FARMERS' STRATEGIES TO MANAGE CROP RISK IN THE WEST AFRICAN SEMI-ARID TROPICS

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Farmers in the West African semi-arid tropics (WASAT) use various methods to protect household food consumption against unpredictable changes in production. Some methods directly reduce yield risk, while others generate compensatory income (consumption purchasing power) in the event that production shortfalls nevertheless occur. To optimize adoption and impact, new technologies and policies should at least be consistent with (and, if possible, enhance) farmer risk management.

This note sets out a framework to enumerate the main risk management practices employed by WASAT farmers and illustrates the practices using household survey data collected by ICRISAT in six villages in Burkina Faso during the period 1981 - 1985. Three agroclimatic zones with striking contrasts in production potential were included in the survey (Sahel, Sudan savanna, and North Guinea savanna). Rainfall averages during the survey years were 380, 550, and 775 mm in the Sahel, Sudan and North Guinea zones, respectively. Coefficients of variation (CV) on annual rainfall were 24%, [illegible] and 5%. CV's on cereal yields were even greater at 71%, 34%, and 24% across the three zones.

RISK MANAGEMENT METHODS - A CONCEPTUAL FRAMEWORK

Evidence strongly suggests that food security - i.e. the satisfaction of minimum consumption requirements throughout the year - is the overriding objective of WASAT farm households (Norman et al., 1981). Methods to ensure food security can focus on each major food source: production, purchases, and transfers. Risk can be managed at several <u>levels</u> of operation: (1) plant, (2) plot, (3) farm, (4) whole household, (5) village, and (6) region. Methods to ensure 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 <u>when</u> they are applied relative to the occurrence of production shocks. "Ex ante" methods are designed to place households in a less vulnerable position before the occurrence of a shock. "Current" methods involve the reallocation of resources at the time a shock occurs with the goal of minimizing its production impact. "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.

EX ANTE METHODS AT THE PLOT AND FARM LEVELS

Diversification of crops, varieties, and land types are the most common "ex ante" methods for stabilizing agricultural income. Crop diversification reduces farm-level income variability to the extent that individual crop yields are not closely correlated. Intercropping is a form of crop diversification that further improves stability if crop mixtures reduce the incidence of pests and diseases, or if the component crops can compensate yield losses in stress conditions. Diversification of varieties with varying maturities permit staggered plantings, spreading the risk of period-specific stresses. Diversification of varieties with varying susceptability also reduces the risk of pest and disease loss where there is genetic variability in resistance or tolerance to biotic stresses. Plot diversification exploits imperfect correlation of crop stress across micro-environments.

Crop, plot and land types of diversification were measured using the Simpson index (Patil and Taillie, 1982). An index value of 1 represents

perfect specialization and a value of 0 perfect diversification. Crop indice calculated for the Sahel, Sudan, and North Guinea zones were .50, .42, and .21, respectively; land type (toposequence position) indices were .60, .54, and .47. These results reflect the effects of higher rainfall and a longer growing period on farmers' ability to grow a more diversified set of crop enterprises and to cultivate a wider range of land types.

Growing diverse varieties allows farmers to respond to changing environmental conditions across years and within seasons. In one of the villages in the Sahel, six of the seven millet cultivars in current use had been adopted during the last 15 years. Moreover, all were earlier than the varieties they had replaced, reflecting adaptation to lower precipitation during the last 20 years (Matlon, 1987). We observed similar patterns in the Sudan and North Guinean zones. But it is only in the latter zones that farmers were able to switch varieties in late planting situations. Because of the much shorter rainfall period in the Sahel, little varietal diversification was observed, and most of millet area was sown to a single variety.

SEQUENTIAL DECISION MAKING - CURRENT METHODS AT THE PLOT LEVEL

At the beginning of the cropping season, farmers have subjective expectations based on experience concerning the onset, amounts, distribution, and duration of rains. As the season progresses these expectations are revised and farmers sequentially adjust their cropping patterns to fit the emerging rainfall. Hand planting and irregular early season rainfall combine to extend major first plantings from between 50 days in the Sahel to over 100 days in the North Guinea zone. Maintaining flexibility to modify cropping patterns during this period is crucial for the success of sequential adaptation methods.

Farmers introduce modifications by: (1) shifting crops along the toposequence; (2) switching crops and/or varieties with late first plantings and replantings; (3) increasing plant densities through late plantings or replanting of the main crop or intercrop, or decreasing densities through thinning; and (4) adjusting the dates, number, and intensity of weedings across crops and plots. The application of these methods varies across zones and years with few consistent patterns (Kristjanson, 1987). 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. The opposite was true of the North Guinean zone.

In order to estimate the value of flexibility in millet and sorghum systems, Kristjanson used a multi-stage production function technique which accounted for the sequential nature of the input decisions based on emerging climatic information. Results showed that the value of maintaining flexibility to employ new information was large and significant in the Sudan and North Guinean zones but not in the Sahel. Traditional practices apparently offer little flexibility in the tightly constrained Sahelian conditions. The value of flexibility was greatest for sorghum cultivation in the Sudan. This reflects the greater sensitivity of sorghum to drought stress (compared to millet) and the greater climatic risks of the Sudan savanna compared to the Northern Guinean zone.

Kristjanson also measured the impact of several management practices on farmers' flexibility. Earlier planting improves flexibility and reduces risk by allowing farmers to exploit early rains and giving sufficient time to replant when rains at seedling stage fail. Shorter-cycle varieties of millet

and sorghum also gave farmers more options as to the timing of plantings and replantings. Inorganic fertilizer use was positively associated with greate flexibility. Finally, the results suggested that animal traction plowing reduced flexibility. Because farmers in each study zone generally plant sorghum and millet without soil preparation, this probably reflects early season labor conflicts between plowing and timely planting.

COMPENSATORY EX POST METHODS AT THE HOUSEHOLD AND REGIONAL LEVELS

When crop failure occurs despite "ex ante" and "current" risk management practices, farmers may protect household consumption by absorbing production risk through transfers and purchases paid from earnings in off-farm employment and asset liquidation. Severe drought in the Sahel and Sudan zones of Burkina Faso during 1984 reduced cereal yields to only 42% of their average 1981-1983 levels and domestic food production met only 29% of annual energy requirements (WHO, 1985) in each zone. Despite identical production deficits, actual consumption in the Sahel slightly exceeded requirements during the succeeding 12 months, whereas average consumption among Sudan zone households fell 18% below requirement standards (Reardon and Matlon, 1987). Purchases of cereal explained nearly all of the regional difference. 34% of food energy consumed by Sahelian households was purchased, an amount 40% greater 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 "current" 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% of total income in the Sahel sample during 1984, against 55% in the Sudan (Reardon et al., 1988). Since income from livestock and employment in non-farm enterprises is largely determined by external economic conditions, it has relatively low covariation with local cropping outcomes and thus buffers household consumption from the effects of localized production shortfalls.

IMPLICATIONS

In order to improve adoption potential, new technologies should maintain or enhance farmers' flexibility to adjust cropping patterns in response to early and mid-season rainfall. This goal can be reflected in several crop improvement objectives: (1) development of cultivars with a degree of photoperiod sensitivity; (2) development of sets of cultivars with varying maturities and plant structures to permit later plantings and to open new intercrop and relay crop possibilities; and (3) reducing susceptibility 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 which reduce soil moisture deficits at the beginning and end of the growing season would have a similar impact by extending the effective growing period. Conversely, technologies which exacerbate early season labor conflicts or which require a high degree of timeliness in key operations, reduce flexibility and are less likely to be adopted. To the

extent that multiple component packages reduce farmer flexibility they are also likely to be less attractive than single component technologies.

Policies to 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: (1) investments in market infrastructure to reduce inter-regional margins for cereals and livestock; (2) increasing off-season employment opportunities in the farm sector through investments in dry-season cropping alternatives, and in the non-farm sector punctual food-for-work projects and longer term incentives for non-farm enterprises; and (3) concessional sales of cereals to limit post-drought price increases.

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