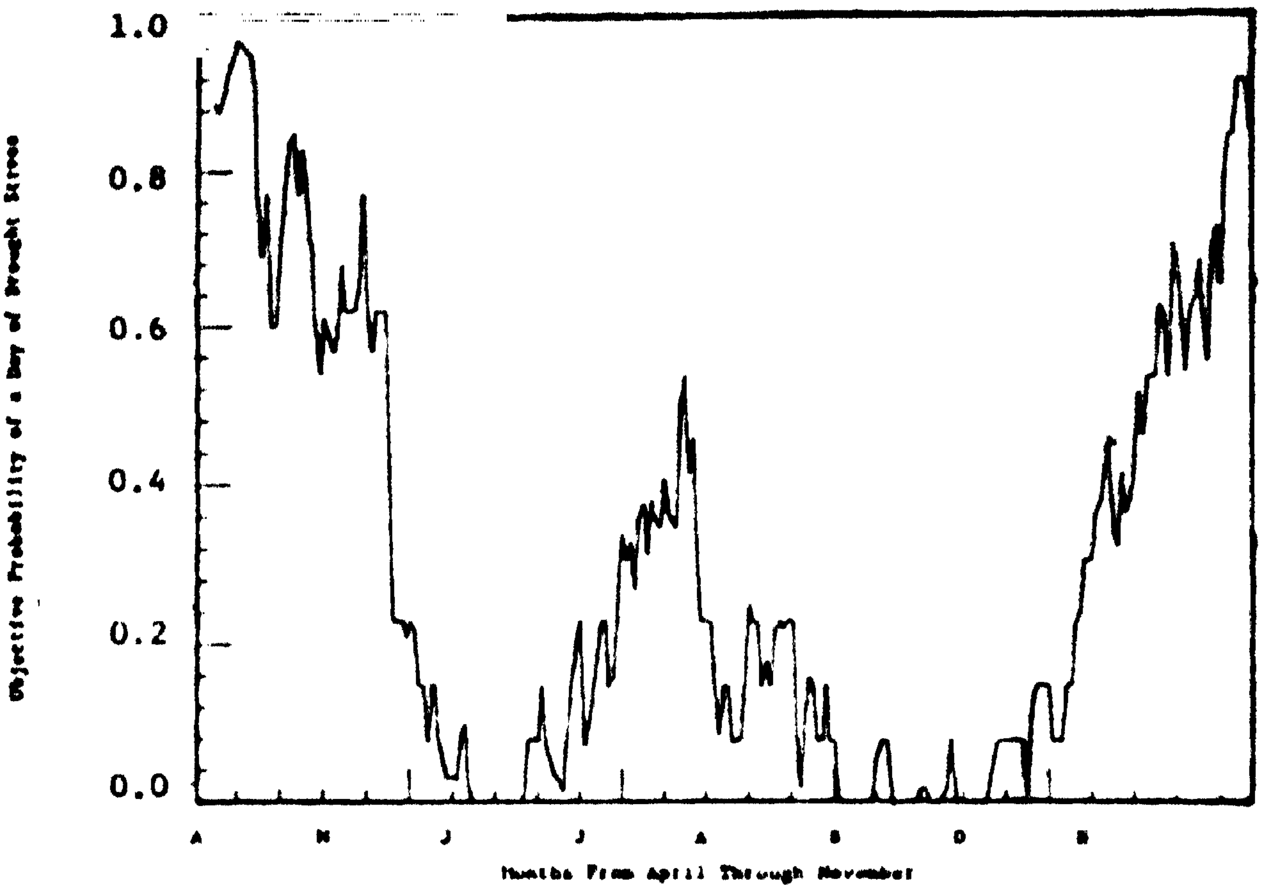

Figure 1. Average incidence of drought stress for Village N.

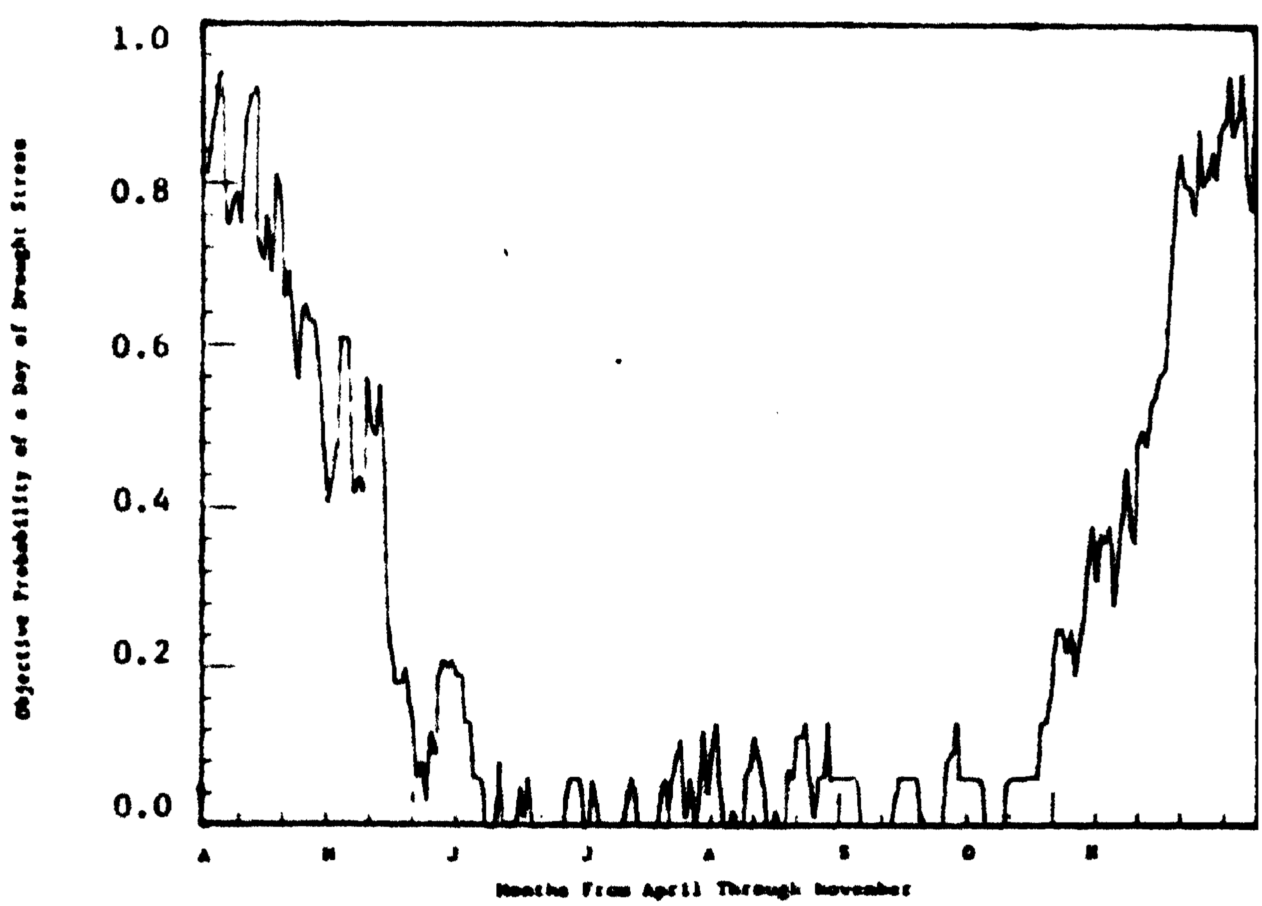

Figure 2. Average incidence of drought stress for Village A.

Source: Walker (1980).

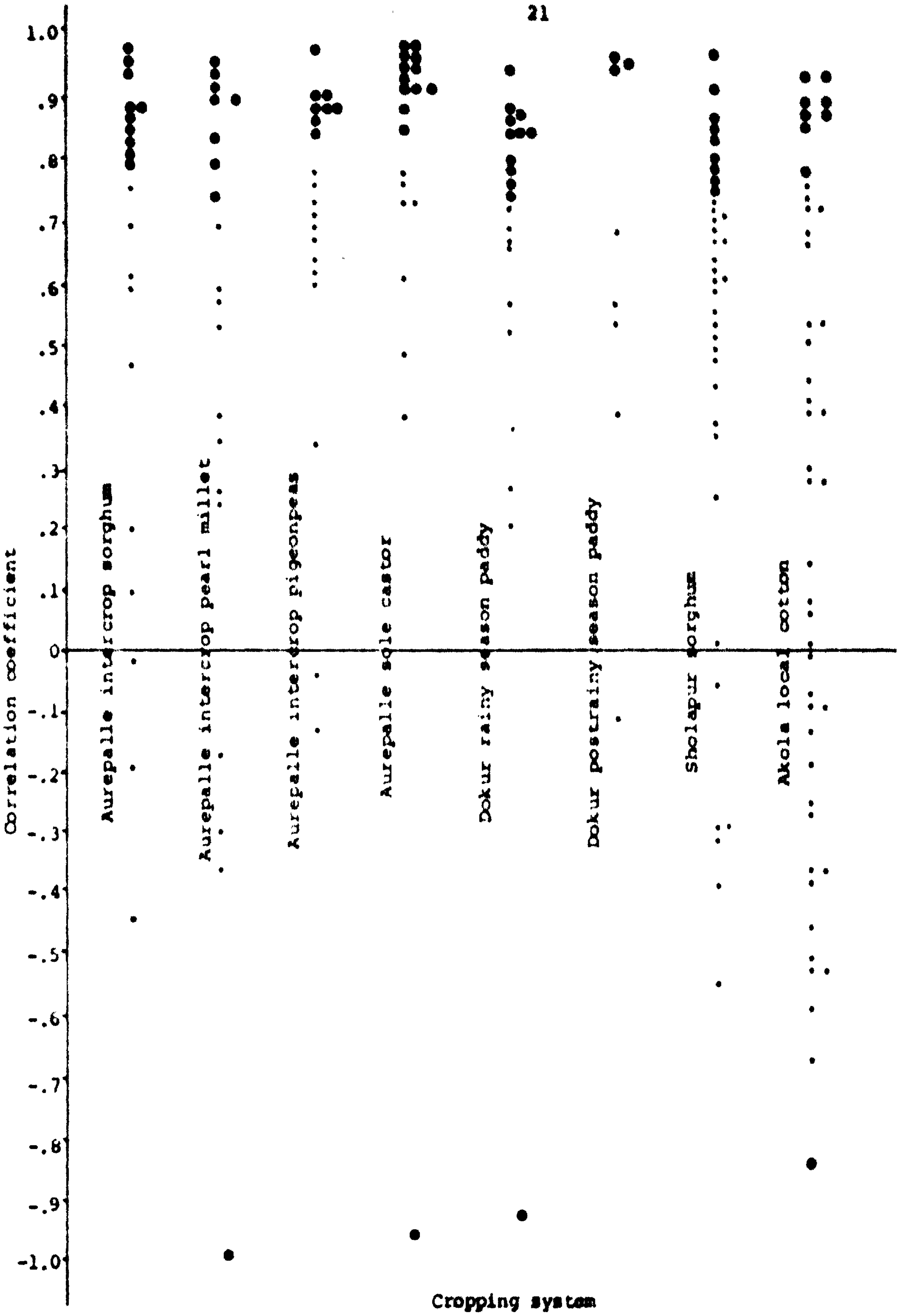

Figure 3. Correlations of farmer and village average yield from 1975-76 to 1979-80 or 1980-81

● statistically significant at the 5% level

. statistically insignificant

(Walker and Subba Rao 1982). For stable yield performers like local cotton in Akola, crop insurance programs designed along a homogeneous area approach will not be susceptible to the risk of catastrophic loss, nor will they be effective in achieving crop revenue stability for many farmers in the target population.

Other considerations impinge on the applicability of a homogeneous area approach for small farmers in Latin America. Prime agricultural land that is likely to be more homogeneous within a region is farmed by large commercial producers (Sanders and Lynam 1981). Furthermore, the definition of homogeneity has little empirical basis becuase crop reporting and yield estimation at a national and regional level are not founded or have only recently been based on an area sampling frame for many countries.

Tenancy

There are many reasons for tenancy (Newbery 1975, Binswanger and Rosenzweig 1981), and an almost unlimited number of ways to specify a contract. Risk sharing is often cited as an important reason, but what is frequently overlooked is that tenancy affords a means to manage losses incurred in previous cropping years. This is particularly true in areas where the incidence of drought accentuates the importance and extent of tenancy.

The potential for loss management in tenancy contracts is illustrated with data from two ICRISAT VLS villages which are located in the drought prone district of Sholapur in India. A severe drought in 1972-73 led to large scale deaths and sale of bullocks in the area. This reduced the capacity of many farm households to reinitiate cultivation in the post-drought year. About 24% of all farm households in the two villages had to lease out all their land (Jodha et al. 1977). Tenancy transactions tended to equalize land-bullock ratios. Before the transactions, land area per owned bullock in the two villages was 18.3 and 30.9 hectares for land owners and 3.4 and 7.2 hectares for tenants. Following tenancy, land area per bullock declined to 5.5 and 5.8 hectares for land owners and increased to 7.2 and 8.2 hectares for tenants (Jodha 1981a). Recent evidence also suggests that sharecropping in the Sholapur villages is more common on inferior land that is more susceptible to crop failure (Singh and Walker 1982).

The term underlying tenancy contracts were flexible enough to satisfy the needs of different parties. Table 7 presents the distribution of tenancy observations according to their terms, conditions, and risk-sharing implications for three years in the same Sholapur villages. The arrangements are defined from the perspective of landowners, many of whom lost productive capacity because of drought. Payment of a fixed rental independent of the size of the harvest by the tenant or solely net output sharing with the landowner implies risk transfer. When input and

Table 7. Insurance implications of tenancy in Sholapur villages, 1975-78.[a]

Tenancy arrangements	Insurance implications: Implicit risk sharing	Risk transfer to the tenant	Explicit risk sharing	Risk loss management	No. of tenancy cases
A. FIXED RENTAL					
1. Subject to harvest	x				1
2. Independent of harvest		x			2
3. With advance loan but subject to harvest	x			x	2
B. CROP SHARING					
4. Input-output sharing			x		14
5. Input (excluding bullock) output sharing			x	x	28
6. Input-output sharing with adjustable advance loan			x	x	30
7. Net output sharing		x			19
8. Net output sharing with adjustable advance loan		x		x	17
C. SPECIAL CASES					
9. Risky-plot tenancy (with no fixed rental, no advance loan but meager crop share)	x				19
10. Mid-season leasing with share in output		x			9
11. Land-lease linked to labor & credit contracts			x	x	22
TOTAL					163

a. Source: Constructed from Jodha (1981 a). The table indicates insurance implications of tenancy as viewed by the landowner.

output are shared by both parties, explicit risk sharing occurs. Finally there are tenancy arrangements that help in the management of risk losses. These are conditioned by the lagged impact of drought induced losses. They include: (1) sharing of all inputs except bullocks (which were lost during the past drought), (2) crop input-output sharing arrangements subject to an advance loan to the landowner adjustable against his shares to meet his preharvest resource constraints, (3) land lease arrangements linked to labor and credit, and (4) other factor-and product-market contracts between the landowner and the tenant.

Tenancy arrangements involving the transfer of risk - items 2,7,8,10- in Table 7 comprised about 29% of the tenancy observations. About 57% had explicit risk sharing connotations and over 60% had risk-loss management implications.

The Sholapur example is clearly a case where tenancy was a mechanism facilitating the equalization of factor endowments and enabling the sharing of production risk. In Asia, most comparative empirical studies suggest that, once other variables are accounted for, the efficiency cost (in terms of low input intensity or nonadoption) from tenancy is negligible (Binswanger and Rosenzweig 1981). In Latin America, fewer empirical studies (Colmenares 1975, Cutie 1975, Walker 1980) are available, but they also point to this conclusion.

Intercropping

Perhaps no single feature of small farmer agriculture is as striking as the high incidence of intercropping or mixed cropping (Jodha 1981c, and Norman 1974). Intercropping is often praised as a risk reducing practice in the agronomic and economic literature (Papendick et al. 1976, Bliss 1977). Risk reduction due to diversification has to be separated from the risk reducing attributes of intercropping per se; that is the pure risk effect of intercropping must be evaluated from pure stand comparisons. This is the perspective most agronomists adopt when they compute land equivalent ratios of yield in pure stand and intercropped treatments.[10]

The following three potential sources of greater yield stability in intercropping have been identified (Willey 1981): (1) intercrop yield compensation, (2) lower disease and pest incidence, and (3) higher yield response in stress conditions. The third source of risk reduction has been documented in experimental field trials where intercropping has given a greater relative yield advantage over sole cropping under conditions of moisture stress (ICRISAT Annual Report 1979/80, p.209). These results probably depend on differences in plant population between intercropping and pure stand treatments.

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10. Aside from risk reduction, intercropping may be superior to sole cropping in other dimensions (Jodha 1981c, Norman 1974).

The second potential source of risk reduction is extremely host, pest, and parasite specific (Bhatnagar and Davies, 1981). For instance in India there is firm evidence that the incidence of wilt on pigeonpeas is reduced when they are intercropped with sorghum (Willey, Rao, and Natarajan, 1980), about the same amount of evidence that pod borer is potentially a more important yield reducer to pigeonpeas in a sorghum intercrop (Bhatnagar and Davies, 1981), and fragmentary evidence that sterility mosaic is also a greater hazard in intercropping. Although generalizations are often made the intercropping reduces pest attack, one can find enough counterfactual examples in the agronomic literature that suggest that pest incidence is conditioned by complex cropping system by season by location interactions. A concluding comment by the chairman to a session on plant protection and intercropping in a recent international workshop on intercropping is probably not far off the mark, "it appears that intercropping can sometimes reduce incidence, sometimes increase incidence, and sometimes have no effect at all "(ICRISAT 1981, p.260)".

Yield compensation arises from the spatial and chronological response among species or varieties to the incidence and timing of biological and agroclimatic risk. Because these sources of risk have a differential effect on crop productivity, risk reduction in intercropping orginates from the ability of at least one crop in the system to compensate for the failure or low yield of another crop. For example, in cereal mixtures, some cereals such as millet can partially compensate for low plant stand of other crops through greater tillering. Compensation is conditioned by a crop's ability to take advantage of augmented light, soil nutrients, or soil moisture reserves "released" by other crops that are adversely affected by sources of risk. Compensation would not be possible in pure stands because all plants in the plot would be affected in the same way.[11]

If yield compensation was common, the yield covariance between species planted in a mixed or intercropped system would be less than for proportional areas of the same crops planted in pure stands. In extreme cases of high compensation in high risk environments, we would expect to see negatively covariate yields. Unfortunately, large multiyear and multilocational data sets are not available to establish intercropping-pure stand comparisons.[12] A less than ideal but still promising alter-

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11. This is an overstatement for some sources of risk such as insect and disease damage which may differentially affect plants in pure stands and thus widen the scope for compensation.

12. In one of the few attempts to assemble and analyze such data, Rao and Willey (1980) evaluated yield stability in a sorghum-pigeonpea intercrop. Based on bounded rationality and variance criteria, they found that intercropping provided greater yield stability than sole cropping, but the nature of their data does not permit the separation of pure time and location effects, that is, yield stability and adaptability are confounded.

native is to evaluate the risk performance of common intercropping systems in farmers' fields. We hypothesize that where compensation is greater yields between crops will be less positively covariate. We would therefore assign low risk reducing potential for cropping systems where intercrop yields are significantly and positively correlated over time.

An agronomic risk assessment provides some rudimentary insight on the size of expected compensation effects. Two intercropping systems, one traditional and one somewhat improved, are chosen for analysis. Time-series yield profiles are constructed from ICRISAT's Village Level Studies in the Semi-Arid Tropics of India. Plot data are available from 30 farming households in each village (Aurepalle and Kanzara) for six cropping years from 1975-76 to 1980-81. The two cropping systems are the most common ones encountered in the village where they are practiced.

The traditional system in Aurepalle consists of row intercropping two medium-duration cereals, local pearl millet and sorghum, with a long-duration grain legume, pigeonpea. The three crops are grown in a high risk, low fertility environment. Observed sources of risk and expected strengths of yield compensation are described in Table 8.

From Table 8, we would expect a strong compensatory yield effect between pearl millet and sorghum only when shootfly inflicts damage on sorghum.[13] There is more scope for compensation among pigeonpeas and the two cereals. A clear general inference from Table 8 is that the later the yield reducer hits specific crops in the system the less scope there is for compensation. We would expect virtually no inter-species compensation from late and midseason drought, excess late season rain, and pod borer attack.

In order to test the hypotheses suggested by Table 8, we calculated the yield correlation coefficients for the three crops for the 169 plots in the sample.[14] If compensation effects were strong over many years we

13. If the initial monsoon rains are late, the incidence of shootfly increases, and farmers respond by planting more castor in fields originally destined for the cereal-pigeonpea mixture. Farmers, therefore, do not have to rely solely on potential yield compensation from intercropping.

14. The yield data are adjusted for management effects by regressing yield on farmer and season binary variables using least squares dummy variable regressions (Maddala, 1977). For four farmers, sorghum yields are "corrected" for linear management effects; for pearl millet and pigeonpea, there is little evidence of significant differences in technical efficiency among farmers. This is what one would expect with a low input traditional cropping system. It is important to note that yield variability from plot specific sources has not been explicitly controlled for in the data.

Table 8. Sources of risk and predicted yield compensation in a traditional sorghum, pearl millet, and pigeon pea intercropping system in Aurepalle.

Source of risk	Affected crop	Impact	Crop with potential for yield compensation[a]		
			Sorghum	P.Millet	P. Pea
Shootfly attack	Sorghum	Poor stand establishment		✓✓	✓✓
Early season drought	Sorghum Millet	Poor stand establishment			✓✓
Midseason drought	Sorghum Millet	Reduced yield			✓
Excess late season rain	Sorghum	Ear head bugs, grain mold			
Late season drought	Pigeon pea	Reduced yield			
Pod borer attack	Pigeon pea	Damaged pigeon pea pods			

[a] Checks denote the expected strength of compensation.

would expect a negative correlation between yields of the two crops, that is, low yields from one crop would be associated with compensation or higher yields arising from reduced competition from the other crop. Lower correlation coefficients would imply greater risk buffering capacity. The size of such correlations based on yield data purged of management effects depends on the multivariate distributions of yield risk and their crop specific interactions. For this particular cropping system, we would expect a positive correlation between sorghum and millet yield and a zero or slightly negative correlation between the yield of either cereal and pigeonpea.

As expected sorghum and pearl millet yields are significantly and positively correlated at .63, while they are insignificantly associated with pigeonpea yield at .06 and .11, respectively. The evidence indirectly suggests that for this cropping system intercropping provides little risk protection per se. The same finding applies to the second cropping system featuring three long duration crops, local cotton, local sorghum, and pigeonpea that are cultivated in a more assured rainfall environment in Kanzara village. Adjusted yield data for 190 plots show significant correlations (.42, .25 and .15) at the 5% level between yields of cotton and sorghum, cotton and pigeonpeas, and sorghum and pigeonpeas. One would expect such a result for crops that mature at about the same time.

Another approach to the analysis of yield stability in intercropping is to adopt a bounded rationality perspective and test the extent that intercropping reduces the risk of crop failure (Singh 1981; Singh and Walker 1982). These studies are based on data from about 5700 fields cultivated by 180 farming households in the ICRISAT VLS villages. About 60% of the plots were planted in sole stands and the remainder were intercropped. Equating complete crop failure to those plots where no grain was harvested by the farmer gives empirical probabilities of crop failure of about .11 and .05 for sole cropping and intercropping, respectively (Table 9). Defining crop failure in this way stacks the odds in favor of accepting the hypothesis that ceteris paribus intercropping leads to a significant reduction in crop failure. This is in fact what Singh and Walker (1982) find in a dichotomous variable probit analysis where complete crop failure is regressed on soil, seasonal, cropping year, village, and management variables. Intercropping is positively and significantly associated with crop success.

Changing the definition of the dependent variable to partial crop failure reverses these findings. Although the probability that all crops fail in an intercrop is low, failure of at least one crop is fairly common and exceeds .20 for this data set. When the dependent variable is redefined as failure of the main crop, intercropping enhances the likelihood of crop failure.

Table 9. Complete and partial crop failure for 180 farmers in six villages of the Semi-Arid Tropics of India from 1975-76 to 1979-80.

Crop failure by type of cropping system	Number of plots where no grain was harvested	% of failed to total plots
Complete crop failure		
Sole cropping	403	10.8
Intercropping	107	5.4
Partial crop failure in intercropping		
First crop only	52	2.6
Second crop only	189	9.6
Third crop only	72	3.7
First and second crop	84	4.3
First and third crop	9	0.5
Second and third crop	45	2.3

Source: Constructed from Singh 1981 and unpublished VLS data.

Like the results of the preceding analysis, these findings are only suggestive because we do not have data on identifical crops in pure stands in farmers' fields. It is safe however to say that the effect of intercropping on crop failure is extremely sensitive to how crop failure is defined. The truth probably lies somewhere between the definitions of complete and partial crop failure. In other words, for most cropping systems studied in the villages, the pure risk reduction impact of intercropping on crop failure is probably negligible. We conclude that the risk protection offered by intercropping in and of itself is a much smaller order of magnitude than that afforded through enterprise diversification. By the same token, intercropping does not appear to imply a significant efficiency loss.

RISK MANAGEMENT AND THE DESIGN OF CROP INSURANCE PROGRAMS

Any new policy aimed at enhancing risk management by small producers should augment or make more effective the choices available to farmers to manage risk. An analogy can be drawn to public sector price stabilization policies that may displace traders and speculators, reduce price stability imparted to the market through private arbitrage, and thus result in little or no improvement in price stabilization (Peck 1977). Well intentioned rural development projects that wed crop insurance to new technical packages in an effort to speed up initial adoption and diffusion have the potential to diminish the effectiveness of risk management. "Bad" agronomic advice clustered into a package mixed with crqp insurance as an enticement for farmers can lead to disasterous and costly results. The fault does not lie with crop insurance per se but rather with the lack of information on how well the recommended technology holds up in farmers' fields and with sequential tying conditions embodied in a package approach that limit the small farmer's flexibility to respond to rapidly changing yield risk during the cropping season.

A pilot crop insurance scheme for hybrid cotton in Gujarat in India is illustrative of what can happen when "optimal" technology is packaged for extension to farmers and meets suboptimal field conditions. This bold experiment was promoted by the Gujarat State Fertilizers Company, was financed by a commercial bank, and was backed by the General Insurance Corporation of India (Choudhary, 1977). About 150 farmers participated in the scheme during its operation from 1972-73 to 1974-75. Claims for indeminities were monitored on an individual plot basis and were determined by crop cuts taken by staff from the fertilizer company.

Participants were insured up to the cost of cultivation which was about Rs. 2000 per acre which is equivalent to about a 100% increase in expenditure over what they typically invested for local or <u>desi</u> cotton.

Because of this intensive level of investment and because previous experience by the fertilizer company showed that hybrid cotton was a high risk, high return venture, the project certainly looked like a good test case where crop insurance could mitigate the severity of risk as a constraint to the adoption of improved practices.

The evaluation study (Choudhary 1977) requested by the state fertilizer company reported a number of unanticipated to outcomes from the scheme. In all three cropping years, nonparticipant households cultivating local cotton had net returns per acre higher than participant households with insured plots. In two of the three years, participating households also received higher returns from local cotton grown in uninsured plots than from hybrid cotton planted in insured fields. Indeminities paid during the three cropping year were 53, 1642, and 434% of the value of the premia collected. The observations from the evaluation report listed in Table 10 provide a thumbnail sketch of reasons for these results.[15]

PROVISION OF INFORMATION, RISK ADJUSTMENT, AND CROP INSURANCE

With hindsight it is easy to see what went wrong with the hybrid cotton project which is one of the few experiences with institutional crop insurance in India. This case study underscores the importance of providing information through on-farm testing of technology in less protected environments to understand sources of risk and their interaction with prospective technologies. There is mounting normative and positive evidence (Goodwin et al. 1980, Walker 1981) that differences in risk perceptions are much more important determinants in decision making under uncertainty than differences in risk attitudes. Promising new research and extension approaches, such as the research methodology used by the Instituto de Ciencias de Tecnologia Agropecuaria (ICTA) in Guatemala (Hildebrand 1977) and the Training and Visit (T&V) Extension System (Benor and Harrison 1977) in parts of Asia, are available to allow farmers to be more active participants in the technology generation and diffusion process on a routine basis.[16] An investment in activities that that generate more and better quality technical and institutional information could more favorably enhance small farmer risk adjustment than an investment in crop insurance.

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15. Choudary concluded that "such a scheme would be more suitable where production is stable, perennial irrigation sources are in existence, and farmers have assured access to irrigation facilities (p. 7)". Such a protected environment would also wipe out any potential payoff from crop insurance.

16. Nonetheless, no improvement in methodology will compensate for the declining trends documented by Trigo and Pineiro (1981) in budgetary support for agricultural research and manpower training in several countries in Latin America.

Table 10. Observations by Choudhary (1977) on the Crop Insurance Scheme for Hybrid-4 cotton in Gujarat.

Type of observation	Excerpt
Problems of moral hazard	It was further alleged by villagers that some of the participants had avoided interculturing, weeding, application of last dose of fertilizers, etc., when they realized that they would not obtain the expected yield (p.144). When the participants felt that, due to adverse climate or other reasons, they would hardly obtain more than the minimum assured yield, they did not take care to follow the instructions on the insured plots (p.188).
Unreliability and lack of profitability of the recommended technology	Due to heavy and constant rains in the months of August and September 1973, tractor mounted sprayers and dusters were immovable in black cotton soil (p.181) It was surprising to find that the non participant households earned a net profit of Rs. 698, while the participant households sustained a loss of Rs. 425 per acre (p.143).
Inflexibility of the package approach	Due to heavy rainfall, the participants did not use fertilizers and pesticides in required quantities on uninsured plots but they could still get the yield equal to the average assessed yield on the insured plots (p.142).
Unperceived source of risk	In some cases, ..., where wells were the only source of irrigation, well owners promised to supply water to farmers for growing Hybrid-4 cotton but when the crop required to be irrigated, they did not supply the water for one reason or another, with the result, farmers grew unirrigated Hybrid-4 cotton (p. 72).

Information on sources of risk is also important for the ex-ante evaluation of crop insurance. The importance lies not in actuarial calculations but rather in achieving a preliminary understanding of the effectiveness of small farmer risk management in coping with varying sources of sequential risk that conditions technology by environment interactions. For example, we illustrated that small farmers and farmers in general have various means at their disposal to adjust to risk at the time of planting. As the crop reaches physiological maturity the scope for risk management appears to narrow exponentially. This probably explains to some extent why there is a demand for private sector crop insurance that is contractually tied to sources of risk that inflict damage near harvest. If breeders cannot incorporate sources of resistance into the crop - it is difficult to find cultivars resistant to fire and hail - and agronomic control is not possible, then the potential benefits from crop insurance would appear more tangible.

IMPLICATIONS AND CONCLUSIONS

In the analysis of small farmer risk adjustment, we have highlighted a few implications for crop insurance. Programs should be designed with a minimum of typing conditions so that the integrity of farm risk management is preserved. An understanding of the sources and timing of agroclimatic risk is valuable to determine whether commodity crop insurance expands the set of risk management options available to the farmer or substitutes for effective management practices. Heterogeneity of production microenvironments may allow regional crop insurance programs to pool risks more widely over many areas, but small farmers may also be able to diffuse risks through spatial diversification and other enabling mechanisms.

Even within a village, a homogeneous area approach to crop insurance may not lead to crop revenue stability for many producers. We cited one example where, for about 40% of the farmers, yields were inversely related to village average yields over six cropping years. For the other cropping systems, yields varied significantly on average over time and resulted in positively correlated farmer and village average yields. This finding suggests that a homogeneous area approach will have greater success in achieving crop revenue stability for those cropping systems that are associated with high yield risk in unassured production environments.

Based on village-level data in rural South India, we found convincing evidence that tenancy was actively used to spread production risk within and across cropping years. Contrary to expectations, intercropping in and of itself did not appear to contribute much to yield stability.

The effectiveness of risk adjustment by small farm households is largely an empirical issue. Households economics that features intertemporal decision making can furnish some insight, but the single most important constraint to improving our understanding of small farmer's risk adjustment is the paucity of panel data over many years of relatively large samples. For crop insurance, knowledge about the influence of crop revenue on consumption stability is sorely needed. While we may not know as much as we would want, we are sure that when tenancy is banned, mechanization is subsidized, and capital is underpriced in the formal market, risk management by small farm households suffers and the burden of adjustment falls more heavily on landless laborers. We are less sure that a public sector remedial program of crop insurance is a partial cure or even a step in the right direction.

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