# SCOPE 27 - Climate Impact Assessment

## 17 Adjustment in Self-provisioning Societies

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**N. S. JODHA* AND A. C. MASCARENHAS†**

** International Crops Research Institute*
*for the Semi-Arid Tropics*
*Andhra Pradesh, India*
*† Institute for Resource Assessment*
*University of Dar es Salaam*
*Dar es Salaam, Tanzania*

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## 17.1 INTRODUCTION

The impact of climate variation on society and appropriate methods for its assessment will vary according to the society that is being studied. In this chapter we focus on self-provisioning societies, bringing to bear evidence from India and Tanzania. We focus on the variability of climate from one year to the next and over short groups of years, as these variations create pressing problems for self-provisioning societies. We also emphasize drought, which surpasses other climate variations in impact on these societies. For a discussion relevant to the effects of gradual long-term climate change on self-provisioning societies, see Parry (Chapter 14), who offers historical examples from Europe and North America. The question of impacts of seasonality is addressed here in part; for a more extensive treatment, see Chambers (1982). It is also informative to contrast the issues and approaches in this chapter with those in Pilgrim (Chapter 13), who describes social impact assessments undertaken in developed countries.

The two procedural and primary steps in discussing the adjustment mechanisms of self-provisioning societies to climate variability are: to define or identify such societies, and to understand their perception of the phenomenon of climate variability. In place of attempting rigid definitions of the terms, we prefer description of the situations as they obtain in the real-world context.

Literally speaking, a self-provisioning society is one in which its members manage their production and consumption requirements by themselves and the market, or formal exchange transactions, has little place in the system. Such societies, however, are hard to find in the present age except in completely isolated remote habitats. A more meaningful definition of the term would include farming communities where the bulk of production inputs originate from a person's own farm and household and the bulk of output not only is consumed by the household, but also satisfies most of its consumption needs. Market, or formal, exchange plays a very limited role as a link between the farm household's production and consumption activities. Even when dependence on the market is significant (as in the case of small-holder producers of certain cash crops such as cotton), the objective in using the market is largely to support subsistence. Methodologically, using the ratios of: 1. home-supplied inputs to the total inputs used on farms, 2. self-consumed output to the total output of the farm, and 3. the farm's own supplies to the total consumption requirements, one can not only segregate self-provisioning farming communities from highly commercialized farming communities, but also easily rank the communities on the basis of their degree of self-provisioning or subsistence character.

Several field studies, in largely rainfed farming areas of tropical India, have noted the extent of self-provisioning. According to these studies, important own-farm-originated inputs such as human labor, bullock labor, seed, manures, and fodder for draft animals account for 65–90 percent of the total used amount of concerned input (Bharadwaj, 1974). A similar range applies to the share of total consumption items originating from `own farm'. The extent of self-provisioning is even higher in most parts of Africa

(Ruthenberg, 1968, 1976; Collinson, 1972; Lagemann, 1977; Abalu and D'Silva, 1980).

The literature on subsistence or peasant agriculture has discussed at length the features of such communities (see, for example, Krishna, 1969; Mellor, 1969; Wharton, 1969). Two features of such communities which have significant bearing on their adjustment to climate variability are discussed below.

First, to the extent that the household is both a major supplier of production inputs and major final user of the bulk of the output, the production and consumption decisions are quite interlinked. The integration of household (as a family unit) and farm (as a production unit or a firm) helps offer greater internal flexibility for sustaining the impact of climate variability.

Second, lesser dependence of farm households on the market implies their lesser integration with the rest of the economy. This in turn reduces the capacity of farm households to transmit shocks of climatic variability to others, for example, input suppliers and output buyers. (This situation contrasts with that of commercial firms during a crisis period.) Consequently, unless helped by external agencies or public relief, farmers in self-provisioning societies have to bear the weather-induced risk on their own. Further, since their dependence on the market for the purchase of inputs and disposal of products is limited, climate-induced production uncertainties play a more important role than price and technology-related uncertainties in shaping their adjustment strategies (Wharton, 1968).

### 17.1.1 Climate Variability

The rationale and operational efficacy of farmers' adjustment strategies to climate variability can be appreciated better once one has some idea of farmers' own perceptions of the phenomenon. Rainfall—its amount, timing, and duration—is identified by subsistence farmers as the dominating climate variable. Areas of subsistence agriculture, where rains constitute a principal source of risk, generally are characterized by high interyear and intrayear variability of rains. When rains are normal or higher than normal they seldom get special attention. But rains lower than normal or their unfavorable distribution are considered a cause for concern. Further, the role of rainfall variability is perceived in a rather short-term intrayear or interyear context and defensive measures are adopted accordingly. The varieties of measures adopted in order to meet the short-term situation, however, constitute integral parts of the overall farming systems, which in turn have evolved over generations in response to the long-term behavior of climate variables (especially rainfall) in a given geographical region. Hence, the subsistence farmer's adjustment mechanisms to weather-induced risk can be better understood in terms of the relevant features of his farming system that help accommodate the periodic shocks generated by short-term fluctuations in weather conditions.

To further facilitate the understanding and identification of areas for improving the potential efficiency of adjustment mechanisms, features of farming systems can be grouped in two categories. The first category can be called *adaptations* and includes elements through which farming systems have accommodated to long-term agroclimatic features of the regions. These elements help in harnessing favorable opportunities offered by the environment and also inject preparedness to defend against unfavorable situations created by erratic patterns of rains. The second category includes responses to short-term fluctuations in weather conditions. They are adopted once intraseason weather conditions become unfavorable. We may call them *adjustments.* Adjustments become possible because of the first category of features.

17.1.2 Method of Study

Before we discuss the adaptations and adjustments facilitated by farming systems, a brief digression on methodology to study them in the context of self-provisioning societies may be helpful. In a way, the risk management attributes of a given farming system are largely an outcome of farmers' perceptions of climate-induced risk and efficacy of possible alternatives to handle the risk. Farmers' perceptions, in turn, are largely conditioned by the objective circumstances which generate risk, for example, the pattern of rainfall. Hence, in order to gain understanding of adaptations and adjustments to climate-induced risk, the study-frame should include contrasting situations in terms of rainfall pattern. Climatological data, particularly the extent and distribution of rainfall along with broad information on agricultural activity in the region, can help in the selection of relevant locations for the study (Mallik and Govindaswamy, 1962–63; Sen, 1971; Jodha *et al.*, 1977). Farm surveys of different intensities may be conducted in the selected locations. Data-gathering in self-provisioning or subsistence farming communities requires caution and emphasis on participant observation, as there is likely to be a communication gap between investigators, often urban-trained, and respondents, who are generally illiterate and suspicious. Simple, unstructured questions, supplemented by group discussions, can provide more insight into the rationale behind the components that characterize traditional farming systems (Collinson, 1972; Norman, 1973; Friedrich, 1974; Kearl, 1976; Binswanger and Jodha, 1978).

The information collected should cover farmers' resource bases and their use patterns, types of crop combinations and their time-and-space specific management practices, as well as input-output details, farm production and disposal, and the like. The climate-induced differences between the sets of information relating to areas, years, and seasons with different rainfall patterns can clearly reveal the risk management elements in the farming system. This is illustrated by three studies briefly reported in Tables 17.1, 17.2 and 17.3, contrasting farmer behavior by climate, season and extreme events.

**Table 17.1** Diversification strategies to handle climate risk in two areas in semi-arid tropical India

| | Akola villages | Sholapur villages |
|---|---|---|
| A. *Characteristics of climate risk* | | |
| Annual average rainfall (mm) | 820 | 690 |
| Probability of favorable soil moisture | 0.66 | 0.33 |

| | | |
|---|---|---|
| conditions for rainy season cropping | | |
| B. *Indicators of spatial diversification* | | |
| Number of scattered land fragments per farm | 2.8 | 5.8 |
| Number of split plots per farm | 5.0 | 11.2 |
| Number of fragments per farm by distance from village | | |
| – Zero distance | 0.2 | 0.0 |
| – Up to 0.5 miles (0.8 km) | 0.3 | 1.4 |
| – Up to 1.0 mile (1.6km) | 1.1 | 3.4 |
| – 1 to 2 miles and above (1.6–3.2 km) | 0.1 | 1.0 |
| C. *Indicators of crop-based diversification* | | |
| Number of total sole crops planted | 20 | 34 |
| Number of total combinations of mixed crops planted | 43 | 56 |
| D. *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 *et al.* (1980).
Table adapted from walker and Jodha (1982).

Table 17.1 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, the more risky area, the farmers resort to more resource-based and crop-based diversification as an insurance mechanism against climate-induced risk.

Table 17.2 contrasts the farming practices followed by a similar group of farmers in the Kilosa area of Tanzania during short (uncertain) and long (certain) rains in the same year. The practices and measures which have greater probability of success with uncertain rainfall, or which can offer partial crop salvage values despite unfavorable rains, are adopted more during the short rains.

Table 17.3 contrasts the measures and farming practices followed by farmers in the arid zone of India during a normal rainfall year and a drought year. The practices having greater potential for protecting the crops, saving the resources and augmenting the supplies (even of inferior products) despite the failure of rains gain significance during the drought year.

**Table 17.2** Risk-minimizing farming practices and rain type in four villages of Kilosa, Tanzania during 1980–81

| | Short rains | Long rains | Total |
|---|---|---|---|
| A. *Characteristics of climate risk* | | | |
| Average rainfall (mm) | 260 | 763 | — |
| No. of rainy days | 21 | 68 | — |
| Chances of crop failure in 10 years | 5 | 1 | |
| B. *Indicators of risk-minimizing strategies* | % | % | |
| Share of total low lying areas planted in the year | 83 | 17 | 100 |
| Share of uplands planted | 26 | 74 | 100 |
| Share of compound plot areas planted | 92 | 8 | 100 |
| Share of total salvage crops in total crops of season | 72 | 32 | — |
| Share of intercropping in season | 95 | 79 | — |
| Share of staggered planted area in the season | 35 | 69 | — |

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

**Table 17.3** Loss-minimizing activities during a drought year and a non-drought year in selected villages in the arid zone of India

| | Drought year (1963–64) | Normal year (1964–65) |
|---|---|---|
| A. *Characteristics of weather risk* | | |
| Rainfall during the year | 159 mm | 377 mm |
| Total rainy days | 8 days | 21 days |
| B. *Risk/loss-minimizing measures: crop practices* | | |
| Collected weeded material as fodder | 53 plots | 5 plots |
| Harvested field borders for fodder | 68 plots | 6 plots |
| Harvested premature crops | 27 plots | — |
| Harvested crop byproduct only | 49 plots | 2 plots |
| Harvested mature crop | 16 plots | 144 plots |
| Interculturing done | 7 plots | 65 plots |

| | | |
|---|---|---|
| Weeding done more than once | 18 plots | — |
| Thinning done | 37 plots | — |
| Post-sowing operations abandoned | 36 plots | — |
| Hired resource used for post-sowing operations | 2 plots | 24 plots |
| Harvested premature *Z. nummulariia* (bush) for fodder | 92 plots | — |
| Lopped trees for fodder/fuel | 53 plots | 4 plots |
| *C. Risk/loss minimizing measures: social practices* | | |
| Cases of nonpayment of dues | 49 | 7 |
| Marriages, etc. postponed | 9 | — |
| Children withdrawn from school | 34 plots | 3 |

After Jodha (1967).

As these illustrations indicate, the main focus of such studies is to capture the contrast among farming practices as dictated by temporal and spatial differences in rainfall patterns. Depending upon requirements, the investigations can be extended to further depths, as will be indicated by subsequent tables.

## 17.2 RELEVANT FEATURES OF FARMING SYSTEMS

The features of traditional farming systems that have evolved to handle climate-induced risk can be defined as (a) adaptations, and (b) adjustments, classified by their long- or short-term character. These features are interrelated and constitute a complex of crop-based, resource-based and management practice-based measures. Some of them are group-centered, requiring social action, while others are individual-centered, in the control of the farm unit. In some of them 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 is largely a function of farmers' perceptions of a risky situation and the efficacy of a particular measure to meet the situation. Since the ultimate objective of these measures is to cope with a common factor, risk generated by weather or climate, one comes across a broad similarity in adaptation/adjustment measures in different locations such as India and Africa, despite their cultural, infrastructural and demographic differences.

### 17.2.1 Long-term Adaptations

The evolution of farming systems in climatically unstable areas has bestowed several features which ensure the flexibility and viability of the system in the face of climatic hazards.

#### *17.2.1.1 Diversified Production Strategy*

The farming activities are diversified to accommodate the temporal and spatial variability characterizing the natural resource base (land, rainfall, etc.) conditioning the overall production possibilities available to the farmers. The degree of diversification can readily be perceived from the farmers' choice of enterprise combinations (such as mixed farming through cropping and stock farming) with varied capacities to ensure earning in good and bad rain years, and from the 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, and so forth (Collinson, 1972; Ruthenberg, 1976; Abalu and D'Silva, 1980; Jodha, 1980). Table 17.1 illustrates the relative extent of resource-based and crop-based diversification attempted by farmers in two agroclimatically different areas of semi-arid tropical India.

*17.2.1.2 Operational Diversification*

Diversification in farming does not end with resource- and crop-based diversification. Traditional agronomic and other management practices also have a significant scope for diversification and flexibility. These practices include lowland-upland (toposequential) planting, staggering of planting and other operations, splitting of plots, splitting of inputs, and skipping certain inputs as warranted by the situation (Jodha, 1967; Ruthenberg, 1968; Collinson, 1972). Table 17.2 illustrates some degrees of diversification attempted by Tanzanian farmers during short and long rains.

Diversification based on resource bases, crops and operations helps generate operations with varying probabilities of success in the face of highly variable weather conditions. The farmers' concentration on specific practices changes according to their comparative advantages in the emerging intraseason weather situation. In the favorable season the options with high payoffs get better attention, whereas in less favorable seasons the options with greater insurance elements are emphasized. This is illustrated in Table 17.2, which shows the priority given to high insurance measures during short (uncertain) rains in the Kilosa area of Tanzania, and Table 17.3 for a drought period in India.

*17.2.1.3 Flexible Resource Use Patterns*

The degree of diversification and consequent flexibility of the farming system is further strengthened by the diversity and flexibility of resource and consumption patterns. This flexibility is facilitated in turn by the fact that the household is both a production and a consumption unit. Household production and consumption in self-provisioning farming societies are therefore highly interlinked physically, as well as financially. Since the household is a major supplier of production input (human and bullock labor, seed, feed, fodder, manure, etc.) it offers effective control over resource use to contract or expand the farm operations (or their intensity) as required by quick response to emerging weather situations during the season (Jodha, 1967; Collinson, 1972, 1977). A variety of recycling devices, including a limited prior commitment of resources for current production and an accretionary process of asset or capital formation, further help to inject flexibility in resource use (Jodha, 1967).

*17.2.1.4 Flexible Consumption Patterns*

Similarly, since the household is a major direct consumer of its own farm output (except some cash crops), the fluctuations in production largely get absorbed internally. Highly flexible demand and consumer preference (for example, preparedness to consume damaged grains or even green cobs/pods in place of fully ripe grain, consume normally non-edible stuffs, or drastically cut food intake during poor crop years) helps match the demand situation to the emerging supply situation. The flexibility on the consumption front is further strengthened by on-farm storage and a variety of recycling and food processing devices (which may often convert non-edibles into edibles) (see Jodha, 1967, 1975; Collinson, 1972,

*17.2.1.5 Adapting the Environment*

The above discussion shows that farmers operating under an unstable environment try several ways of adapting their production and consumption activities to the variability of climate. They also know that greater stability of their farming system could be achieved by some means of adapting the environment to their requirements. Since erratic rainfall is the key variable to determining instability or risk to their farming, any means to manipulate rainfall or other effective moisture to their crops is considered as a permanent or more reliable source of stability. This leads to attempts to place irrigation facilities in at least part of the land. 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 yet other areas, both in India and Tanzania, moisture availability, depending on soil characteristics and topography, is manipulated by means of conservation measures such as contour bunding, field border bunding, ridges and furrows, and the like (Ruthenberg, 1968; Jodha, 1980,1982).

*17.2.1.6 Traditional Forms of Rural Cooperation*

Traditional forms of rural cooperation and informal institutional arrangements also have the capability for mutual sharing of risk during bad years and helping to fully harness the potential of bumper crop years (Jodha, 1967; Kirkby, 1974; Wisner and Mbithi, 1974; Hitchcock, 1979). However, under the pressure of modernization and commercialization and institutional interventions by governments, these traditional collective means to facilitate flexibility to the farming system are fast disappearing (Jodha, 1978; Walker and Jodha, 1982).

17.2.2 Short-term Adjustments

The features of farming systems which take the form of responses to short-term climate-induced crises (such as midseason failure of rains) are called adjustments. Adjustment measures, unlike adaptations, are initiated once unfavorable weather performance is known. For example, once midseason failure of rains is certain farmers can initiate two types of action. The first category is directed towards minimizing the losses due to unfavorable weather; we call it specific risk/loss minimizing measures; Berry *et al.* (1972) describe it as measures to modify the loss potential. The second category includes all steps undertaken to manage the losses or adjust to the losses. We designate them specific risk/loss management measures. In Table 17.4 we relate the specific adjustment measures to the adaptive features of farming systems described in Sections 17.2.1.1 through 17.2.1.6. The characteristics of the short-term adjustment measures grouped together under two categories are elaborated in Sections 17.2.2.1 and 17.2.2.2.

*17.2.2.1 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 following categories.

1. *Salvage operations.* Several recovery efforts, depending on the situation, are made. Examples are: recovery of fodder (byproduct) in the face of the definite impossibility of getting the main product; harvesting green cobs/pods in place of a ripe crop; collection of weeded material (as fodder) rather than allowing it to go to waste; concentration on normally low-value production activities such as harvesting field borders for fodder (for details, see Jodha, 1967 and Table 3: Jodha, 1982).
2. *Midseason corrections/adjustments in operations.* Depending on which crop, plot or operation has higher chances of success in the face of unfavorable rainfall, selectivity and discrimination become important features of the decisions regarding deployment of resources, intensity of operations, etc. for different crops and/or plots. For instance, in the face of a midseason dry spell, plots lying lowest in the toposequence get more attention; intensive weeding and emergency thinning is done in the case of drought-resistant and still promising-looking crops; and depending on the moisture situation, especially after the break of the dry spell, partial resowing and patch cultivation is done (see Jodha, 1967, 1982; Berry *et al.*, 1972; Wisner and Mbithi, 1974; and Tables 17.2 and 17.3 above).
3. *Cutback on resource use.* Cost saving is attempted by reducing dependence on hired resources. Owned resources are used where usually hired resources are employed. Family resources also are spared for alternative earning opportunities outside the family farm. Operations, techniques and priorities are changed for the maximum saving of resources (Jodha, 1967, 1982; Berry *et al.*, 1972; Wisner and Mbithi, 1974).

Table 17.3 summarizes the details of some farm operations which become important only during unfavorable rain years. These operations in their respective ways help the risk/loss minimization measures adopted by the farmer.

*17.2.2.2 Risk/Loss Management Measures*

Under this category measures are directed towards ensuring the survival and maintenance of the productive capacity of the farm household in the face of a crisis situation caused by the failure of the crop. These measures have been put into five subgroups and are illustrated by detailed data from various droughtaffected areas in India. A broadly comparable situation has been observed in the very dry villages of Kilosa, bordering Dodoma in the arid region of Tanzania (Jodha, 1982), but comparable quantitative details could not be collected. Mascarenhas (1973) provides a detailed discussion of relevant issues and problems in the context of Tanzania. Broad similarity in farmers' approaches to meet the consequences of droughts in different countries can be seen from various studies on the subject (Dupree and Roder, 1974; Hankins, 1974; Heijnen and Kates, 1974; Kirkby, 1974; Wisner and Mbithi, 1974).

1. *Reduction in current commitments.* This is attempted through postponement, cancellation, or reduction of expenditures related to current consumption, future production, payment of dues, and so forth. Table 17.5 (adapted from Jodha, 1981) summarizes the situation in drought and post-drought years in three areas of western India. It reveals that consumption expenditures of sample farmers during drought years (compared to non-drought years) declined by 8–13 percent in the affected areas of the states of Gujarat and Rajasthan. The magnitude of decline varied significantly among the different expenditure categories. For instance, decline in the expenditure for total food items was the smallest of all the categories. To prevent further decline in this category, however, expenses on other 'non-essential' consumption items like protective food (including milk, meat, vegetables, sugar, fruits, etc.), education, medicine, clothing and socioreligious ceremonies were curtailed drastically. But despite maintenance of the level of expenses for food in drought years near to those of non-drought years, the per capita food intake (due to high prices) declined by 12–23 percent in different areas. For similar observations in drought-prone areas of Kenya, see Wisner and Mbithi (1974). See Escudero (Chapter 10) for a discussion of the relation of climate variability to nutrition.
2. *Resource augmentation.* This is attempted through the use of hitherto rejected or non-edible produce and the conservation and recycling of food/fodder, using different processing techniques (Jodha, 1967; Berry *et al.*, 1972; Hitchcock, 1979).
3. *Asset/inventory depletion.* During the crisis period it is quite usual to sell or mortgage assets or inventories accumulated over the run of good crop years. The main reason for asset depletion through distress sales is for augmentation of liquid resources to supplement meager income during drought years. Apart from deliberate disposal, asset losses are due also to deaths of animals and to theft, quite common during stress periods. Compared to the respective pre-drought years, assets declined by 15-42 percent in different areas during the drought years, as revealed by Table 17.6. In most cases the productive assets, particularly livestock, had the highest (19–60 percent) decline. Moreover, the recovery of depleted assets in post-drought years was not quick enough. By the time asset losses are fully recouped the next drought may occur. Thus over an irregularly occurring famine cycle the asset depletion–replenishment cycle completes itself without leaving surplus resources for agricultural investment and growth in drought-prone areas (Binswanger, 1978). Besides asset depletion, the drought-affected farm households resort to heavy borrowing through formal and informal land and labor debts during the crisis period. As indicated by Table 17.6, in these areas the incidence of indebtedness increased from 63 to 224 percent within a single drought year. The long-term consequences of such indebtedness include permanent pauperization of the people (for evidence see Jodha, 1981, Table 8).
4. *Other measures for sustenance income.* Other loss management devices during drought years include dependence on public relief works, hiring out of human labor and bullocks, earning during outmigration, remittances from well-off relatives, sale of handicrafts, and various means of mutual risk-sharing.

Table 17.7 presents the relative contribution of different sources of income towards the sustenance of farmers during a drought year. Public relief works account for the single biggest source of sustenance income in most of the areas. 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 for sustenance are quite weak.

5. *Outmigration.* This is an important measure to adjust to the spatial variability of rainfall. Farmers, with or without animals, travel long distances during stress periods. Jodha (1978) reported that about 37–60 percent of farm households were affected by outmigration during drought years in different areas. The one-way distance covered ranged from 50–243 kilometers. Outmigration involves both real and nominal costs. An important component of the cost is loss of animals through death, desertion or theft. The extent of animals lost by outmigrants in different areas ranged between 28 and 53 percent of the original number of animals. The practice of migration is more common among the pastoralists in Africa, but no details are readily available to quantify the situation.

**Table 17.4** Adaptive features of farming systems and farmers' adjustment mechanisms to climate-induced risk

| | | Short-term adjustments through: | | | | | | | | | Features observed in | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (A) risk/loss minimization | | | | (B) risk/loss management | | | | | | |
| Adaptive features of farming systems | Long-term flexibility or reliability | Salvage operations | Midseason adjustment | Cut back on hired resources | Change in techniques | Cut in current commitments (consumption etc.) | Resources augmentation (conservation/recycling) | Supplementary earning (migration) | Inventory depletion (assets) | Dependence on others | India | Africa |
| 1. *Diversified production strategy* (through) | | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop/stock 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 |
| 2. *Operational diversification* | | | | | | | | | | | | |
| Toposequential planting | | x | x | | | | | | | | P | x |
| Staggered planting | | | 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 |
| 3. *Flexible resource use patterns* | | | | | | | | | | | | |
| High dependence on own resources | x | | x | x | x | | | x | | | x | x |
| Limited ex-ante commitment to a current production | | | x | x | x | | | | | | x | x |
| Accretionery | x | | | x | | x | x | | x | | x | x |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| process asset buildup | | | | | | | | | | | |
| Recycling the resources | x | | x | x | | | x | x | | x | x |
| 4. *Flexible consumption patterns* | | | | | | | | | | | |
| 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 | |
| 5. *Adapting the environment* | | | | | | | | | | | |
| Irrigation | x | x | x | | | | | | | x | x |
| Moisture conservation | x | x | x | | | | | | | x | P |
| Perennial crops | x | | x | | | | x | | | P | x |
| 6. *Traditional forms of rural cooperation* | x | | | | | | x | | x | x | x |

P = partial.

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 Africa (Tanzania).

**Table 17.5** Changes in expenditures and food grain consumption in three drought-prone areas of India

| Items | 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 |
| Socioreligious ceremonies[d] | 54 | 148 | -63.5 | 57 | 110 | -48.2 | 61 | 88 | -30.7 |
| Others[c] | 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 of data: Jodhpur area: Jodha (1975); Barmer and Banaskantha areas: Chaudhuri and Bapat (1975); Sholapur area: data collected under

ICRISAT Village Level Studies (Jodha *et al.*, 1977); Aurangabad area: Borkar and Nadkarni (1975). For details of number of sample

households see Table 17.7.

[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] Socioreligious 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.

Adapted from Jodha (1981).

**Table 17.6** Changes in assets and liabilities in five drought-prone areas of India

Average per household value of assets and liabilities[a] in (A) pre-drought years[b] (B) drought years and (C) post-drought years in:

| | Jodhpur (Rajasthan) | | | Barmer (Rajasthan) | | | Banaskantha (Gujarat) | | | Sholapur (Maharashtra) | | | Aurangabad (Maharashtra) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (A) | (B) | (C) | (A) | (B) | (C) | (A) | (B) | (C) | (A) | (B) | (C) | (A) | (B) |
| | 62-63[b] | 63-64 | 64-65 | 68-69 | 69-70 | 70-71 | 68-69 | 69-70 | 70-71 | 71-72 | 72-73 | 73-74 | 71-72 | 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 | | NA |
| (% change) | | -(30.2) | +(5.9) | | -(4.6) | -(1.8) | | -(2.7) | — | | -(31.1) | +(16.4) | | NA |
| 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] | | | | | | | | | | | | | | |
| Debts outstanding | 189 | 552 | 637 | 498 | 873 | 949 | 111 | 360 | 302 | 375 | 613 | 651 | NA | NA |
| (% change) | | +(192.0) | +(15.4) | | +(75.3) | +(8.7) | | +(224.3) | -(16.1) | | +(63.5) | +(6.2) | | |

Source of data: See Table 17.5.

[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, goats, etc.

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

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

[f] Consumer durables—only important items like radios, watches, bicycles and modern furniture included.

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

NA: Not available.

Adapted from Jodha (1981).

**Table 17.7** Sources of sustenance income in five drought-prone areas of India

| Details | Jodhpur (Rajasthan) | Barmer (Rajasthan) | Banaskantha (Gujarat) | Sholapur (Maharashtra) | Aurangabad (Maharashtra) |
|---|---|---|---|---|---|
| Drought year | 1963–64 | 1969–70 | 1969–70 | 1972–73 | 1972–73 |
| Sample households (No.) | 144 | 100 | 100 | 80 | 128 |
| Average amount of sustenance income (Rs/household)[a] | 3133 | 2996 | 2627 | 2944 | 2715 |
| % share of sources in sustenance income | | | | | |
| Cultivation [b] | 2.1 | - | - | 14.4 | 6.8 |
| Animal husbandry | 10.2 | 7.2 | 4.8 | 1.0 | NA |
| Wage income from relief works | 24.9 | 22.4 | 25.3 | 46.5 | 56.2 |
| Institutional help` | NA | 30.4 | 6.4 | NA | NA |
| Sale of assets | 25.9 | 12.5 | 24.9 | 17.3 | 13.5 |

| | | | | | |
|---|---|---|---|---|---|
| Borrowings (credit) | 10.4 | 12.8 | 11.7 | 7.9 | 6.3 |
| Others' | 26.5 | 14.7 | 26.9 | 12.9 | 17.2 |

[a] Sustenance income is 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 outmigration), 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.

## 17.3 THE POTENTIAL OPTIONS FOR RISK STRATEGY

Having learned about the farmers' traditional mechanisms to handle climate-induced risk and their strong and weak points, one can proceed to identify some new measures which can potentially strengthen the farmers' methods (Spitz, 1980). The new measures, of course, are not to substitute for the existing mechanisms. Rather they should help generate more options for the farmer to adapt and adjust to the risky environment. The potential options contain technological and institutional measures that share the insurance elements of traditional measures. Their conceivable superiority, however, lies in providing both insurance and increased capacity for the farmers to more easily withstand periodic stress situations.

The new institutional options indicated are also not very new. The focus of institutional measures (i.e., government policies and programs) is on the need for designing them to adapt to the realities of unstable agricultural situations. Most of the current programs and policies need to be more sensitive to the problems created by climate variability before they can complement the farmers' own measures to handle risk (Wisner and Mbithi, 1974; Jodha, 1981).

### 17.3.1 Potential Technological Options

Potential technological measures are summarized in Tables 17.8, 17.9, and 17.10. Specific practices and their attributes in terms of potential adaptation and adjustment benefits are indicated, as well as the relevance of the measures to farmers' past experience and resource capacity, helpful in facilitating adoption of the techniques. In keeping with the classification of traditional measures, the new technological measures, which can significantly add to the flexibility and productive capacity of the farming system, can be broadly classified under three groups: Table 17.8, resource measures; Table 17.9, crop measures, and Table 17.10, management practice measures. These measures are at different stages of development and availability to the farmer. Moreover, they are of a general nature and specific changes may be necessary to suit local circumstances in different areas.

### *17.3.1.1 Resource Measures*

These include all the measures in dealing with the improvement, management and manipulation of the resource base—particularly the natural resource base—of farming. Variability of rainfall is the principal source of instability of farming in tropical arid and semi-arid areas. Agricultural scientists maintain that the moisture available in most years, if properly utilized, is sufficient for raising one or (in some areas) two rainfed crops. The main problem is intraseason temporal distribution of rains. It is not uncommon to witness 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 use pattern can be manipulated to increase its effective availability for crop production. This is attempted through storage of water on the soil surface (in tanks, etc.) and in the profile of the soil. This helps generate the following options to adapt the environment (moisturewise) to the crops planted (see Table 17.8).

**Table 17.8** Potential technological options: resource measures

| | Attributes | | | |
|---|---|---|---|---|
| Resource measures: relating to conservation, management of soil and moisture | Long-term adaptation through: | Short-term adjustment through: | Relevance to: | |
| | Flexibility-based options | Salvage operations | Farmers' experience | Farmers' resource capacity |

| | Growth-induced cushion/stability | | Adjustment to intra-season weather | India | Africa | India | Africa | Specific agroclimatic conditions | Reference for experimental evidence |
|---|---|---|---|---|---|---|---|---|---|
| 1. *Runoff collection and recycling* | x | x | | P | | | | R | 1,2 |
| 2. *Soil/moisture conservation through* | | | | | | | | | |
| – contour bunds | x | x | x | P | | P | | R,Bm | 3 |
| – graded bunds | x | x | | P | | | | R,B | 3 |
| – broad bed and furrows | x | x | x | P | | | | B | 1,2,4,5 |
| – broad-based terraces | x | x | | | | | | Bd,R | 3 |
| – mulching | x | x | x | P | P | P | P | R,B | 3 |
| – contour cultivation | x | x | | | P | P | P | Bd | 3 |
| – tie-ridging | x | x | x | | P | | P | Bm,R | 6 |

References: 1. Ryan *et al.*,1979; 2. Binswanger *et al.*,1980; 3. Randhawa and Rao.1981; 4. Ryan and Sarin, 1981; 5. Virmani *et al.*, 1981; 6. Le Mere, 1972.

Abbreviations: P. partial; R, red soils; Bd, deep black soils, D, dependable rainfall; Bm, medium black soils.

1. *Runoff collection and recycling of water. By* means of proper layout of the landscape on a watershed basis, the facilities for drainage of excess water into small tanks can be arranged. The water thus harnessed during not infrequent heavy storms can be utilized for supplemental or life-saving irrigation during the midseason drought, or for raising post-rainy season crops. The evidence from experimental work at ICRISAT and the national institutes in India indicates that this measure can make a significant contribution towards the stability and growth of rainfed agriculture in Alfisols (red soil) areas (Ryan *et al.*, 1979; Binswanger *et al.*, 1980). However, the measure may face some problems of an institutional nature as it involves soil and water management on a watershed basis, and even a single small watershed involves a number of small farmers who may or may not agree to a collective decision (Doherty and Jodha, 1979).
2. *Soil/moisture conservation measures.* In addition to traditional field border bunding, experimental

work on soil/moisture management has developed further options to suit different soil type and rainfall conditions. A few that have shown promise are graded bunds, broadbeds and furrows, broad-based terraces, land smoothing, contour bunds, tie-ridging, contour cultivation, furrows (in grasslands) and mulching (for details see Le Mere, 1972; Ryan *et al.*, 1979; Binswanger *et al.*, 1980; Randhawa and Rao, 1981; Virmani *et al.*, 1981). Some of these measures, when used with other components of modern technology such as improved seed and fertilizer, can raise production substantially. In areas where water stagnation rather than moisture stress operates as a main constraint, the above-mentioned measures help in better drainage to improve crops.

*17.3.1.2 Crop Measures*

The new crop technologies offer better and more crop options to the farmer. Certain crops can now be developed, improved or adapted to the environment through scientific research. In some cases the alternative crops available mean the substitution of the traditional crops of one region by traditional crops from other regions. The variety of perennial and annual crops recommended for different agroclimatic zones (Kassam 1976; Spratt and Chowdhury, 1978; Anon., 1979; De Vries and Mvena, 1979; Mukuru, 1980) offer choices for crops to suit different weather conditions, for example, early rain, late rain, inadequate or excess rain, midseason drought, and the like. Depending on their various characteristics, the crops may offer possible stability and higher yields (see Table 17.9).

*17.3.1.3 Management Practice 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 (De Vries, 1976; Monyo *et al.*, 1976; Keregero *et al.*, 1977; Krishnamoorthy *et al.*, 1977; Virmani *et al.*, 1981). Many of them involve only changes in husbandry practices rather than substantial input costs. The practices relate to operation at various stages of crop seasons and they are designed to effect efficient use of the environment—soil, moisture, and the like (see Table 17.10).

**Table 17.9** Potential technological options: crop measures

| | Attributes | | |
|---|---|---|---|
| Crop measures:<br>crop choice/substitution based on crop characteristics* | Long-term adaptation through: | Short-term adjustment through: | Relevance to: |

| | | Growth-induced cushion/stability | Flexibility-based options | Adjustment to intra-season weather | Salvage operations | | Farmers' experience | | Farmers' resource capacity | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 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 effiency | x | | | x | | P | P | p | |
| 6. | Adapted to new agronormic practices | x | x | | x | | | | P | P |
| 7. | Resistant to pests/insects | x | | | x | | P | P | P | P |

* For experimental evidence see Kassam (1976); Krishnamoorthy *et al.* (1977); Spratt and Chowdhury (1978); Anon. (1979);
Mukuru (1980), Randhawawa and Rao (1981).

For instance, the practice of dry seeding eliminates the loss of time involved in traditional systems, where crops are planted after the rains when fields are ready. This period may be as long as 10 days or more in many areas. Dry sowing has several favorable implications for plant stand and growth. The variety of crops with different physiological habits has facilitated the manipulation of sowing dates to suit the timings of rainfall. This has obvious flexibility implications.

Practices relating to plant population, spacing, and midseason changes therein also help better adjustment to emerging weather conditions. Similarly, intensive weed management and the selective use of fertilizer also help to bring about high and stable crop production.

Practices such as intercropping and sequential and relay cropping, involving crops with varying capacity to benefit over time and space from the environment, also add to higher and more stable production.

**Table 17.10** Potential technological options: management practice measures

| | Attributes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Long-term adaptation through: | | Short-term adjustment through: | | Relevance to: | | | |
| | | Flexibility-based options | Salvage operations | Adjustment to intra-season weather | Farmers' experience India | Farmers' experience Africa | Farmers' resource capacity India | Farmers' resource capacity Africa |
| 1. Dry seeding | x | x | | x | P | | P | P |
| 2. Flexible sowing time | | x | x | x | P | P | P | P |
| 3. Transplanting some crops | | x | | | | P | P | P |
| 4. Plant population and manipulation practices | | x | | x | P | P | P | P |
| 5. Varying level and selective use of | x | x | | | P | P | P | P |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| fertilizer | | | | | | | | |
| 6. Intensive weed management | x | | x | x | P | P | P | P |
| 7. Midseason thinning, ratooning, gap filling | | x | x | x | P | P | P | P |
| 8. Intercropping with HYVs | x | x | | x | P | | | |
| 9. Sequential/relay cropping | x | x | | x | P | | | P |
| 10. Post-harvest tillage | | x | | | | P | | |

* For experimental evidence, see footnote to Table 17.9

P = Partial

Post-harvest plowing is one practice which helps weed and moisture control and prepares soil well for effective dry seeding. In some areas this is a traditional practice, but it is often done much after the crop has been harvested. By then soil is completely dry, weeds have already matured and scattered their seeds, and animals are very weak, since it is the dry season.

17.3.2 Potential Institutional Options

Most of the institutional measures discussed below are not new. What is new is renewed emphasis on their reorientation to become more relevant to the situations in areas with drought hazard. The potential institutional measures—public policies and programs conducive to increased effectiveness of farmers' mechanisms to handle weather-induced risk—are summarized in Table 17.11. They are subgrouped under three categories.

1. *Contingency support facilities.* These measures are directed to supplement farmers' own efforts to manage the crisis situation generated by drought-induced scarcities. They are largely short-term measures.
2. *Area-based infrastructure.* This includes long-term and permanent measures to facilitate growth of the regions often hit by droughts.
3. *Schemes supporting adoption of new technology.* These measures include the infrastructure and other support facilities essential for adoption of the new technological options discussed in the preceding section.

The long- and short-term consequences of the measures under the aforementioned three categories are also indicated in Table 17.11. For detailed discussion of the potential role of these measures in helping farmers' traditional adjustment mechanisms see Wisner and Mbithi (1974); Dandekar (1976); Mascarenhas (1979); and Jodha (1981).

## 17.4 CONCLUSION

Subsistence farmers, through trial and error over a period of generations, have evolved various mechanisms to handle drought-induced risk. The strongest component of these risk-handling mechanisms is the diversification and consequent flexibility of the farming systems. Farmers in low and unstable rainfall areas are faced with very limited production alternatives. They try to multiply the total options by manipulating crop combinations and varying methods of resource use and farm practices. In the process they gain stability in production but do sacrifice the more remunerative opportunities occasionally presented by the rainfall pattern. In other words, farmers' production strategies are geared largely towards handling the negative aspects of climate, such as droughts, rather than concentrating on positive aspects. This is because climate is recognized more as a source of distress than as a positive resource for production activities.

**Table 17.11** Potential institutional options

| Institutional measures: programs/policies* | Attributes in terms of support to: | | | Relevance to current experience of the countries | |
|---|---|---|---|---|---|
| | Adaptation | Adjustment | | | |
| | Long-term growth and flexibility | Loss minimization | Loss management | India | Africa |
| 1. *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 |
| 2. *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/stock insurance | x | x | | | |
| | Non-farm employment | x | | x | P | P |
| 3. | *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 |

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

P = partial.

These mechanisms, which show considerable similarity across geographical, cultural and demographic contexts in the tropical underdeveloped world, have lost part of their effectiveness. 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. If, however, climate is considered as a positive factor of production rather than as a mere source of distress and new technological options supported by relevant institutional measures are adopted, the farmers' adjustment mechanisms probably can become stronger than they have ever been.

Although evolved over generations, the traditional structure of options to handle climate-induced risks is fairly static and does not include several new options based on modern scientific advancements in agricultural technology. Traditional technology can at best ensure the balancing of losses and gains at the end of a famine cycle. It does not offer enough scope for generating a surplus for reinvestment and growth to ensure stronger internal cushions for the farmers effectively to sustain the impacts of subsequent droughts. Public relief programs have assumed a significant role in complementing the farmers' own attempts to handle climate-induced risk. Many new options, both technological and institutional, exist in experimental settings or limited practice to assist them also. The best of these options are elaborations of traditional measures and draw inspiration from the underlying principles of diversification and insurance. But they also build up the farmers' long-term capacity to withstand periodic stress and break the cycle of drought pauperization.

## REFERENCES

Abalu, G. O. I., and D'Silva, B. (1980). Socio-economic analysis of existing farming systems and practices in northern Nigeria. In *Socio-economic Constraints to Development of Semi-arid Tropical Agriculture*, pp. 3-10. ICRISAT Economics Program, Patancheru, A.P., India.

Anon. (1979). *Improved Agronomic Practices for Dryland Crops in India.* All India Coordinated Project for Dryland Agriculture (ICAR), Hyderabad.

Berry, L., Hankins, T., Kates, R. W., Maki, L., and Porter, P. (1972). *Human Adjustment to Agricultural Drought in Tanzania: Pilot Investigations.* Research Paper No. 13, BRALUP, University of Dar es Salaam, Tanzania.

Bharadwaj, K. (1974). *Production Conditions in Indian Agriculture.* Cambridge University Press, Cambridge.

Binswanger, H. P. (1978). Risk attitudes of rural households in semi-arid tropical India. *Economic and Political Weekly,* **13** (25), A49-A62.

Binswanger, H. P., and Jodha, N. S. (1978). *Manual of Instructions for Economic Investigators in ICRISAT's Village Level Studies.* ICRISAT Economics Program, Patancheru, A.P., India.

Binswanger, H. P., Virmani, S. M., and Kampen, J. (1980). Farming systems components for selected areas in India: Evidence from India. *Research Bulletin* No. 2, ICRISAT, Patancheru, A.P., India.

Borkar, V. V., and Nadkarni, M. V. (1975). *Impact of Drought on Rural Life.* Popular Prakashan, Bombay.

Chambers, R. (1982). Health, agriculture, and rural poverty: Why seasons matter. *Journal of Development Studies*, **18**, 217-238.

Chaudhuri, K. M., and Bapat, M. T. (1975). *A Study of Impact of Famine and Relief Measures in Gujarat and Rajasthan.* Agro-economic Research Centre, Vallabh Vidyanagar, India.

Collinson, M. P. (1972). *Farm Management in Peasant Agriculture: A Handbook for Rural Development Planning in Africa.* Praeger Publishers, New York.

Collinson, M. P. (1977). Demonstration of an interdisciplinary approach to plan adaptive agricultural research programs (drier areas of Mragoro and Kilosa, Tanzania). CIMMYT East African Economics Program, Nairobi.

Dandekar, V. M. (1976). Crop insurance in India. *Economic and Political Weekly,* **11** (6), A61-A80.

De Vries, J. (1976). Has extension failed? A case study of maize growing practices in Iringa, Tanzania. *Rural Economy Research Paper No. 1,* Faculty of Agriculture, Forestry, and Veterinary Science, University of Dar es Salaam, Tanzania.

De Vries, J., and Mvena, Z. S. K. (1979). Sorghum production by small holders in Morogoro district, Tanzania. *Rural Economy Research Paper No. 9*, Faculty of Agriculture, Forestry, and Veterinary Science, University of Dar es Salaam, Tanzania.

Doherty, V. S., and Jodha, N. S. (1979). Conditions for group action among farmers. In Worg, J. (Ed.) *Group Farming in Asia*, pp. 207-224. Singapore University Press, Singapore.

Dupree, H., and Roder, W. (1974). Coping with drought in a preindustrial, preliterate farming society. In White, G. F. (Ed.) *Natural Hazards*, pp. 115-119. Oxford University Press, New York.

Friedrich, K. H. (1974). *The Collecting and Analysis of Micro-economic Data in Developing Countries.* Food and Agriculture Organization, Rome.

Hankins, T. D. (1974). Response to drought in Sukumaland, Tanzania. In White, G. F. (Ed.) *Natural Hazards*, pp. 98-104. Oxford University Press, New York.

Heijnen, J., and Kates, R. W. (1974). Northeast Tanzania: Comparative observations along a moisture gradient. In White, G. F. (Ed.) *Natural Hazards*, pp. 105-114. Oxford University Press, New York.

Hitchcock, R. K. (1979). The traditional response to drought in Botswana. In Hinchey, M. T. (Ed.) *Proceedings of the Symposium on Droughts in Botswana*. Botswana Society and Clark University Press, Worcester, Massachusetts.

Jodha, N. S. (1967). *Capital Formation in Arid Agriculture: A Study of Resource Conservation and Reclamation Measures Applied to Arid Agriculture.* Unpublished thesis, University of Jodhpur, Rajasthan.

Jodha, N. S. (1975). Famine and famine policies: Some empirical evidence. *Economic and Political Weekly*, **10** (41),1609-1623.

Jodha, N. S. (1978). Effectiveness of farmers' adjustments to risk. *Economic and Political Weekly*, **13** (25), A38-A47.

Jodha, N. S. (1980). Intercropping in traditional farming systems. *Journal of Development Studies*, **16** (4), 227-247.

Jodha, N. S. (1981). Role of credit in farmers' adjustment against risk in arid and semi-arid tropical areas of India. *Economic and Political Weekly,* **16** (42-43), 1696-1709.

Jodha, N. S. (1982). *A Study of Traditional Farming Systems in Selected Villages of Tanzania.* ICRISAT Program Progress Report, Patancheru, A.P., India.

Jodha, N. S., Asokan, M., and Ryan, J. G. (1977). *Village Study Methodology and Resource Endowment of Selected Villages in ICRISAT's Village Level Studies.* ICRISAT Economics Program Occasional Paper No. 16, Patancheru, A. P., India.

Kassam, A. H. (1976). *Crops of the West African Semi-arid Tropics.* ICRISAT, Patancheru, A.P., India.

Kearle, B. (1976). *Field Data Collection in the Social Sciences: Experience in Africa and the Middle East.* Agricultural Development Council, New York.

Keregoro, K. J. B., De Vries, J., and Bartlett, C. D. S. (1977). Farmer `resistance' to extension advice: Who is to blame. A case study of cotton production in Mara region, Tanzania. *Rural Economy Research Paper No. 5,* Faculty of Agriculture, Forestry, and Veterinary Science, University of Dar es Salaam, Tanzania.

Kirkby, A. V. (1974). Individual and community responses to rainfall variability in Oaxaca, Mexico. In White, G. F. (Ed.) *Natural Hazards,* pp. 119-128. Oxford University Press, New York.

Krishna, R. (1969). Models of family farms. In Wharton, C. R., Jr. (Ed.) *Subsistence Agriculture and Economic Development,* pp. 185-190. Aldine Publishing Co., Chicago, Illinois.

Krishnamoorthy, C., Chowdhury, S. L., Anderson, D. T., and Dryden, R. D. (1977). Crop management in semi-arid farming. *Second FAO/SIDA Seminar on Field Food Crops in Africa and the Near East, Lahore, Pakistan.* All India Coordinated Research Project for Dryland Agriculture, Hyderabad.

Lagemann, J. (1977). *Traditional African Farming Systems in Eastern Nigeria.* Weltforum, Munich.

Le Mere, P. H. (1972). Tie-ridging as a means of soil and water conservation and of yield improvement. *Proceedings of the Second Inter-African Soils Conference,* Ukiruguru, Tanzania.

Mallik, A. K., and Govindaswamy, T. S. (1962-63). The drought problem of India in relation to agriculture. *Annals of Arid Zone,* **l** (1 and 2),106-113.

Mascarenhas, A. C. (Ed.) (1973). Studies in famines and food shortages. *Journal of the Geographical Association of Tanzania,* No. 8.

Mascarenhas, A. C. (1979). After villagisation what? In Biswark, M., and Cranford, P. (Eds.) *Towards Socialism in Tanzania.* University of Toronto Press, Toronto, Canada.

Mellor, J. W. (1969). The subsistence farmer in the traditional economies. In Wharton, C. R., Jr. (Ed.) *Subsistence Agriculture and Economic Development*, pp. 209-227. Aldine Publishing Co., Chicago, Illinois.

Monyo, J. H., Ker, A. D. R., and Campbell, M. (1976). *Intercropping in Semi-arid Tropics (a symposium report).* International Development Research Centre, Ottawa, Canada.

Mukuru, S. Z. (1980). *National Sorghum Improvement Program in Tanzania: Annual Report 1979-1980.* ARI, Ilonga, Tanzania.

Norman, D. W. (1973). *Methodology and Problems of Farm Management Investigations: Experiences from Northern Nigeria.* African Rural Employment Study, Zaria, Nigeria.

Randhawa, N. S., and Rama Mohan Rao, M. S. (1981). Management of deep black soils for improving production levels of cereals, oilseeds and pulses in semi-arid regions. *Seminar on Improving Management of Deep Black Soils for Improving Production Levels of Cereals, Oilseeds and Pulses in Semi-arid Regions,* pp. 66-77. ICRISAT, Patancheru, A. P., India.

Ruthenberg, H. (Ed.) (1968). *Smallholder Farming and Development in Tanzania.* Weltforum, Munich.

Ruthenberg, H. (1976). *Farming Systems in the Tropics* (2nd edition). Clarendon Press, Oxford.

Ryan, J. G., and Sarin, R. (1981). Economics of technology options in relatively dependable rainfall regions of the Indian semi-arid tropics. *Seminar on Improving Management of Deep Black Soils for Improving Production Levels of Cereals, Oilseeds and Pulses in Semi-arid Regions.* ICRISAT, Patancheru, A. P., India.

Ryan, J. J., Sarin, R., and Pereira, M. (1979). Assessment of prospective soil-, water-, and crop-management technologies for the semi-arid tropics of peninsular India. *Workshop on Socio-economic Constraints to Development of Semi-arid Tropical Agriculture*, pp. 52-72. ICRISAT, Hyderabad.

Sen, S. R. (1971). Droughts in India-certain dimensional considerations. In Sen, S. R. (Ed.) *Growth and Stability in Indian Agriculture.* Firma K. L. Mukhopadhyay, Calcutta.

Spitz, P. (1980). Drought and self-provisioning. In Ausubel, J., and Biswas, A. K. (Eds.) *Climatic Constraints and Human Activities*, pp. 125-147. Pergamon Press, Oxford.

Spratt, E. D., and Chowdhury, S. L. (1978). *Improved Cropping Systems for Rainfed Agriculture in India.* Field Crops Research, Amsterdam.

Virmani, S. M., Willey, R. W., and Reddy, M. S. (1981). Problems, prospects and technology for increasing cereal and pulse production from deep black soils. *Seminar on Improving Management of Deep Black Soils for Improving Production Levels of Cereals, Oilseeds and Pulses in Semi-arid Regions.* ICRISAT, Patancheru, A. P., India.

Walker, T. S., and Jodha, N. S. (1982). Efficiency of risk management by small farmers. Submitted at *Conference on Agricultural Risks, Insurance, and Credit in Latin America at IICA, San José, Costa Rica.*

Wharton, C. R., Jr. (1968). Risk, uncertainty and subsistence farmer: Technological innovation and resistance to change in the context of survival. Paper presented at the *Joint Session of the American Economic Association and the Association for Comparative Economics, Chicago, Illinois.*

Wharton, C. R., Jr. (1969). Subsistence agriculture: Concept and scope. In Wharton, C. R., Jr. (Ed.) *Subsistence Agriculture and Economic Development*, pp. 6-12. Aldine Publishing Co., Chicago, Illinois.

Wisner, B., and Mbithi, P. M. (1974). Drought in eastern Kenya: Nutritional status and farmer activity. In White, G. F. (Ed.) *Natural Hazards*, pp. 87-97. Oxford University Press, New York.

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