PN-AAS-233 ISN = 38945

THE NEWSLETTER ARTICLE

ADJUSTMENT TO CLIMATIC VARIABILITY IN SELF PROVISIONING SOCIETIES: SOME EVIDENCE FROM INDIA AND TANZANIA

N.S. Jodha* and A.C. Mascarenhas**

INTRODUCTION

Climatic variability in the sense of inter-season or intra-season fluctuations in agriculturally relevant weather conditions is an important source of instability in farming. Depending upon the level of infrastructural development and integration of agriculture with the rest of the economy a variety of measures ranging from provision of assured irrigation to crop insurance schemes have been evolved to counter the weather induced instability in agriculture. However, in the case of self provisioning or subsistence oriented societies most of the formal means to combat instability and risk are not yet available. They still rely heavily on traditional adjustment devices. The latter in turn are integral parts of the traditional farming systems.

The adjustment mechanisms to face weather induced instability and risk in agriculture can be put under two categories. The first category could be called "adaptation" and include the features through which farming systems have adapted to the long term agroclimatic features of the region.

These features help in harnessing the favorable opportunities offered by the environment and also inject preparedness to defend against unfavorable situations created by erratic rainfall. The second category of features of farming systems include responses to short term fluctuations in weather conditions. They are adopted once intra-season weather conditions become unfavorable. We may call them "adjustments". Adjustments become possible because of adaptations.

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*Senior Economist, Economics Program, ICRISAT, Patancheru P.O., Andhra Pradesh 502 324, India; formerly Principal Economist, International Institute of Tropical Agriculture (IITA), Kilosa, Tanzania. **Director, Bureau of Resource Assessment and Landuse Planning, University of Dar Es Salaam, Tanzania. The authors are thankful to Bob Kates, James Ryan, Thomas Walker and Matthias von Oppen for valuable comments on an earlier draft of this paper. However, the authors alone are responsible for any errors of omission or commission. This is a revised version of a paper presented at the meeting of the Scientific Committee on Problems of Environment (SCOPE), set up by the International Council of Scientific Unions, at the Canadian Climate Center, Toronto, September 27-October 1, 1981. Submitted as C.P.No. 129 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

This paper using farm level data from parts of India and Tanzania discusses the adjustment mechanisms of self provisioning societies against weather induced instability in agriculture. The potential options emanating largely from new technologies to strengthen farmers' risk strategies are also discussed.

However, before we proceed further a few procedural issues may be touched. They are: to define or identify self provisioning societies and their perception of climatic variability. In place of strictly defining terms we prefer the description of situations as they obtain in the real world.

Self Provisioning Societies

Literally speaking, a self provisioning society is one where its members manage their production and consumption requirements by themselves, and the market or formal exchange transactions have little place in the system. However, such societies are hard to find in the present age except in completely remote habitats. A more meaningful definition of the term would include farming communities where the bulk of farm production inputs originate from the own farm and household, and most of the output is consumed by the household and satisfies the lion's share of the consumption needs of the household. The market or formal exchange plays a limited role as a link between the farmhousehold's production and consumption activities. Even when the dependence on the market is significant (as in the case of small holder producers of only certain cash crops like cotton) the objective in using the market is largely to support subsistence, rather than profit maximization. Methodologically, using the ratios of (i) home supplied inputs to the total inputs used on farms; (ii) home consumed output to total output; (iii) own farm consumption to total consumption, one can segregate self provisioning farming communities from highly commercialized farming communities and rank them on the basis of their degree of self provisioning or subsistence character.

In the largely rainfed farming areas in India several field studies have noted the extent of self provisioning. The important own- farm originated inputs such as human labor, bullock labor, seed, manures and fodder for draft animals account for 65-90% of total input use (Bharadwaj 1974). A similar percentage applies to the share of total consumption items originating from the consumer's farm. The extent of self provisioning is much higher in most parts of Africa (Ruthenberg 1968, 1976; Collinson 1972; Lagemann 1977, Abalu and D'Silva 1980).

The literature on subsistence agriculture or peasant agriculture has discussed the features of such communities at length (see Wharton 1969, Krishna 1969 and Mellor 1969).

The two features of such communities which have significant bearing on their adjustment to climatic variability are discussed below. On the one hand, to the extent tne household is both a major supplier of production- inputs and a major user of the final output, the production and consumption decisions are interlinked. The integration of the household (as a family unit) and farm (as a production unit or a firm) helps offer greater internal flexibility for alleviating the impact of climatic variability.

On the other hand, a reduced dependence of the farm households on the market implies less integration with the rest of the economy. This in turn reduces the farm households' capacities to transmit shocks of climatic variability to others, i.e. input suppliers, output buyers, landless laborers, etc. (unlike several commercial firms during the crisis period). Consequently, unless helped by external agencies like public relief works the farmers in self provisioning societies have to bear the weather-induced risk on their own. Furthermore, since their dependence on the market for purchase of inputs and disposal of the products is quite limited, weather-induced production uncertainties play a more important role than price and technology related uncertainties in shaping their adjustment strategies (Wharton 1968, Barah and Binswanger 1982).

Climatic Variability and Farmer Responses

The rationale and operational efficacy of farmers' adjustment strategies against climatic variability (used interchangeably with the term weather variability in this paper) can be appreciated better once one has some idea of farmers' perceptions. Accordingly, rainfall -- involving its amount, timing and duration -- is identified by the farmers as the dominating climatic variable. The agroclimatic areas, where low rainfall constitutes a principal source of risk, are characterized by high inter-year and intra-year variability of rains. Nevertheless, whenthe rains are normal or higher than normal (without serious flooding), they seldom get special attention. Rains lower than the normal or their unfavorable distributions are considered a cause of concern. Furthermore, the role of rainfall variability is perceived by the farmer in a short term context and defensive measures are adopted accordingly. However, as mentioned earlier the diverse measures adopted in order to meet the short term situation constitute integral parts of the farming systems which have evolved over generations in response to long term behavior of climatic and other variables, in a given geographical region.

The farmer's choice of adaptations and adjustments is ultimately influenced by the risk generating agroclimatic circumstances. Hence the patterns of farming practices differentiated on the basis of characteristics of weather

risk (ie. extent and reliability of rainfall in particular) can reveal the risk management elements in the farming systems. This is illustrated by three studies briefly reported in Tables 1, 2 and 3. Table 1 contrasts the extent of risk management practices in two areas of India with vastly different amounts of rainfall and probabilities of soil moisture to help the germination of crops. In Sholapur, more risky area of Shirapur farmers resort to more resource based and crop based diversification as an insurance mechanism against weather induced risk than in the more rainfall assured Akola region.

Table 2 contrasts the farming practices followed by farmers in Kilosa, Tanzania during short (uncertain) and long (certain) rains in the same year. Under the bimodal pattern the early rains received during November to mid-January are more uncertain. The late rains from February to early May are more certain and intense. Often there is not much difference in the total duration of rains, yet the two phases of rains are termed as short (early and un- certain) rains and long (late and certain) rains in the region. Practices which have grater probability of success or which can offer partial salvage value (eg. some returns in the form of green cobs, pods, etc.) despite unfavorable rains are adopted more during the short rains. Besides uncertainty of 'short rains', farmers' experience about relative incidence of diseases and pests in late or early planted crops affect their choice for salvage crops.

Table 3 contrasts the measures followed by farmers in the arid zone of India during a normal rainfall year and a drought year. Practices having greater potential for protecting crops, saving resources, and augmenting supplies (even of inferior products) despite the failure of rains gain significance during the drought year.

RELEVANT FEATURES OF FARMING SYSTEMS

The interrelated features of farming systems grouped under 'adaptations' or 'adjustments' are either group centered or individual centered. In some, traditional technology plays an important role and in others the role of institutional factors is more significant. The actual adoption of a measure or combination of measures earlier is largely a function of farmers' perception of a risky situation and efficacy of a particular measure to meet the situation. Since the ultimate objective of these measures is to handle a common factor, ie. risk generated by weather there is often a similiarity in adaptation/adjustment measures in different locations despite their cultural, infrastructural, and demographic differences.

Adaptations The evolution of farming systems in climatically unstable areas has imparted several features to the farming system which ensures its flexibility and viability in the

Table 1. Indicators of diversification strategies to handle weather risk in two areas with different degrees of weather risk in Semi-Arid Tropical India

	Akola villages	Sholapur villages
Characteristics of weather-risk		
Annual average rainfall (mm)	820	690
Probability of favorable soil moisture conditions for rainy season cropping	.66	.33
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		
-		
- Up to 0.5 miles	0.5	1.4
- Up to 1.0 mile	1.1	3.4
- Above 1 mile	0.1	1.0
Indicators of crop-based diversification		
Number of total sole crops planted	20	34
Number of total combinations of inter-crops planted	43	56
Crop-stock based mixed farming		
Crop income-livestock income ratio	94:6	89:11

Source: ICRISAT's village level studies (Jodha et al. 1977); Binswanger, Virmani, and Kampen 1980.
Table adapted from Walker and Jodha (1982)

Table 2. Relative differences in risk minimising farming practices during (uncertain) short rains and (more certain) long rains in four villages of Kilosa, Tanzania, 1980-81

	Short rains	Long rains
Characteristics of weather risk:		
Average rainfall (mm)	260	763
No. of rainy days	21	68
Chances of crop failure in 10 years[a]	5	1
Indicators of risk minimising strategies:		
Share of total low lying areas planted in the year (%)	83	17
Share of uplands planted (%)	26	74
Share of compound plot areas planted (%)	92	8
Share of total salvage crops in total crops of season (%)[b]	72	32
Share of intercropping in season (%)	95	79
Share of staggered planted area in the season (%)[c]	35	69

Source: Jodha (1982). Table adapted from Walker and Jodha (1982).

a. The term 'crop failure' refers to the situation when crops do not reach their maturity stage and hence even if some yield is received it is far below the normal. It varies from crop to crop. Yields are influenced most by season's rainfall. However, diseases, insects, and pests also play some role.

b. Salvage crops are those which can be utilized even when they do not mature due to failure of rains. For example, grain legumes whose leaves are consumed, or maize whose green cobs are consumed.

c. Despite more certainty of long rains, there is higher extent of staggered planting in this season to guard against intra-season variability of rains.

Table 3. Details of risk-loss minimizing activities during a drought year and non-drought year by farmers in the selected villages in arid zones of India

	Unit of observation	Drought year (1963-64)	Normal year (1964-65)
Characteristics of weather risk:			
Rainfall during the year	mm	159	377
Total rainy days	No.	8	21
Plot-based loss minimizing measures:[a]			
Collected weeded material as fodder	No.of plots	53	5
Harvested field borders for fodder	"	68	6
Harvested crops prematurely	"	27	0
Harvested crop byproduct only	"	49	2
Harvested mature crops	"	16	144
Interculturing done	"	7	65
Weeding done more than once	"	18	0
Thinning done	"	37	0
Post-sowing operations not done	"	36	0
Hired resources used for post-sowing operations	"	2	24
Harvested premature Z. Numularia (bush) for fodder	"	92	0
Lopped trees for fodder/fuel	"	53	4
Household-based loss minimizing measures[b]			
Cases of nonpayment of dues	No.	49	4
Marriages, etc. postponed	No.	9	0
Children withdrawn from school	No.	34	3

Source: Jodha (1967).

a. Total number of plots (monitored for 3 years for a land transformation study) was 168.

b. Total number of sample households was 140.

face of climatic hazards (Table 4).

(1)Diversified production strategy: Farming activities are fairly diversified to accommodate the temporal and spatial variability characterizing the natural resource base which condition the over all production possibilities available to farmers (Table 1). The degree of diversification can be readily perceived from the farmers' choice of enterprise combinations such as mixed cropping and livestock farming which have different capacities to ensure earnings in good and bad rainfall years; choice of crops with varying attributes in terms of maturity period, drought tolerance, input requirements, main product-by product ratios, end uses of the product, etc (Ruthenberg 1976, Collinson 1972, Haswell 1973, Jodha 1980, Abalu and D'Silva 1980).

(2) Operational diversifiction: Diversification in farming does not end with resource and crop based diversification. Traditional agronomic and management practices can also play a significant role in diversification and flexibility. Some are toposequential planting, staggering of planting and other operations, splitting of plots, spliting of input doses or skipping use of certain inputs as warranted by the situation (Ruthenberg 1968, Jodha 1967, Collinson 1972) (Table 2). Of the multiple options generated by the resource; crop; and operation-based diversification, some have high insurance capacity and others have high payoff potential. The farmer choses their combination according to the season (Tables 2, 3).

(3) Flexible resource use pattern: Because in subsistence farming communities the household is a major supplier of production inputs (human and bullock labor, seed, feed, fodder, manure, etc.), it offers effective command over resource use to contract or expand the farm operations (or their intensity) as required by quick response to changing weather during the season (Collinson 1972, 1977, Jodha 1967). A variety of recycling devices, limited ex ante commitment of resources for current production, an accretionary process of asset or capital formation further help in injecting flexibility in the farm level resource use (Jodha 1967). (4) Flexible consumption pattern: In self provisioning societies consumption demands are highly responsive to changes in not only real income but the overall availabilities of commodities. Consequently in households which are major direct consumers of their own farm output (except some cash crops) fluctuations in production are largely absorbed internally. Highly flexible demand and consumer preference (eg. preparedness to consume damaged grains or even green cobs/pods in place of fully ripe grain, normally non-edible items or to drastically cut the food intake during a poor crop year) help adjust demand to the emerging supply situation. The flexibility of consumption is further strengthened by on-farm storage and a variety of recycling and food processing devices which

convert nonedibles into edibles (see Jodha 19677, 1975; Collinson 1972).

(5) Limited access to permanent sources of stability: A large measure of stability could be introduced to farming systems by adapting environment (ie. through irrigation) to their recuirements. Any means to manipulate rainfall or the effective availability of moisture to crops is a source of stability. This leads to attempts to investment in irrigation for at least some plots. In some drought prone areas of India, wells or tanks (based on storage of surface runoff) are used as sources of irrigation by a limited number of farmers. In other areas of India and Tanzania (depending on soil characteristics and topography) moisture availability is manipulated by means of conservation measures like contour bunding, field border bunding, and ridges and furrows (Jodha 1980, 1982, Ruthenberg 1968). Diversification of sources of income particularly through inclusion of occupations earnings of whichare not linked to rainfall conditions (e.g. non-agricultural jobs) is another source of stability. However, in self provisioning societies there are not many such activities (Jodha et al. 1977).

(6) Traditioinal forms of rural cooperation: Traditional forms of rural cooperation and informal institutional arrangements also enhance mutual sharing of risk during bad years and also help to fully harness the potential of bumper crop years (Jodha 1967, Hitchcock 1979, Wisner and Mbithi 1974, Kirkby 1974). However, it maybe noted that under the pressure of modernization and commercialization of communities and institutional interventions by governments, these traditional collective means to impart flexibility fo farming systems are fast losing their effectiveness (Jodha 1978, Walker and Jodha 1982).

Adjustments

Adjustment measures, unlike adaptations, are initiated once the unfavorable performance of weather becomes apparent. For instance, when the midseason failure of rains is known farmers take two types of actions: (a) those directed towards minimizing the losses due to unfavorable weather and (b) steps undertaken to manage the losses or adjust to losses. We refer to the former as specific risk-loss minimizing measures or what Berry et al. (1972) describe as measures to modify the loss potential; we designate the latter as risk/loss management measures.

(a) Specific Risk/Loss Minimizing Measures:

Following the intraseason failure of rains certain measures are adopted for extracting whatever little the adversely affected crops can offer at a minimum of additional input cost. The measures can be further grouped under the

Table 4. Farmers' adaptations and adjustment mechanisms for weather induced risk:[a]

Relevant features of Farming systems	Long term adaptation and flexibility	Short term adjustments through: Risk/loss minimization				Risk/loss management					Features observed in	
		Salvage operations	Mid-season adjustment	Cut back on hired resources	Change in techniques	Cut in current commitments (consumption etc.)	Resource augmentation (Conservation/recycling)	Supplementary earning (migration)	Inventory depletion (Asset)	Dependence on others	India	Tanzania
Diversified production strategy: (through)												
- Crop-livestock mixed farming	x	x	x				x	x	x	x	x	x
- Mixed cropping	x	x	x								x	x
- Combining crops of varying maturity, drought tolerance, input needs and end uses	x	x	x								x	x
Operational diversification:												
- Toposequential planting		x	x									x
- Staggered planting			x	x							x	x
- Plot scattering splitting		x	x								x	x
- Varied plant spacing			x	x	x						x	x
- Input use skipping/splitting			x	x	x						x	x

Table 4 (contd.)

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Resource availability and flexible use pattern:												
- High dependence on own resources	x		x	x	x			x			x	x
- Limited ex-ante commitment to current production			x	x	x						x	x
- Accretionery process asset build up	x			x		x	x		x		x	x
- Re-cycling resources	x		x		x			x	x		x	x
Flexible consumption pattern:												
- Close link between consumption and production	x	x	x			x	x				x	x
- Recycling the products	x					x	x				x	
- On farm storage	x					x			x		x	x
- Flexible long term commitment	x					x		x			x	

contd.

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Traditional forms of rural cooperation/risk sharing etc.	x							x		x	x	x
Limited extent of reliable sources of stability:												
- Irrigation	x	x	x								x	x
- Moisture conservation	x	x	x								x	P
- Perennial crops	x		x					x			P	x

For discussion and evidence see: Jodha (1967, 1978, 1981) for India; Berry et al. (1972), Hankins (1974), Heijnen and Kates (1974) and Jodha (1982) for Tanzania.

P indicates partially observed or quantified evidence is lacking.

following categories.

(i) Salvage operations: Depending on the situation several recovery efforts are made. Examples are: recovery of fodder (byproduct) when the main product can not be harvested, harvesting green cobs/pods in place of a ripe crop, collectioin of weeded material (as fodder) rather than allowing it to be wasted concentration on normally low value production activities such as harvesting field borders for fodder due to decline in opportunity cost of labor (for details, see Jodha 1967, and Table 3, Jodha 1982).

(ii) Mid-season correction/adjustments in operations: To meet mid-season contingencies selectivity and discrimination become important features of farmers' decisions regarding deployment of resources and intensity of operations for different crops and plots. For instance, in response to a mid-season dry spell, plots lying lowest inthe toposequence receive more attention; intensive weeding and emergency thinning is done in the case of drought resistant and as yet promising looking crops. Depending on moisture situation after the break of the dry spell, partial resowing and patch cultivation is often carried out (see Winser and Mbithi 1974, Berry et al. 1972, Jodha 1967, 1982 and Tables 2 and 3).

(iii) Reduction in resource use: Cost saving is attempted by reducing dependence on hired resources. Owned resources are used where usually hired resources are employed. Family resources are also spared for alternative earning opportunities outside their farm (Table 3). Operations, techniques and priorities are changed for saving maximum resources (Wisner and Mbithi 1974, Berry et al. 1972, Jodha 1967, 1982).

(b) Specific Risk/Loss Management Measures:

These measures are directed towards ensuring the survival and maintenance of productive capacity of the farm household in the face of a crisis situation caused by the failure of crops. Measures are classified intosix subgroups and are illustrated by data from various drought affected areas in India. A similar situation was observed in the very dry villages of Kilosa bordering Dodoma (arid) region of Tanzania (Jodha 1982) but comparable quantitative data could not be collectd. Mascarenhas (1973) provides a detailed discussion of issues and problems involved in the context of Tanzania. A broad similarity in the

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(i) Reduction in current commitments: This is attempted through postponemnet, cancellation, and reduction of

expenditure related to current consumption, future production and payment of dues, etc. Table 5 (adapted from Jodha 1981) summarizes the situation in drought and post-drought years ih three areas of western India. It reveals that the consumption expenditure (even in terms of higher prices of the drought years) of a sample of farmers during the drought years declined by 8-13% in the affected areas of Gujarat and Rajasthan states. The magnitude of decline varied significantly amongst the different expenditure categories. The decline in expenditure on food was smallest of all categories. However, to prevent a further decline in this category expenses on other "non-essential" consumption items like protective food (infuding milk, meat, vegetables, sugar, fruits, etc.) education, medicine, clothing and socio-religious ceremonies were curtailed drastically. This decline ranged from 16-44% in Jodhpur, 15-18% in Barmer and 28-31% in Banaskantha. Despite maintenance of the level of expenses on food in drought years nearer to that in non-drought years, the per capita food intake (due to high prices) declined by 8-13%. Wisner and Mbithi (1974) found similar patterns in drought prone areas of Kenya.

(ii) Resource augmentation: This is attempted through use of hitherto rejected or non-edible foods and the recycling and conversion of food/fodder using different processing techniques (Berry et al. 1972, Hitchcock 1979 and Jodha 1967).

(iii) Asset/inventory depletion: It is quite common to sell or mortgage the assets/inventories accumulated over the run of good crop years during the crisis periods. The main reason for asset depletion through distress sales is augmentation of liquid resources to supplement meager income during drought years. Apart from deliberate disposal, asset losses due to death of animals and theft of items are quite common during the stress periods. As revealed by Table 6 compared to respective pre-drought years, during the drought years assets declined by 15-42% in different areas. In most cases productive assets, particularly livestock, had the highest (21-60%) decline. Moreover, recovery of depleted assets in post- drought years is quite slow. By the time asset losses are fully recouped the next drought may occur. Thus an asset depletion-replenishment cycle can complete itself without leaving surplus resources for investment and growth of agriculture in drought prone areas (Jodha 1978). Apart from asset depletion drought-affected farm households resort to heavy borrowing through formal/informal land/labor and credit contracts during the crisis periods. In these areas the incidence of indebtedness increased from 54-224% within a single drought year (Table 5). The long term consequences of such indebtedness include permanent pauperization of the people (for evidence, see Jodha 1981, particularly Table 8).

Table 5. Changes in consumption expenditures and food grain consumption of households during drought and non-drought years in three areas.

DETAILS	AREAS (Districts with States)								
	Jodhpur (Rajasthan)			Barmer (Rajasthan)			Banaskantha (Gujarat)		
	63-64+[a] A	64-65* B	(B-A)/B	69-70† A	70-71* B	(B-A)/B	69-70† A	70-71* B	(B-A)/B
	(Rs)	(Rs)	(%)	(Rs)	(Rs)	(%)	(Rs)	(Rs)	(%)
Per-household consumption expenditure on:[b]									
Total food items	1181	1200	-1.6	1183	1153	+2.6	1701	1805	-5.8
Protective foods[c]	291	409	-28.8	235	406	-42.1	501	694	-28.3
Clothing, fuel etc.	274	327	-16.2	269	316	-14.8	334	483	-30.9
Socio-religious ceremonies[d]	54	148	-63.5	57	110	-48.2	61	88	-30.7
Others[e]	168	259	-35.2	102	175	-41.7	127	98	+29.6
Total	1677	1934	-13.3	1611	1754	-8.2	2223	2474	-10.2
Consumption per adult unit per day(g)									
Total foodgrains	514	594	-13.9	535	606	-11.7	567	740	-23.4
Superior cereals[f]	112	58	+93.1	40	7	+82.5	42	27	+35.7

SOURCE : Jodhpur area (Jodha 1975), Barmer & Banaskantha areas (Chaudhari & Bapat 1975), Aurangabad area (Borkar and Nadkarni 1975), Sholapur area - data collected under ICRISAT Village Level Studies (Jodha et al. 1977). For details of number of sample households, see Table 7.

a. † Drought years; * Post-drought (normal) years.

b To facilitate comparisons, all rupee values in this and the subsequent tables have been converted into 1972-73 value of the rupee, using index of general prices for agricultural laborers in the respective states.

c Includes milk, fats, sugar, jaggery, fruits, etc. These are included in total food items, also.

d Socio-religious ceremonies related to deaths, births, marriages, and festivals.

e Includes education, medicine, recreation, travel, payment to village functionaries for day-to-day services, remittances to children studying outside, etc.

f Mainly wheat available through fair-price shops during the drought year.

(iv) Other measures for sustenancy income: Other loss management devices during the drought years include dependence on public relief works, hiring out of human labor and bullocks, earnings from out migration, remittances, handicrafts, and various means of mutual risk sharing.

Public relief works account for the single biggest source of sustenance income in most of the areas (Table 7). The sale of assets is the next major single source of sustenance income. The data suggest that in the absence of public relief, the farmers' adjustment devices are inadequate.

(v) Outmigration: This is an important measure to adjust to spatial variability of rainfall. Farmers travel long distances during stress periods. Jodha (1978) reported that 37-60% of farm households were affected by outmigration during drought years in different aras of India. The one way distance covered ranged from 50-243 kilometers. Outmigration involves both nominal and real costs. An important component of the cost is loss of animals, through death, desertion or theft during the process. The extent of animals lost by outmigrants ranged between 28-53% of the original number of animals in different areas. The practice of migration is more common in pastoral areas of Africa but no details are readily available to quantify the situation.

The Inferences

The brief review of farmers methods to handle weather induced risk leads to the following inferences. First, the strongest point of the risk handling mechanisms is the diversificatioin and consequent flexibility of the farming systems. The farmers in low and unstable rainfall areas are faced with very limited productive alternatives. Nevertheless, farmers try to multiply the total options by means of manipulating the crop combinations and by varying methods of resource use and farm practices. In the process, they gain stability in production but at the expense of more profitable opportunities occasionally presented by the rainfall pattern. In other words, farmers' production strategies are largely geared towards handling the negative aspects of weather, i.e. droughts, rather than concentrating on positive aspects of weather. Climate is recognized more as a source of distress than as a productive resource.

Secondly, though evolved over many generatioins, the traditional structure of options to handle weather induced risks is fairly static and several new optioins based on modern scientific advances in agricultural technology have not been incorporated into farmer's risk management. The traditional technology underlying the methods of handling risk at best can ensure balancing of losses and gains at the end of a famine cycle. But it does not offer enough scope

Table 6 Changes in asset and liability position of drought-affected households in five drought-prone areas of India.

Particulars	Average per household value of assets and liabilities[a] in (A)predrought years (B)drought years and (C)postdrought years in:													
	Jodhpur (Rajasthan)			Barmer (Rajasthan)			Banaskantha (Gujarat)			Sholapur (Maharashtra)			Aurangabad (Maharashtra)	
	(A) 62-63[b]	(B) 63-64	(C) 64-65	(A) 68-69	(B) 69-70	(C) 70-71	(A) 68-69	(B) 69-70	(C) 70-71	(A) 71-72	(B) 72-73	(C) 73-74	(A) 71-72	(B) 72-73
	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)	(Rs)
ASSETS														
Livestock[c]	1546	849	1230	1287	786	837	1565	1222	1498	2096	1707	1549	732	464
(% change)[d]		-(45.1)	+(44.9)		-(60.4)	-(6.5)		-(21.2)	+(22.6)		-(18.6)	-(9.3)		-(36.3)
Agrl. implements[e]	409	372	389	202	201	201	645	638	635	496	465	483	751	685
(% change)		-(9.0)	+(4.6)		-(0.5)	-		-(1.1)	-(0.5)		-(6.3)	+(3.9)		-(10.1)
Consumer durables[f]	658	459	486	175	167	164	292	284	284	106	73	85		N.A.
(% change)		-(30.2)	+(5.9)		-(4.6)	-(1.8)		-(2.7)	-		-(31.1)	+(16.4)		N.A.
Financial assets[g]	1239	840	726	1226	947	921	1668	1398	1380	310	216	190	296	258
(% change)		-(32.2)	-(13.6)		-(22.7)	-(2.7)		-(16.2)	-(1.3)		-(30.3)	-(12.0)		-(12.8)
Total assets	3852	2520	2831	3590	2101	2123	4170	3542	3797	3008	2461	2307	1779	1407
(% change)		-(34.6)	+(12.3)		-(41.5)	+(1.1)		-(15.0)	+(7.0)		-(18.2)	-(6.3)		-(20.9)
INDEBTEDNESS[h]														
Debt outstandings	189	552	637	498	873	949	111	360	302	375	613	651	N.A.	N.A.
(% change)		+(192.0)	+(15.4)		+(75.3)	+(8.7)		+(224.3)	-(16.1)		+(63.5)	+(6.2)		

SOURCE : Jodhpur area (Jodha 1975), Barmer and Banaskantha areas (Chaudhari and Bapat 1975), Aurangabad area (Borkar and Nadkarni 1975), Sholapur area - data collected under ICRISAT Village Level Studies (Jodha *et al.* 1977). For details of number of sample households see Table 7.

[a] Value of assets and liabilities (in Rs) expressed in terms of 1972-73 prices. Assets exclude land and buildings.

[b] Pre-drought year indicates the situation at the beginning of the drought year.

[c] Draft animals, milch stock, sheep, goat, etc.

[d] Percentage change over the preceding period. The change is composed of sales, gifts, losses (of animals due to death, etc.).

[e] Farm equipments, tools, machinery, and handicraft tools.

[f] Consumer durables--only important items like radio, watch, bicycle, and modern furniture included.

[g] Includes jewelery, cooperative shares, L.I.C. policies, etc. In Aurangabad, only jewelery is included.

[h] Average per household amount of debts outstanding net of repayments. In Sholapur it excludes old debts imposed on farmers as bunding loans, well loans disbursed under Zaveri Scheme and Zilla Parishad fodder grants during the past droughts. This amount comes to Rs 723/- per household at 1972-73 prices.

N.A. : Not Available.

Table 7. Sources of sustenance income of rural households during the drought years in five drought-prone areas of India.

Details	AREAS (Districts with States)				
	Jodhpur (Rajasthan)	Barmer (Rajasthan)	Banaskantha (Gujarat)	Aurangabad (Maharashtra)	Sholapur (Maharashtra)
Drought year	1963-34	1969-70	1969-70	1972-73	1972-73
Sample households (No.)	144	100	100	128	80
Average amount of sustenance income (Rs / household)[a]	3133	2996	2627	2715	2944
% share of sources in sustenance income					
Cultivation[b]	2.1	-	-	6.8	14.4
Animal husbandary	10.2	7.2	4.8	NA	1.0
Wage income from relief works	24.9	22.4	25.3	56.2	46.5
Institutional help[c]	NA	30.4	6.4	NA	NA
Sale of assets	25.9	12.5	24.9	13.5	17.3
Borrowings (credit)[d]	10.4	12.8	11.7	6.3	7.9
Others[e]	26.5	14.7	26.9	17.2	12.9

SOURCE : See Table 5.

[a] Sustenance income defined as total inflow of cash and kind including borrowing, except term loans unrelated to sustenance during the drought. Value of sustenance income is expressed in terms of 1972-73 prices.

[b] In Aurangabad villages, income is from all household production including cultivation.

[c] This includes free or subsidized supplies of food grain and fodder including those provided by charitable institutions and the government during the period of migration. In some cases the help also included milk powder, vitamin tablets, medicine, clothing, transport facilities, and water supply, etc.

[d] All borrowings--in cash or kind--taken against mortgage or labor or land-lease contract and others. This does not include the credit in terms of postponement or cancellation of recovery of land revenue and other dues from the farmers. This also excludes term loans not related to loss management during the drought years.

[e] Includes income from other casual or agricultural wage employment (including during the out-migration), handicrafts, transport, remittances and free help from well-off relatives, etc. In the case of Jodhpur villages it includes value of old stocks of food grain and fodder.

NA : Not Available.

for generating a surplus for reinvestment and growth to ensure a stronger internal cushion for farmers to sustain effectively the impact of subsequent droughts.

Thirdly, the group based measures to handle risk are fast losing their effectiveness due to increased demographic pressures, commercialization or market orientation of farming, and a number of institutional changes initiated by governments.

Finally, despite all the adaptations and adjustments attempted by the farmer, traditional measures are not able to sustain the farmer during drought periods. Public relief has assumed a significant role complementing the farmers' own attempts to handle weather induced risk.

The above inferences help in identifying the weakness of traditional methods of risk management and possible directions for seeking potential measures to strengthen the farmers' mechanisms to handle weather-induced risk (Walker and Jodha 1982).

THE POTENTIAL OPTIONS FOR IMPROVING RISK STRATEGIES

New measures to handle risk, are not substitute for the existing mechanisms. Instead they should help generate more options for the farmer to adapt and adjust to the risky environment. The potential options contain technological and institutional elements. Most of these technological measures share the insurance elements characterizing the traditional measures; however, their potential superiority lies in ensuring both insurance and growth or building up of the farmers' capacity to withstand periodic stress situations more easily.

The new institutional options indicated are really not very new. The focus of institutional measures discussed is on the need for adapting government policies and programs to the realities of an unstable agricultural situation. Most of the on-going programs and policies need to be more sensitive to the proiblem created by weather variability before they could complement the farmers' own measures to handle risk (Wisner and Mbithi 1974, Jodha 1981). The potential technological and institutional options to help risk management by farmers are broadly presented in Tables 8 and 9 with minimum description in the text.

Tables 8A, B, and C summaries the potential technological mesasures. Besides indicating specific measures, their attributes in terms of potential adaptation and adjustment benefits, relevance of the measure to farmers' past experience and resource capacity (to facilitate easy adoption of new measure) are also mentioned. The new technological measures which can significantly add to the flexibility and productive capacity of the farming

Table 8A. Potential adjustment measures against weather induced risk: from potential technologies aimed at enhancing resources

Resource centered measures: relating to conservation, management of soil and moisture	ATTRIBUTES								Reference for experimental evidence[a]
	Long term adaptations through		Short term adjustment through:	Relevance to:					
	Growth induced cushion/stability	Flexibility based options	Adjustment to intra-seasonal weather	Farmers' experience		Farmers' resource capacity		Specific agroclimatic conditions	
				India	Africa	India	Africa		
Runoff collection and recycling	x	x		P				R	1,2
Soil-moisture conservation through									
- Contour bunds	x	x	x	P		P		S,R,Bm	3
- graded bunds	x	x		P				R,D	3
- broad bed and furrows	x	x	x	P				D	1,2,4,5
- broad based terraces	x	x						Bd,R	3
- mulching	x	x	x	P	P	P	P	S,R,D	3
- contour cultivation	x	x			P	P	P	Bd	3
- tie-ridging	x	x	x		P		P	Bm,R	6

[a]References: 1) Ryan et al. 1979; 2) Binswanger et al. 1980; 3) Randhawa et al. 1981; 4) Ryan et al. 1981; 5) Virmani et al. 1981; 6) Le Mere 1972

Abbreviation: P = Partial; R = Red soils; Bd = Deep black soils; D = Dependable rainfall; Bm = Medium black soils, S = Sandy Loam soils.

system, can be broadly classified under three groups: (A) Resource centered measures, (B) Crop centered measures, and (C) Management practice centered measures. These measures are at different stages of development and extension to the farmer. Moreover, they are of a general nature and specific changes to suit local circumstances in different areas maybe necessary.

A. Resource Centered Measures

Agricultural scientists maintain that in most years, if effectively utilized, the available moisture is sufficient for raising one or (in some areas) two rainfed crops. The main problem is the intraseasonal distribution of rainfall. It is not uncommon to have both severe flooding and extreme moisture stress for crops in different parts of the same crop season. The distribution of the rains cannot be controlled, but its utilizatioin can be manipulated to increase its effective availability for crop production. This can be achieved through surface storage of water (in tanks, etc.) and in the soil profile. These help generate the options to adapt the moisture environment to crop requirements (Table 8A).

(i) Runoff collection and recycling: By means of proper layout of the landscape on a watershed basis the facilities for drainage of exceess water into small tanks can be organized. The water thus harnessed during the frequent heavy storms can be utilized for supplemental or life saving irrigation during the mid-season droughts or for raising postrainy season crops. The evidence from experimental work at ICRISAT and national institutes in India suggests that this measure can make a significant contribution towards stability and growth of rainfed agriculture in Alfisols (red soil) areas (Ryan et al. 1979, Binswanger et al. 1980). However, this technology may face some institutional problems as it involves soil and water management on a small (5-30 ha) watershed basis generally involving a number of farmers who may or may not agree to collective decisions (Doherty and Jodha 1979).

(ii) Soil-moisture conservation measures: In addition to traditional field border bunding, experimental work on soil moisture management has led to the design of conservation techniques suited to different agroclimatic regions. Some examples are: graded bunds, broadbeds and furrows, broad based terraces, land smoothing, contour bunds, tie-ridging, contour cultivation, furrows (in grasslands), and mulching (Randhawa and Rao 1981, Le Mere 1972, Binswanger et al. 1980, Virmani et al. 1981, Ryan et al. 1981). When used with other components of modern technology, eg. improved seed and fertilizer, some of these measures can raise production substantially. In some areas where water stagnation rather than moisture stress operates as the main constraint, the measures designed to help in

improved drainage can substantially increase production (Ryan et al. 1982). However, a large scale demonstration of efficacy of the above measures is yet to take place to asses the farmer's response to them. Their location specificity and absence or very impressive performance unless adopted along with new crop technology may hinder their wide spread adoption.

B. Crop Centered Measures

New crop technologies offer better and more crop options to farmers. The crops included are either selected or deve loped to suit a particular environment through scientific research. In certain cases, alternative crops mean sub stitution of traditional crops of a region by traditional crops from other regions. The variety of perennial (in cluding grasses and trees) and annual crops (both species and cultivars) recommended for different agroclimatic zones (Kassam 1976, Mukuru 1980, Sperling 1976, Anon 1979, De Vries and Mvena 1979, Spratt and Chaudhuri 1978, Hazra and Patil 1982) offer crop choices to suit different soil types and weather conditions, eg. early rain, late rain, inadequate to excess rain, mid-season drought, etc. Depending on their various characteristics the crops may offer enhance stability and higher yields (Table 8B). This may be added that cost of complementary inputs (eg. fertilizers) and rigidity of recommended package may obstruct the wide spread adoption of crop centered technologies.

C. Management Practice Centered Measures

Based on agronomic trials involving knowledge of new crops and their physiology in relation to varying types and levels of inputs, scientists have evolved a range of management practices (Anon 1982, Virmani et al. 1981, Rastogi 1981, Krishnamoorthy et al. 1977, Keregero et al. 1977, De Vries 1976, Monyo et al. 1976) Many of them involve simple changes in management practices rather than substantial additional cost. The practices relate to operations at various stages of crop growth and they are designed to make more efficient use of the agroclimatic environment (Table 8C).

Dry seeding eliminates the loss of time involved in most traditional systems where the crop is planted after the rains when field conditions allow. This delay may be as long as 10 days or more in many areas. Dry sowing has several favorable implications for plant stand and growth. The increasing variety of crops with different physiological traits has facilitated the manipulation of sowing dates to suit the timing of rainfall. This can be complemented by information about the start of rains available through public broadcasting services. Practices relating to plant population, spacing, and mid-season changes therein also

Table 8B. Potential adjustment measures against weather induced risk: potential technologies aimed at crop improvements.

Crop centered measures: crop choice/substitution based on crop characteristics:[1]	Attributes							
	Long-term adaptation through:		Short-term adjustment through:		Relevance to farmers'			
					experience in:		resource capacity in:	
	Growth induced cushion/stability	Flexibility based options	Salvage operations	Adjustment to intra-season weather	India	Africa	India	Africa
1. Insensitivity to temporal variability of rains (e.g. perennials)	x	x			P	P	P	P
2. Resistance to drought	x	x	x		P	P	P	P
3. Varying maturity periods	x	x	x	x	P	P	P	
4. Responsive to fertilizer (+ moisture)	x				P		P	
5. Moisture use efficiency	x			x	P	P	P	
6. Adapted to new agronomic practices	x	x		x			P	P
7. Resistant to pests/ insects	x			x	P	P	P	P

[1] For experimental evidence see Anon 1979; Randhawa et al. 1981; Spratt et al. 1978; Krishnamoorthy et al. 1977; Kassam 1976; Collinson 1977; Mukuru 1980, Anon 1982, Hazra et al. 1982, Rastogi 1981).

P = partial.

Table 8C. Potential adjustment measures against weather-induced risk: from potential technologies aimed at improving management practices

Measures relating to management practices[1]	ATTRIBUTES							
	Long-term adaptation through:		Short-term adjustment through:		Relevance to farmers'			
					experience in:		resource capacity in:	
	Growth induced cushion/stability	Flexibility based options	Salvage operations	Adjustment to intra-seaonal weather	India	Africa	India	Africa
Dry seeding	x	x		x		P	P	P
Flexible sowing time		x	x	x	P	P	P	P
Transplanting some crops		x			P		P	P
App. plant population and manipulation		x		x	P	P	P	P
Varying level and selective use of fertilizer	x	x			P	P	P	P
Intensive weed management	x		x	x	P	P	P	P
Mid-season thinning, ratooning, gap filling		x	x	x	P	P	P	P
Intercropping with HYVs	x	x			P			
Sequential/relay cropping	x	x		x		P		P
Post-harvest tillage		x			P			

[1]For experimental evidence, see footnote to Statement 11 B.

P = Partial

improve adjustment to emerging weather conditions. Similarly, intensive weed management and selective use of fertilizer in split applications also helps to increase and stabilize production. Inter cropping, sequential and relay cropping involving crops with varying capacities to benefit over time and space from the environment contribute to risk reduction. Timely, post harvest plowing is one practice which helps weed and moisture control and prepares the soil to facilitate dry seeding. In some areas, this is a traditional practice, but it is often done much later after the crop is harvested when the soil is completely dry. This is not as effective as timely postharvest plowing before weeds have already scattered their seeds, and animals in the dry season are too weak to work on dry soil.

Potential Institutional Options

Public policies and programs conducive to increased effectiveness of farmers' mechanisms to handle weather-induced risk are summarized in Table 9. Most of these institutional measures are not new. What is new is their suggested reorientation so as to make them more relevant to drought situations. They are grouped under three categories.

(1) Contingency Support Facilities: These measures are directed to supplement farmers' own efforts to manage crisis situation generated by drought induced scarcities. They are largely short term measures.

(2) Area-Based Infrastructure: These include long term and permanent measures to facilitate growth of drought prone regions.

(3) Scheme Supporting Adoption of New Technology: These measures include infrastructure and other support facilities essential for adoption of new technological options discussed earlier. For detailed discussion of the potential role of these measures in helping farmers' traditional adjustment mechanisms, see Dandekar (1976), Jodha (1981), Wisner and Mbithi (1974), and Mascarenhas (1979).

CONCLUSION

Through trial and error over a period of generations subsistence farmers have evolved mechanisms to handle drought induced risk. These mechanisms, though losing their effectiveness, show considerable similarities across geographical, cultural, and demographic contexts in tropical less developed countries

In the recent period governments (in association with other organizations) have also responded to drought through relief. Nevertheless, the private and public measures to handle drought-risk share a common weakness. Both are primarily crisis oriented. In other words, their main focus

Table 9. Potential institutional measures to support farmers' adjustment mechanisms against risk

Institution measures: programs/policies[1]	Attributes in terms of support to:			Relevance to current experience of the countries	
	Adaptation	Adjustment			
	Long-term growth and flexibility	Loss minimisation	Loss management	India	Africa
Contingency support facilities:					
Relief (employment) works		x	x	x	x
Consumption credit			x	P	
Fodder banks		x	x	P	
Seedling nurseries		x		P	
Custom hire services		x		P	P
Area based infrastructure:					
Diversified credit	x		x	P	P
Marketing and transport	x	x		P	p
Price support for crop and stock	x			P	
Crop-livestock insurance	x	x			
Non-farm employment	x		x	P	P
Support for new technology:					
Village/farm centered Conservation measures	x	x		x	x
Self/community managed irrigation	x	x		P	
Local level input-distribution	x	x		P	P

[1]For detailed discussion and/or evidence on these and related measures see Wisner and Mbithi (1974), Mascarenhas (1973, 1979), Jodha (1981).

is to protect against drought or adjust to drought induced crises. Hence, efforts are designed to largely handle negative events in the weather cycle. In the process, the potential of positive events (ie. good rainfall years) in the weather cycle to build up a strong buffer or cushion to face a crisis situation rather comfortably and without outside support is ignored.

New technologies for rainfed agriculture, which recognizes climate not as a source of distress but as a productive resource, offers a number of options to reorient the approach to the management of drought-induced risk. Their adoption may be essential if drought prone areas are to be saved from becoming permanent liabilities for other areas.

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