FARMER RISK MANAGEMENT STRATEGIES:

THE CASE OF THE WEST AFRICAN SEMI-ARID TROPICS

by

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A number of African countries have recently adopted structural adjustment programs and moved towards freer markets in hopes of reversing declining per capita food production. Unfortunately, although a necessary condition, policy reform and market liberalization may not be sufficient to accomplish this purpose, given the highly risky environment in which producers operate. Drought, flooding, disease, pest infestation, and unanticipated interruptions in labor supply are among the risks prevalent in the West African semi-arid tropics (WASAT). Farmers in the WASAT use various methods to protect household food consumption from stochastic production shocks. Since these strategies condition farmers' responses to new options, an understanding of their risk management strategies is essential if productivity is to be increased. To optimize impact, technologies and policies should conform to and reinforce these strategies. Conversely, if new interventions undermine key components of such strategies, broad adoption and impact will be blocked and/or farmer welfare reduced. This lack of reinforcement of risk strategies has been found to be an important factor explaining low levels of adoption of productivity-enhancing technologies in the WASAT.

This paper sets out a conceptual framework within which to identify and analyze the main risk management practices employed by WASAT farmers. The majority of farmers adopt these practices due not to their attitudes towards risk (i.e. degree of risk aversion), but to the particular physical and economic environment they face. Much recent analysis of agricultural production has attempted to incorporate risk (e.g. in mean-variance or stochastic dominance models). However, model results typically rely on risk preferences, which involves the specification of a measure of risk aversion (Anderson et al., Newbery and Stiglitz). As

a result, much analysis of agricultural decision-making under risk is conditional on particular risk preferences. The fact that attitudes toward risk can vary considerably among individuals and over time sharply decreases the normative usefulness of these risk models. In other words, if variations in behavior can be explained by differences in (risk) preferences among individuals, then the research results on agricultural decisions under risk cannot be easily translated into farm management or policy recommendations. This paper demonstrates how focusing on reactions to risk, rather than on attitudes towards risk, leads directly to better informed policy and technology development decisions.

To illustrate the framework, the paper draws on primary farm-level data collected in Burkina Faso to compare the most common risk management methods across three major agroclimatic zones of Sub-Saharan Africa. The International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) collected the data in six villages (150 farming households) from 1981-85. The three zones included in the survey - Sahel (northern Burkina Faso), Sudan savanna (central), and North Guinea savanna (southern) - represent striking contrasts in production potential and risk. Climatic constraints are most limiting in the Sahel (with an average of 438 mm. annual rainfall in the study villages from 1981-85), declining in importance in the Sudanian (608 mm.) and the Guinean zones (768 mm.).

Risk Management Methods - A Conceptual Framework

Evidence strongly suggests that food security is the overriding objective of household production and employment among WASAT farmers (Norman, et al.). Food security can be ensured through any combination of three modes of acquisition: own-production, purchases, and transfers.

Risk management methods, moreover, are applied at several levels of

operation: (1) plant, (2) plot, (3) farm, (4) whole household, (5) village, and (6) region. Methods to ensure own-production involve actions at levels (1) through (3); purchases are secured at levels (3) through (6); and transfers are secured at levels (5) and (6).

Risk management methods also differ according to when they are applied relative to the occurrence of production shocks (e.g. drought). "Ex ante" methods are designed to place households in a less vulnerable position before a shock occurs. "Interactive" methods involve the reallocation of resources at the time of a shock with the goal of minimizing its impact on production. "Ex post" methods, involving actions taken after a shock has already reduced production, aim to minimize the subsequent impact on consumption. Table 1 uses this three-way classification to describe the principal risk management methods employed by farmers in the WASAT.

This classification does not imply that these practices are exclusively attributed to risk reduction objectives in all cases. Several of the methods listed are known to achieve lower variance in returns and higher average returns compared to alternative practices. An example is intercropping compared to solecropping in low-input systems. Moreover, although some practices reduce production risk without necessarily improving expected returns, they may be implemented by particular farmers for reasons not explicitly related to risk. Examples of the latter include crop diversification that farmers may practice to meet consumption objectives in the face of product market deficiencies, and plot fragmentation due to land inheritance.

Ex Ante Methods at the Plot and Farm Levels

Diversification - of crops, cultivars, and plot locations - is one of the most common means by which farmers attempt to stabilize agricultural

Table 1 **An Inventory of Risk Management Methods Used by Farmers in Semi-Arid West Africa**

Scale	Time Frame: Ex Ante	Interactive	Ex Post
Plant	Varietal selection for stress resistance/tolerance	Replanting with earlier maturing varieties	
Plot	Early/staggered planting dates Low hill density High seed rates Intercropping Run-off management Delayed fertilizer application	Changing crops with replanting Changing plant density through thinning or replanting	Grazing of failed plots for animal maintenance Late planting for forage production
Farm	Diversified cropping pattern Land type diversification Plot fragmentation	Shifting crops between land types	
Household, Village, Region	Cereal stocks Livestock, assets Social networks Non-farm employment networks	Farm wage labor	Cereal rationing Asset sales for food purchases Migration employment

income. Crop diversification reduces farm-level income variability to the extent that individual crop yields are not closely correlated across years (Walker and Jodha, Lang et al.). As one form of crop diversification, intercropping further improves stability at the plot level to the extent that crop mixtures achieve higher yields than sole equivalents in stress conditions, reduce the incidence of pests and diseases, or manifest compensatory yield behavior due to differences in crop structure, physiology, or phenology (Norman).

The ICRISAT survey data revealed significant differences in the degree of crop diversification across study zones. Due to agroclimatic constraints, cropping patterns in Burkina Faso are the least diversified in the riskier, lower potential zones surveyed. Millet-based crop enterprises dominate Sahelian cropping systems, occupying 93 percent of total cultivated area. Cropping patterns in the high potential and relatively low risk North Guinean zone are the most diversified, with no single crop-based enterprise occupying more than one-third of cultivated area. A total of 156 distinct crop enterprises were identified in the North Guinean zone compared to 65 and 56, respectively, in the Sahel and Sudan zones.

Diversification of varieties with varying maturities permits staggered plantings, which can reduce the risks of period-specific stresses. Varietal diversification also decreases the risk of pest and disease loss where there is genetic variability in resistance or tolerance to biotic stresses. Management of local varieties is very dynamic, with new varieties introduced and substituted in response to changing environmental conditions. In one of the Sahel study villages, for example, six of the seven millet cultivars in current use had been adopted during the last 15 years. Of the six new cultivars, five were local varieties that had been introduced by farmers acting independently of the agricultural extension

system. All were of relatively shorter maturity than the varieties they replaced, reflecting adaptation to lower precipitation during the last 20 years. Similar patterns were observed in the Sudan and North Guinean zones, but it is only in these zones that farmers were able to exploit this genetic diversity by changing varieties in late planting situations. Because of the much shorter rainfall period in the Sahel, very little effective varietal diversification was observed.

Land type diversification is found throughout the WASAT, where the physical and chemical properties of soil vary systematically with location on the toposequence (van Stavern and Stoop). Farmers match crops to the micro-environments that they best fit agronomically. For example, they plant millet at the top of slopes where soils are sandier and water run-off is a problem, and rice in the lowlands where heavier soils are found and run-off collects. This reduces the risk of crop losses due to stresses associated with specific land types. The impacts of localized factors such as drought or pest infestation are reduced if plots are highly dispersed spatially as well. Farmers in the Burkina survey cultivated a large number of plots in highly fragmented and dispersed patterns. Plot fragmentation was found to be lowest in the Sahel, with an average of 10 plots per farming unit, highest in the Sudan (23 plots), and intermediate in the Guinean zone (15 plots).

With respect to ex ante risk management methods, it is apparent that where these methods are needed the most (i.e. the Sahel), they are less utilized due to physical and climactic constraints. In the Sudan and North Guinean zones, which have higher agronomic potential (and higher potential for the adoption of productivity-increasing techniques), ex ante diversification of crops, varieties, and land types is found extensively within farmers' traditional cropping patterns.

Sequential Decision Making: Interactive Methods at the Plot Level

At the beginning of the cropping season farmers have subjective expectations based on experience concerning the onset, amount, distribution, and duration of rainfall. As the season progresses they revise these expectations and sequentially adjust their cropping patterns to fit the emerging rainfall. Time consuming hand planting and irregular distribution of early season rainfall combine to extend the time it takes to finish the first plantings from between 50 days in the Sahel to over 100 days in the North Guinean zone. Maintaining the flexibility to modify cropping patterns during this period is crucial to the success of sequential adaptation methods.

Farmers introduce modifications by: (1) shifting crops to various portions of the toposequence; (2) switching crops and/or varieties with late first plantings and replantings; (3) adjusting plant densities positively through late plantings or replantings of the main crop or intercrop, or negatively through thinning; and (4) adjusting the dates, number, and intensity of weedings across crops and plots (including abandoning marginal crops and locations).

The Burkina survey data showed that these adjustments were used extensively across zones, although with considerable variation in frequency across years. For example, reseeding of major cereals was consistently high in the Sudan zone (ranging from 10 to 50 percent of sown area) and as high as 30 percent in the Sahel and 80 percent in the North Guinean zone in particular years. However, while the need for adjustments was larger and more frequent in the Sahel, the flexibility to execute them was more limited by the brevity of the cropping season. In the higher potential Sudan and North Guinean zones, farmers had much more flexibility and were able to make sequential adjustments during the cropping season

in response to new information as to the amount and timing of rainfall.

An important implication of the high value farmers put on the flexibility to adapt to changing conditions is the fact that new technologies and techniques may not be adopted if they do not fit into the strategies farmers are following. For example, direct seeding without plowing is the rule in all but the North Guinean zone. Although research station trials demonstrate that yields can be maximized if plowing and fertilization are carried out at the beginning of the rainy season, farmers in each zone rarely use the first rains for plowing, and generally delay fertilizer application until first weeding. Preplanting plowing would conflict with famers' early planting and reseeding strategy. Early planting allows farmers to exploit early rains with sufficient time to replant when rains fail at seedling stage. Delaying chemical fertilizer application until the pattern of rainfall is better known and seedlings are well established reduces labor requirements at first weeding and lowers the risk of loss of purchased fertilizer to weed growth and run-off. Another farm management practice that is followed primarily due to flexibility considerations is planting shorter-cycle varieties of millet and sorghum, which allows more options as to the timing of plantings and replantings.

Compensatory Ex Post Methods at the Household and Regional Levels

When crop failure occurs despite ex ante and interactive risk management practices, farmers may protect household consumption by absorbing production risk through transfers and purchases financed from earnings in off-farm employment and asset liquidation. Severe drought in the Sahel and Sudan zones of Burkina Faso in 1984 reduced cereal yields to only 41 percent of their average 1981-83 levels and domestic food

production met only 29 percent of annual energy requirements (World Health Organization) in each zone. Despite identical production deficits, actual consumption in the Sahel slightly exceeded requirements during the subsequent 12 months, whereas average consumption among Sudan zone households fell 18 percent below requirement standards. Cereal purchases explained nearly all of the regional difference. Of food energy consumed by Sahelian households, 34 percent was purchased, an amount 40 percent more in absolute terms than in the Sudan.

Because climatic conditions chronically limit their ability to protect total crop production through ex ante diversification methods and through interactive management flexibility, Sahelian households had substantially invested in insurance substitutes, such as livestock, which can be sold when crops fail. The value of livestock herds was nearly three and a half times larger among the Sahelian households than the Sudanian households ($125 vs. $38 per adult male equivalent at 1984 prices). Sahelian farmers had also established more non-farm employment options in other sectors and regions than farmers in the Sudan zone. Agricultural income (crop production plus farm wage labor) accounted for only 23 percent of total income in the Sahel sample during 1984, against 55 percent in the Sudan (Reardon et al.). Diversifying household income sources to include livestock and employment in non-farm enterprises reduces overall variability of household income and buffers household consumption from the effects of localized production shortfalls, since these alternative income sources have relatively low covariance with local cropping outcomes.

Implications

This overview of farmers' risk management strategies in the WASAT carries several implications for technology design and policy formulation.

In order to improve the potential for adoption, new technologies should maintain or enhance farmers' flexibility to adjust cropping patterns in response to early and mid-season rainfall. This implies that there is a need to develop new technologies that give farmers more flexibility to respond to early and mid-season shocks and more resistance to late season stresses. Examples include the development of earlier maturing varieties and varieties less susceptible to the most common yield reducers associated with early or late plantings (drought at seedling and grain filling stages, grain mold, insect and bird damage, etc.). Management techniques that reduce soil moisture deficits at the beginning and end of the growing season would have a similar impact by extending the effective growing period, for example, the development of mechanized tied-ridging. Conversely, technologies that exacerbate early season labor conflicts or require a high degree of timeliness in key operations reduce flexibility and are less likely to be adopted.

The common observation that farmers tend to disaggregate packages and adopt single components and/or adjust components to fit different labor profiles can be explained in large part by this analysis. To the extent that multiple component packages reduce farmer flexibility, they are also likely to be less attractive than single component technologies. This does not mean that the potential technical complementarities of a recommended package need to be lost, however. Rather, the extension of improved production packages could itself be based on a sequential strategy. For example, techniques might be adopted to reduce soil moisture stress before promoting moderate levels of fertilizer so as to improve fertilizer use efficiency and reduce the risk of loss. Both of these components could precede the promotion of input responsive cultivars that yield less than local cultivars under soil water and fertility stress conditions, but substantially more when these constraints are relaxed.

Policy instruments have the greatest potential impact on the ex ante and ex post components of farmers' strategies. Policies that improve purchasing power reinforce risk management strategies and are important in regions where diversification and cropping flexibility are limited by environmental constraints. Relevant policy actions include investments in market infrastructure, increasing off-season employment opportunities, and concessional sales of cereals to limit post-drought price increases.

Recent empirical evidence shows that an important part of farmers' risk management strategies relies upon purchased food, and that in any given year net sellers of food crops can become net buyers (Weber et. al, Reardon et al.). Investments that reduce marketing and information costs and improve the efficiency of inter-regional cereal transfers are therefore highly complementary with farmers' efforts to ensure food security through market interaction. For countries moving away from inefficient parastatal marketing systems, this implies the need for investment in infrastructure and information systems that support the private sector. Efforts focused on improving agricultural marketing functions, including post-harvest handling, storage, processing, and transport, will improve the efficiency of markets and lead to increased farm production and income.

Policies that help develop more diversified nonfarm income opportunities serve to reinforce farmers' ex post risk management strategies. The most effective market oriented options are those types of employment least closely associated with local cropping outcomes through input or output linkages. For example, policies that facilitate income generation through seasonal labor migration, or through sales of farm goods to coastal or urban areas, may be highly effective from a risk reduction perspective. Timely food for work projects may also be an extremely effective means of generating and targeting purchasing power

immediately following droughts with the added benefit of infrastructural spin-offs.

Food relief, either through grants or concessional food sales, is the last and probably least secure element in farmers' risk management strategies. In any given year and location, however, if targeted properly, it can be a decisive means of increasing food availability at the local level while reducing prices and thereby increasing real incomes more generally.

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