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Risk Benefits, Crop Insurance, and Dryland Agriculture

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Participation by farmers in voluntary, public-sector crop insurance programmes has historically been low. We analyse one important determinant of farmers' participation—the potential for crop insurance to reduce household income variability. Based on simulated crop insurance designs carried out on household panel data, we find that crop insurance is not effective in smoothing fluctuations in income.

The simulation results point to some general conditions that have to be satisfied if crop insurance is to generate measurable risk benefits. We argue that those conditions are unlikely to be met in India's Semi-Arid Tropics. What defeats crop insurance in dryland agriculture is area variability which is largely attributed to households responding to rainfall events.

Because crop insurance scores such low marks as an effective stabilisation policy, rainfall lotteries and rural public works are also evaluated. Both of these institutional alternatives could be or are superior to crop insurance as a means to reduce income variability for large numbers of rural households in India's Semi-Arid Tropics.

IN a recent issue of the *EPW*, Dandekar (1985) discussed in detail the workings of the pilot crop insurance schemes tested since 1979 in several states of India. Dandekar expressed concern that farmers' participation in the schemes left a lot to be desired.

Lack of farmer acceptance is not unique to the Indian pilot schemes, but is characteristic of voluntary public-sector crop insurance programmes including some that are subsidised much more heavily than the Indian pilot schemes (Nieuwoldt and Bullock 1985; Gardner and Kramer 1986). In this paper, we argue that farmers are reluctant to participate because crop insurance is not effective in protecting households from crop income risk even in highly uncertain, dryland production environments typical of the Semi-Arid Tropics (SAT) where yield risk is often an order of magnitude three to four times greater than price risk.

The argument is based on the modest and in most cases negligible risk benefits estimated from simulated crop insurance designs carried out on data from a 9-year household panel. Such data are a unique source of information to evaluate the consequences of different stabilisation policies on fluctuations in household income. The village study results point to some general principles or conditions that have to be satisfied if crop insurance is to generate sizeable risk benefits. In particular, what defeats crop insurance in dryland agriculture is area variability which is largely conditioned by households' response to the weather.

Because crop insurance scores such low marks as an effective stabilisation policy, two institutional alternatives, rainfall lotteries and rural public works, are examined later in the paper. We believe that both of those alternatives could be or are superior to crop insurance as a means to reduce income variability for large number of rural households in India's SAT.

Before addressing risk benefits conceptually and empirically, we briefly review why risk benefits have remained a neglected theme in the literature and how crop insurance has evolved as a policy in India. That knowledge is essential to following the reasoning in the rest of the paper which ends with a discussion of some economically questionable suggestions often made to surmount the problem of low farmer participation in voluntary crop insurance programmes.

Cost of Crop Insurance

The risk benefits of and the consequent demand for crop insurance has not attracted as much attention in the literature as the cost of providing insurance. Concentrating research effort on the supply side is justified because the fundamental problem with public sector crop insurance is that the costs to the exchequer are potentially high and those of an ill-conceived programme can be catastrophic. The two developing countries that have invested most heavily in crop insurance are Mexico and Brazil. In 1981, the Mexican government spent more than Rs 600 crore in subsidies on crop insurance that over time evolved into an income maintenance scheme for poor dryland cereal and grain legume producers (Bassoco, Carter, and Norton 1986). In that same year, indemnities paid to farmers approached Rs 300 crore in a federal crop insurance programme in Brazil (de Rezende Lopes and Leite de Silva Dias 1986). That programme paid out about 40 times more than it took in during its initial years of operation in 1975 and 1976.

Expenses on administration are often only a small component of total costs. Hidden costs are associated with moral hazard and adverse selection which can be endemic in ill-designed crop insurance programmes. Moral hazard is synonymous with farmers taking advantage of weaknesses in programme design while adverse selection means that participants in the programme are not representative of the target population of interest. For example, farmers in the heavily subsidised Brazilian programme found it profitable to plant upland rice with grass seed and claim indemnities on the failed upland rice which was not harvested. They had their pasture established courtesy of the government's subsidised crop insurance programme (de Rezende Lopes and Leite de Silva Dias 1986).

Farmers on more marginal land within a designated region have often been more likely to participate in crop insurance (Walker 1982). Better farmers are adversely selected against which invalidates the basis for actuarial calculations in a voluntary crop insurance programme. Given the scope for moral hazard and adverse selection to manifest themselves, most practitioners recommend that programmes evolve over time after an initial phase of experimentation characterised by learning by doing.

Crop Insurance in India

With regard to crop insurance, India has done better than most countries for two reasons: (1) the public sector has not invested that much in crop insurance and (2) whatever investment that has been made has been allocated to schemes that, for the most part, were financially sound.

The recent history of crop insurance in India is chronicled in Dandekar (1976), Agarwal (1980) and Dandekar (1985). That history is marked by the following events:

(1) In 1965, the Centre proposed a Model Crop Insurance Scheme.
(2) The state governments refused to participate in that scheme without substantial subsidisation by the Centre.
(3) In 1971, an Expert Committee was formed to evaluate the Model Scheme. It decided against crop insurance.
(4) In 1972, an experimental crop insurance scheme was established to promote

hybrid cotton production in selected areas of Gujarat.[1]

(5) In 1979-80, an innovative pilot crop insurance programme, based on a homogeneous area rather than an individual farmer approach, along the lines suggested by Dandekar (1976) was initiated by the Government Insurance Corporation and the state governments in selected areas of Gujarat, Tamil Nadu, and West Bengal. That programme was subsequently expanded to other states and commodities over time.

The pilot insurance schemes, started in 1979, are financially healthy because assessing premia and especially indemnities on a homogeneous area approach essentially eliminates problems of moral hazard and adverse selection (Dandekar, 1976). Loss ratios, indemnities paid divided by premia collected, have only exceeded 1.0 in relatively few states, crops, seasons, and years (Dandekar, 1985). Data in Dandekar's comprehensive Appendix Tables (pp A-57 and A-58) indicate that over five cropping years from 1979-80 to 1983-84 the total loss ratio was a respectable 1.10. Administrative costs are also less in a homogeneous area approach.

Placing crop insurance on a sound financial footing is a very large achievement, but financial health of the insurer does not translate into participation by farmers. We now turn to analyse reasons for low farmer participation.

Risk Benefits Conceptually

Stabilisation policies like crop insurance can benefit producers in two ways. They can increase mean income levels or reduce income variability (Newbery and Stiglitz, 1981). The former are referred to as transfer benefits, while the latter are usually called risk benefits.[2] Transfer benefits arise largely from the level of programme subsidies and the degree of specialisation into riskier but more profitable technologies or crops as a result of participation in the programme. Transfer benefits are very location specific and depend on commodity supply and demand elasticities. They often wind up in the hands of consumers.

Risk benefits of a stabilisation policy are identified with how much farmers would be willing to pay to smooth fluctuations in income and consumption. How much they would be willing to pay depends on their preferences for risk taking, on their perceptions of how much participation in a crop insurance programme would result in lessened household income variability, and on their ability to adjust to income risk through ι a sactions in credit and asset markets an changes in storage position. If farmers we risk averse, if they perceived that cro insurance could significantly redu household income variability, if they coul not cost effectively adjust to income risk, w would expect them to participate in a cro insurance programme provided the premi costs were not that large.

In this paper, we focus on the second c the three components that condition pa ticipation, namely the perceived conse quences from enrolling in a stabilisation prc gramme, like crop insurance, on househol income variability. The conventional way t analyse variability consequences in th economics literature is to compare the coei ficient of variation (CV) of househol income with and without participation in th programme (Newbery and Stiglitz, 1981) Large risk benefits are obtained when th CV with simulated programme participatio is substantially lower than the actual CV. I contrast, when we impose different pro gramme designs on household incom streams and arrive at little or no change ir income CVs we have every reason to expec that the risk benefits from and the conse quent demand for an unsubsidised crop insurance programme will be negligible. Few farmers would invest in an unsubsidised stabilisation programme if they did not believe that participation would have a measurable impact on dampening income variability. Before outlining the simulated crop insurance designs and quantifying their risk benefits, we describe the data base in the next section.

Table 1: Agroclimatic, Socio-economic, and Technological Features of Three Indian SAT Villages from 1975-76 to 1983-84

Village (Region, District, Soils, Annual Rainfall)	Average Size of Operational Holding (Hectares)	Irrigated Area (Per Cent Gross Cropped Area)	Common Crops	Improved Technologies Adopted
Aurepalle (Telangana, Mahbubnagar, Alfisols, 620mm)	4.3	21.4	Irrigated paddy, castor, sorghum	HYV paddy, HYV castor, fertiliser on irrigated land
Shirapur, (Bombay Deccan, Sholapur, deep vertisoils, 660 mm)	4.8	9.4	Sorghum	Fertiliser on irrigated land
Kanzara (Vidharbha, Akola, medium deep vertisols, 930 mm)	5.0	7.1	Cotton, sorghum	Hybrid sorghum, fertiliser, insecticide and mechanical threshing

Table 2: Descriptive Information on the Common Crops Sown in the Study Villages from 1975-76 to 1983-84

Crop	Village	Number of Farm Households*	Number of Mean Years Cropped	Per cent of Gross Cropped Area	Coefficient of Variation (cv)** in Per Cent: Household Income	Yield	Price
Irrigated paddy	Aurepalle	9	8.1	12	47	31	7
Castor	Aurepalle	23	7.6	34	45	68	22
Sorghum	Aurepalle	21	7.3	18	41	66	12
Sorghum	Shirapur	21	8.3	58	34	69	17
Cotton	Kanzara	26	8.2	51	33	44	15
Hybrid sorghum	Kanzara	18	7.2	8	34	66	13

Notes: * Those that planted the crop for at least 5 years from 1975-76 to 1983-84.
** Simple means across those households that planted the crop in at least 5 years from 1975-76 to 1983-84.

Villages, Data, and the Weather

We rely on longitudinal data from three villages which broadly reflect three soil, climatic, and cropping regions of India's Semi-Arid Tropics (Table 1). Production risk is significantly greater in drought-prone Aurepalle and Shirapur than in rainfall-assured Kanzara.

The institutional environment for risk adjustment is also considerably different among the villages. Shirapur and Kanzara belong to Maharashtra State which has invested heavily in public works projects, most notably the Employment Guarantee Scheme (EGS). The EGS is active in both villages particularly in Shirapur.[3] Non-governmental off-farm wage earnings in excavating and transporting sand for construction contractors have also been a substantial source of employment for labour market participants from Shirapur. In Aurepalle in Mahbubnagar district of Andhra Pradesh, households do not have nearby access to a government employer of last resort, and the labour market is less buoyant than in the Maharashtra villages. Households in Aurepalle have to rely much more heavily on private means to smooth fluctuations in household income.

The data come from the ICRISAT village studies. In 1975, a panel was drawn from a random stratified sample of small-, medium-, and large-sized farming and landless labour households in each village. Forty households were selected in each village, 10 from each stratum. The data source is described in Binswanger and Jodha (1977) and in past articles (Binswanger 1977, Jodha 1981) in the *EPW*. Household data on plot cultivation, transactions, and labour market participation, wages, and employment were collected by a resident investigator during 3 to 4 week periods. Information on eight other schedules was updated annually.

Household income is estimated for nine cropping years from 1975-76 to 1983-84. Concepts and procedures used to estimate income are given in Singh and Asokan (1981). Income conceptually refers to net household income which represents returns to family labour, management, owned bullocks, capital, and land. Revenues and expenses from both farm and non-farm activities were included in estimating net household income. Dowry and other large transactions pertaining to life-cycle events were excluded.

The analysis relates to the 'continuous' cultivator households who remained in the panel from 1975-76 to 1983-84. For those households, information on fluctuations in income is summarised by the coefficient of variation of net household income. A CV is estimated for each household based on 9 years of income data deflated by a village specific consumer price index.

Any analysis of household income variability would be incomplete without placing the period of study into a climatic perspective. Based on data from rain gauges installed in the villages, the 9-year period of analysis was punctuated by good and bad rainfall years. In Aurepalle, there were four 'bad' years when total annual rainfall dipped below 80 per cent of normal. In Shirapur, total annual rainfall also varied considerably over the nine years. Consecutive drought years in 1976-77 and 1977-78 were sandwiched between favourable rainfall years in 1975-76 and 1978-79. Consistent with the descriptor 'rainfall assured', inter-year precipitation was less variable and higher in Kanzara than in the other two villages. All in all, the nine years represented a fair sampling of dry and wet rainfall events, but an exceptionally dry year, such as 1972-73 whose frequency Lajedinsky termed "never in a 100 years" when rainfall was only 25 per cent of normal, did not occur (Walinsky, 1977).

Risk Benefits Empirically

To measure risk benefits derived from participating in a crop insurance programme, we focus on the most common crops grown in each village. Those crops include irrigated paddy in Aurepalle and five dryland crops—kharif sorghum and castor in Aurepalle, rabi sorghum in Shirapur, and desi cotton and hybrid sorghum in Kanzara. We include in the analysis those cultivators who grew the crop in at least five of the nine years. With the exception of hybrid sorghum in Kanzara, many of the sample farm households planted the crop, but in varying area, each year.

Descriptive information on the households cultivating the common crops is presented in Table 2. Several points are worth mentioning. First, many of the so-called common crops were not actually that common reflecting a diversified cropping pattern typical of dryland agriculture in India's SAT. The most common village cropping system is rabi sorghum in Shirapur which accounted for about 58 per cent of gross cropped area in the village. Although hybrid sorghum is the second most common cropping system after desi cotton in Kanzara, it was planted on average to only about 8 per cent of gross cropped area. Secondly, mean household income CVs between 33 and 47 per cent reinforce the popular image of production uncertainty in dryland agriculture in India's SAT. (Still only 10 of the 81 continuous cultivator households had CVs exceeding 50 per cent.) We should also not be surprised that the CVs are higher in Aurepalle than in Shirapur where off-farm employment opportunities are more ample or in Kanzara where the production environment is not as harsh. Lastly, yield variability on average was an order of magnitude 3 to 5 times greater than price variability. Prices were remarkably stable over the period of analysis. Such stability is essential for crop insurance to generate sizeable risk benefits. Unfortunately, as we shall soon see, there are several ingredients in the recipe.

To assess the range of risk benefits potentially offered by crop insurance, we investigate two contrasting designs. One is an individual approach where the basis for both premia and indemnity assessment is each farmer's yield; the other is a homogeneous approach with indemnity claims and premia charges based on village yields. We assume 75 per cent yield coverage in both designs. Farmers are compensated when their yield falls below the 75 per cent level of either their mean yield (in the individual design) or the village average yield (in the homogeneous area approach). Compensated yields are multiplied by the same year's price to exploit the potential stabilising impact of negative yield price covariances. Indemnity payments are then added to household income net of break-even premia costs. It is assumed that the government bears the full administrative costs of the programme.

Our assessment is also based on the assumption that the household does not materially change its behaviour in response to the programme.[4] Thus the simulated results in Table 3 show how much income stability could be achieved over and beyond whatever risk management alternatives the household availed itself of.

Risk benefits from each design are measured in two ways. In columns (3) and (5) of Table 3, we present estimates of the mean per cent reduction in the CV of household income with participation in the crop insurance programme. The estimates in columns (4) and (6) are more formally grounded in economic theory and reflect what a household would be willing to sacrifice in terms of its mean income level to gain the reduction in household income variability derived from crop insurance. The risk benefit for each household is synonymous with the proportional risk premium which is calculated by multiplying one-half the difference between the squared CVs with and without insurance by an index of risk aver-

TABLE 3: SIMULATED RISK BENEFITS FROM PARTICIPATING IN ALTERNATIVE CROP INSURANCE DESIGNS

Crop	Village	Crop Insurance Design			
		Homogeneous Area		Individual	
		Mean Reduction in Per cent in Household Income CV	Mean Proportional Risk Premium*	Mean Reduction in Per cent in Household Income CV	Mean Proportional Risk Premium*
(1)	(2)	(3)	(4)	(5)	(6)
Irrigated paddy	Aurepalle	4.24	0.85	3.93	0.80
Sorghum	Aurepalle	0.58	0.11	0.56	0.09
Castor	Aurepalle	4.04	0.99	3.05	0.64
Sorghum	Shirapur	1.10	0.32	1.66	0.25
Desi cotton	Kanzara	−0.91***	0.05	1.21	0.15
Hybrid sorghum	Kanzara	−0.64***	0.10	−0.40***	0.33
Paddy sorghum, and castor**	Aurepalle	2.60	0.53	2.20	0.50
Cotton and sorghum**	Kanzara	1.55	0.15	1.65	0.18

Notes: * Per cent of mean household income from 1975-76 to 1983-84.
** For households that planted at least one crop in five or more years.
*** Negative signs indicate that participation in the crop insurance design would have increased the mean CV of household income.

sion called the relative risk aversion coefficient. The value of the latter is often assumed to be 1.0 (Newbery and Stiglitz 1981).[5] The proportional risk premium is expressed as a per cent of mean household income.[6]

The results in Table 3 are not encouraging. For all common village crops, the risk benefits from crop insurance range from modest to negligible. Crop insurance is simply not an effective means to reduce income variability for the vast majority of farm households cultivating the crops most often grown in the study villages. Of the common cropping patterns, apparent risk benefits would be derived from insuring castor and paddy in Aurepalle. But insurance would only reduce household income variability by 3 to 4 per cent; such a modest reduction would be worth only about one per cent of mean household income.

Some risk benefits would also accrue to farmers participating in a multi-commodity crop insurance scheme in Aurepalle but even those gains are small compared to a benchmark of perfect net crop revenue stabilisation. If net crop revenue could be stabilised at its mean level over the nine years, the risk benefits could be sizeable ranging from a 62 per cent reduction in household income CV for paddy cultivators in Aurepalle to a 30 per cent decrease for cotton growers in Kanzara. When we estimate and compare mean proportional risk premia from perfect crop revenue stabilisation with those from the simulated crop insurance designs in columns (4) and (6) in Table 3, we find in general that enrolling in the simulated crop insurance schemes exploits relatively little of the potential risk benefits derived from perfect crop revenue stabilisation. The mean proportional risk premium for multiple commodity crop insurance in Aurepalle is about 9 per cent of the estimated mean proportional risk premium from perfect crop revenue stabilisation. Multiple crop insurance in Kanzara only taps about 5 per cent of those potential risk benefits. With the exception of castor in Aurepalle (at 17 per cent), the risk benefits from single commodity crop insurance are less than 10 per cent of those from perfect crop income stabilisation. Single or multi-commodity crop insurance doesn't make much of a dent in crop revenue instability which contributes proportionally more to household income variability than any other major income source (Walker, Singh, Asokan, and Binswanger, 1983).

Two other points are worth noting about the estimates in Table 3. Because both designs offer on average so little in the way of risk benefits we cannot say that an individual approach is superior (in terms of risk benefits) to a homogeneous area approach. We can however state that indemnities paid are more equitably distributed with the individual approach. Some farmers received relatively more indemnities than others in a homogeneous area approach because variability in planted area did not coincide with the timing of indemnity payments. For example, several farmers planting castor in Aurepalle would have received two to three times more in indemnities than they paid in premia; others took in much less than they paid out because they sowed relatively little area of the crop in those years when indemnities were triggered by low village mean yields and planted more area to the crop in the more productive years when indemnities were not paid. In principle, an individual approach doesn't suffer from such inequalities because the programme is tailored to the yield history of each farmer so that over time premia can be adjusted to indemnities paid The scope for such tailoring is one reason why crop insurance practitioners often prefer the individual approach.

The very modest reductions in income CVs in Table 3 indicate that few farmers would be willing to participate in the alternative crop insurance designs. One would have to assume much higher levels of risk aversion, far surpassing those commonly assumed in the literature, to generate significantly higher levels of participation. Additionally, if farmers had to bear the administrative costs, usually estimated at 6 per cent of insured yield for individually designed programmes operating in the world today (Hazell and Valdes 1984), participation would be severely curtailed.

TABLE 4: CROP INSURANCE AND SHORTFALLS IN HOUSEHOLD INCOME

Crop	Village	Number of Shortfall Households*		
		Without Crop Insurance	With Crop Insurance: Homogeneous Area Design	With Crop Insurance: Individual Design
Irrigated paddy	Aurepalle	7	4	4
Sorghum	Aurepalle	8	8	8
Castor	Aurepalle	12	9	11
Sorghum	Shirapur	7	3	4
Desi cotton	Kanzara	5	6	6
Hybrid sorghum	Kanzara	6	5	6
Paddy sorghum, and castor	Aurepalle	12	10	12
Cotton and sorghum	Kanzara	6	6	6

Notes: * Defined as a household which in one or more years recorded an income level less than 50 per cent of its median income from 1975-76 to 1983-84 (see text). The potential number of shortfall households varies by crop and is given in the third column of Table 2.

RISK BENEFITS AND BOUNDED RATIONALITY

The preceding analysis was based on a mean-variance approach. Income variability was measured from the continuous perspectives of CVs. Would the outcome have been more favourable to crop insurance if we used a bounded rationality framework in which risk benefits are assessed in discontinuous terms like disaster levels of income and minimum probabilities? While there are almost a limitless number of threshold levels of income and probabilities from which to choose, one intuitively appealing threshold concept is an income level below which the household is compelled to make a distress sale of land. That disaster level does not apply to the study villages because over the last 40 years distress sales of land have been rare. Moreover, land sales were not bunched in adverse rainfall years suggesting that household risk adjustment was at least minimally effective in dealing with covariate weather risk (Cain, 1981). Even during the massive 1971-73 drought in Western Maharashtra, few households in Shirapur parted with their land.

Rather than ignore the question posed earlier in this section, we did look at one simple bounded rationality event, the probability that a household would suffer a shortfall in income (in at least one of nine years) below 50 per cent of its median income. Many cultivators particularly those in households in Aurepalle fell into the shortfall category. Could participation in crop insurance have prevented them from suffering a such sharp shortfall in income? The data in the last column of Table 4 suggest that crop insurance would have made very little difference. This result is consistent with the realisation that yield risk was only one of several factors contributing to shortfalls in household income (Walker, Singh, Asokan and Binswanger, 1983).

AREA VARIABILITY AND COVARIATE SOURCES OF RISK

Why doesn't crop insurance in general and schemes based on a homogeneous area approach in particular generate larger risk benefits? The answer is clear—too many necessary and sometimes conflicting conditions have to be satisfied. One way to point out those conditions is to outline the features of an environment conducive to farm households receiving significant risk benefits from insurance. The ideal region would be characterised by the following:

(1) crop income should loom large in household income;
(2) farm households should specialise in few crops;

(3) output prices should be stable to ensure that price variability does not unduly influence revenue variability directly or indirectly through fluctuations in areas;
(4) crop supply should not depend heavily on agroclimatic conditions so that the link between weather-induced fluctuations in area and crop income could be broken; and
(5) yields from the insured crops should be exposed to at most a few and not multiple sources of risk so that indemnity assessment based on a homogeneous area approach could be efficient in stabilising income for most farmers in the region.

The first three conditions are self-evident and do not warrant further comment. Conditions (4) and (5) are more subtle. Their understanding is important because regions where (4) obtains are unlikely to overlap with geographic areas where (5) is satisfied.

Condition (4) addresses area variability which severely erodes the capacity of crop insurance to generate risk benefits in uncertain dryland production environments. When we calculate the coefficient of variation of area sown for each household like we did for yields and prices in Table 2, we find that mean area variability exceeds mean yield variability for each common cropping system.

A large share of area variability in dryland agriculture stems from decisions taken by farmers to cope with agroclimatic risk. Examples are not hard to find in India's SAT. Planned area for a crop often deviates markedly from actual area sown. Analysis of data from SAT districts suggests that relatively more area is planted to hardier coarse grains in low rainfall years (Bapna, *et al*, 1984). In the study villages, both castor in Aurepalle and post-rainy season sorghum in Shirapur are planted when farmers have some information on rainfall during the start of the cropping year. When the monsoon is late in Aurepalle, the potential for shootfly to inflict yield losses on sorghum is greater and farmers respond by substituting castor for sorghum. As a consequence of early season drought in 1977-78 the average area sown to local sorghum was halved while mean castor area increased by about 40 per cent. Similarly, in Shirapur farmers react to low rainfall years by planting less area to post-rainy season sorghum which is grown on residual moisture.

Perhaps the most poignant example of area variability in dryland agriculture occurs in the hard rock production regions where area sown depends on surface water collected in tanks and on groundwater stored in dug wells. If not enough water is available, crops, usually paddy, are often not planted. Ramaswamy *et al*'s (1986) finding that paddy yields in their North Arcot study villages in the dry early 1980s in Tamil Nadu did not differ markedly from yields in normal years illustrates that drought often manifests itself in reductions in area more than in shortfalls in yield.[7]

To address area variability in dryland agriculture with crop insurance, one needs to extend Dandekar's recommendation that the basis for indemnity payments with a homogeneous area approach should be a multi-crop yield index. That recommendation should be widened to cover both yield and area components. To derive such a multi-commodity production index, which is actuarily sound and administratively feasible, would be a challenging, even daunting, task.

Subsidised crop insurance programmes that have tried to cope with area variability by insuring failed plantings or ex-post area sown have been fraught with moral hazard probelms and have recorded high loss ratios. The US crop insurance programme in the early 1940s was one such case (Gardner and Kramer, 1986). For crop insurance to yield risk benefits, planned area, which is the basis for insurance, should coincide reasonably well with actual area sown to the insured crop.

In other words, condition (4) says that crop insurance will work better in the more stable production regions where area variability caused by climatic risk is less. Condition (5) implies the opposite. In those more assured production environments, there is not a dominant or monolithic source of risk like drought that affects crop yields in most farmers' fields in roughly the same way within the same cropping, year, i e, in the more assured production regions, the sources of risk are potentially less covariate because biotic stresses like insect pests and disease play a more prominant role. Less covariate sources of risk means that indemnities based on a homogeneous area approach will not stabilise and in some cases may even destabilise income (Roumasett, 1979). For example, for about 35 per cent of the desi cotton growers, from the respondent households in Kanzara, individual farmers' yields were inversely correlated with average yields within the same village from 1975-76 to 1980-81 (Walker and Jodha, 1986). Moreover, if the sources of risk are not that covariate within the homogeneous regions, farmers will rarely be indemnified.

Extending the same line of reasoning with regard to a multi-commodity crop insurance schemes, if the sources of risk are not that covariate across crops then farmers can self insure through crop diversification. In the more rainfall assured Akola region, where production risk arises from several physical and biotic stresses, crop diversification is effective in significantly reducing crop income variability (Walker, Singh, and Jodha, 1983). In the more rainfall unreliable Mahabubnagar and Sholapur regions, where production risk stems mainly from a single covariate source of risk—drought—, more diversified holdings have about the same level of crop income variability as less diversified farms. Therefore, absence of covariate risks in the more stable production environments has two implications for crop insurance based on a homogeneous area approach: (1) the timing of indemnities will not coincide well with years of low crop income for some (and most likely many) farmers in the region, and (2) the effectiveness of crop diversification will reduce the demand for multi-commodity crop insurance.

Conditions (4) and (5) clearly conflict. To satisfy (4) we need relatively assured production regions. To meet (5), we require drought-prone regions. Suppose we map those five necessary conditions and delineate geographic areas where they are satisfied in India's Semi-Arid Tropics. We believe that the intersecting set either in terms of geographic area or number of households would be very small.

RAINFALL LOTTERIES

If crop insurance does not deliver the goods in terms of risk benefits, what other institutional alternatives are available? Rainfall lotteries are one alternative that hold much more promise than crop insurance as an institutional means to cost effectively diminish rural household income variability in India's SAT. Rainfall lotteries or insurance are not a new or novel idea (Bardsley *et al*, 1984) but to our knowledge there are few if any cases where they have been tried though private or public sector finance.

Rainfall lotteries could be patterned along the lines suggested by the Australian Industries Assistance Commission in their 1978 report on Rural Income Fluctuations (Lloyd and Mauldon, 1986). Rainfall for the monsoon season or even for a critical month in the season could be divided into 5 or 10 intervals representing discrete events. Households would be free to buy lottery tickets on those events at the start of the rainy season. Payments would be based on rainfall data from the nearest rain gauge usually located in a taluka or tehsil headquarters. Over time the programme could extend its coverage by installing rain gauges in neighbouring villages. If participants felt that rainfall in their fields and/or village did not accord well with rainfall at the nearest station they would be free to spread their risk by purchasing tickets on rainfall in several nearby stations.

Rainfall lotteries offer several advantages over crop insurance in India's SAT. They would be a fair betting system and (as envisaged by Dandekar (1976) for crop insurance) would be open to all households in the village. If landless labour households felt the demand for their labour was markedly reduced in low rainfall years, they could hedge their future labour income by purchasing tickets on the lowest or what they perceived to be the most adverse rainfall events.

A lottery format would also allow farmers to protect their income from non-linearities between rainfall and yield. Too much rain is often as damaging to crop income in the Semi-Arid Tropics as too little rain. With rainfall lotteries, farmers could guard against unfavourable events associated with or too little too much rainfall.

Although rainfall is more covariate across space than yield, the insurer would likely be less exposed to risk because, with both hedgers and speculators in the market, offsetting positions would be held. Aslo, in a country as large as India, the monsoon is not that covariate across regions. In most years, rainfall is high in some regions, low in others. The geographic coverage for insuring rainfall would be much broader than for insuring yields of specific crops which are planted in well-defined regions. Both the lottery format and the more extensive geographic coverage should ensure that a rainfall insurer would be less exposed to risk of catastrophic loss in India's SAT than a crop insurer. The size of the country makes rainfall lotteries a much more attractive alternative in India than in smaller countries of the Semi-Arid Tropics.

Rainfall appears to be more removed from income than yield; however, in the lower and more variable rainfall dryland agricultural regions, rainfall may be a sounder basis for measuring fluctuations in crop revenues than yield. In those regions, rainfall should be positively covariate with cropped area. Deviations from normal rainfall at sowing also induce farmers to plant less remunerative crops. Hence, in the dryer less assured regions, rainfall may explain more of the variation in crop revenue variability through its combined effect on area and yield variability than the pure impact of yield variability.

A number of other points favour rainfall lotteries over crop insurance. In principle, rainfall is much more observable than yield and should be easier to measure. Participants in a self-funded rainfall lottery should be in a much better position to agree on what rainfall events obtained compared to farmers enrolled in a crop insurance programme which relies on yield assessments based on area sampling frames. Rainfall lotteries should also be relatively free from incentive problems related to moral hazard and adverse selection. They should also be administratively cheaper than crop insurance. Lastly, the actuarial basis for rainfall insurance is much firmer than for crop insurance. Rainfall records are extensive throughout much of India.

Rainfall lotteries also share some of the problems of crop insurance. Participation by the poorest households could be severely limited or even curtailed by liquidity constraints. Questions of how and when to collect bets and distribute winnings would have to be resolved. Installing a rain guage in every village would maximise demand for rainfall insurance, but this would also lead to increased scope to tamper with rainfall data. One could imagine a situation where all villagers collude, bet on the same event, and bribe officials to report fraudulant rainfall data so that that event is obtained. But such abnormal participant behaviour could be easily spotted at the start of the rainy season. When detected, such behaviour would lead to cancelling of the lottery. Inconsistent reporting would also stand out during the monitoring of daily rainfall data generated in a regional network of rain gauges.

Like crop insurance, administration of rainfall insurance would very much entail a learning by doing process ideally with a small start in geographically dispersed regions. The idea of rainfall lotteries may have have enough merit to be carried out experimentally. Primary interest in the experiment would centre on the demand for insurance as reflected by the incidence and characteristics of participants who take hedging positions by purchasing tickets on adverse rainfall events.

Nevertheless, we are not optimistic that participation in a rainfall lottery would generate sizeable risk benefits for participants. Of the three study villages, only in Shirapur was total rainfall significantly correlated with mean village net household income over the nine-year period of analysis.

Also, rural public relief measures are usually triggered on rainfall assessments thereby making rainfall-based insurance (to some extent) redundant. Demand for such insurance would be particularly reduced in regions where politicians are quick to appeal for state and Centre assistance at the slightest indication that the monsoon is capricious (Morris, 1974).

RURAL PUBLIC WORKS SCHEMES

Most readers of the *EPW* are aware of the strengths and weaknesses of public works programmes. In particular, Maharashtra's ambitious Employment Guarantee Scheme (EGS) has been evaluated from several perspectives in past articles in the *EPW* (Dandekar and Sathe, 1980, MHJ, 1980, and MHJ, 1982 only represents a sampling). Nonetheless, few analysts have focused their attention on the elusive issue of risk benefits, that is, how effective has the EGS been in smoothing income variability of potential participants.

Evidence on inter-year fluctuations in participation rates suggests that the EGS has been effective in some localities hit by drought and other events that adversely affect production. The ability of the scheme to respond in times of need is supported by the following examples:

> ... cultivators in Western Maharashtra and Marathwada (central districts) flocked to EGS sites after sowing operations were disrupted by lengthy dry spells during the 1979 monsoon; attendance rose sharply and remained high in Vidarbha (eastern portion of the state) when August flooding destroyed the paddy crop in many localities. Similarly, a poor rabi crop due to insufficient s moisture was reflected in unusually high E attendance during April-July 1983; flood in Marathwada resulted in relatively high p ticipation levels from August 1983 onw (Lieberman, 1984, p 7).

More quantitative, although fragmenta evidence, on the potential for flexible, loc public-works programmes like the EGS generate risk benefits comes from the stu villages. That evidence is based on compa ing levels of household income variability drought prone Shirapur and Aurepall Landless labour households that reli almost entirely on earnings in the dai agricultural labour market in Shirapur ar Kanzara, where the EGS operated sinc 1977, had about 50 per cent less variab income streams than those in Aurepall where rural public work opportunities wei not locally available. Only in Shirapur wa labour's share in income inversely an significantly associated with the CV of ne household income, suggesting that a con siderable number of the respondent house holds relied on off-farm earning oppor tunities to smooth fluctuations in income But these results should be interpreted witl caution because there are only 8-9 house holds in each village by farm-size category Moreover, differences in village ecologie other than the availability of rural public-works employment and other off-farm employment opportunities also conditioned the degree to which shortfalls in income could be compensated for by labour market earnings.

Still, and despite widely acknowledged shortcomings, a public works programme like the EGS is the best institutional bet to protect a large number of poor rural households from the ravages of income variability in India's Semi-Arid Tropics. No other institutional alternative can as cost effectively select for those in need (Jodha, 1978). Evaluations that do not account for the size of risk benefits or that do not consider the opportunity cost of generating such benefits *via* other institutional means do not do justice to such schemes.

CONCLUDING COMMENTS

We conclude by discussing some recommendations, frequently mentioned in the popular literature, on how to overcome the problem of low farmer participation in voluntary insurance programmes. Some individuals advocate compulsory crop insurance. If crop insurance is administered as crop-credit insurance, making crop insurance compulsory increases the cost of credit to clients who would not have voluntarily purchased insurance. Usually such farmers have greater risk bearing capacity and are some of the better clients of the institutional lending agency. Credit from other institutional and private sources will become more attractive to them. The problem of adverse selection is essentially ransferred from the insurer to the credit igency which will lose some of their better clients to other formal and informal sources Binswanger, 1986). As long as crop insurance s linked to credit, voluntary participation s only way to combat adverse selection to he credit agency.

Another way to entice more farmers to participate would be to increase the subsidy content of the programme. But subsidies are difficult to justify on either efficiency or equity grounds. We have already shown that risk benefits are likely to be negligible. Increased transfer benefits occasioned by more subsidies would accrue disproportionately to richer cultivator households who rely more heavily on crop revenue as a source of income and who also have greater access to subsidised institutional credit (Von Pischke, Adams, and Donald, 1983).

Crop insurance in India's SAT should be seen for what it is a regressive and ineffective stabilisation policy. Our results support the main conclusion of the 1971 Expert Committee chaired by Dharm Narain. "The Expert Committee, therefore, concluded that in the context of paucity of resources for planned development, a recurring expenditure on the administration of [the] crop insurance scheme, is not preferable to the direct utilisation of funds for raising agricultural productivity and reducing crop yield variability" (as cited in Agarwal, 1980, p 100).

Notes

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1 Anyone who believes that crop insurance can be used as a tool to transfer modern technology packages should read Choudhary's (1977) evaluation of the crop insurance scheme for hybrid-4 cotton in Gujarat. The scheme is illustrative of what can happen when optimal technology is packaged for extension to farmers and meets suboptimal field conditions. That experience "was not very encouraging for the General Insurance Corporation since it had to shell out in the form of indemnity nearly eleven times the amount it collected as premiums" (Agarwal, 1980, p 111). Choudhary 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, in the form of risk benefits, from crop insurance.

2 Mathematical programming and simulation models are the standard tools used to evaluate the size of risk and transfer benefits. These are often favoured by students in PhD thesis research (Djojo, 1983 and Falatoonzaden, 1983). While such models have their time and place, they have serious shortcomings in coming to grips with the issue of risk benefits. They usually rely on aggregate yield data which may severely underestimate yield risk at the farm level. They cannot readily mimic complex household responses, such as migration and increased labour market participation, to steep shortfalls in welfare. Nor can issues like within-season area adjustments in response to emerging agroclimatic information be readily addressed with such approaches.

3 From 1979-84, the EGS accounted for about 15 and 24 per cent of men's and women's labour employment (including own farm work) in Shirapur. Comparable figures for Kanzara were 13 and 5 per cent.

4 That assumption would not hold for some crops and locations. The assumption is strongest for Kanzara where opportunities for diversification are much greater than in Shirapur and Aurepalle. In Kanzara, yields in and revenues from hybrid sorghum production are considerably more variable than those in competing cotton intercropping systems. If yield variability were reduced in hybrid sorghum, farmers would shift some of their cotton area into hybrid sorghum production (Walker and Subba Rao, 1982). Nonetheless, because the demand for hybrid sorghum is very price inelastic, those transfer benefits would be short-lived and ultimately would end up in the hands of consumers.

5 To some extent, Newbery and Stiglitz based their choice of 1.00 on experimental evidence from the ICRISAT study villages (Binswanger, 1981). From the experimental results, estimates for partial risk aversion are on a much firmer footing than those for relative risk aversion.

6 The formula derived by Newbery and Stiglitz to estimate the proportional risk premium is not mathematically accurate (Kanbur, 1984), but, because we do not address the issue of transfer benefits, their derivation is correct for our application.

7 The role of area variability has not gone unnoticed by economic historians. McAplin (1983) found that year-to-year changes in acreage planted contributed the lion's share to variation in an index she constructed to measure the quality of the agricultural year in the erstwhile Bombay Presidency from 1886-87 to 1919-20.

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