Drought Risk and Drought Response in Morocco:
Vulnerability, Risk Perceptions and Drought Coping among Rainfed Cereal Farmers

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I. Introduction

Drought concerns us when it compromises the long-term productivity and welfare of households. The same drought event, however, can affect households differently due to differences in portfolios of income-generating activities. A household's response to a shock is a function of its unique, idiosyncratic income shock, but also of its relative costs of various coping strategies. For a household that has already drawn down a productive asset to critical levels, selling one more unit could come at a high cost in terms of future productivity. Likewise, a household consuming the bare minimum would be loath to further sacrifice consumption. How a household responds to income shocks is therefore also a function of the composition and levels of its assets. The same outward response has different consequences in terms of consumption, and long-term productivity. This paper presents a model of asset re-allocation in response to drought in which a) each household's idiosyncratic characteristics temper the income shock that it receives and b) a household's coping response is also a function of its asset endowment. It then applies this model to coping responses observed over a cross section of rural Moroccan households after a drought event. We demonstrate the utility of such as model in characterizing households that are particularly vulnerable to drought, and in identifying interventions.

II. Drought and vulnerability

The presence of drought affects households through two principal pathways. The first and obvious pathway is that of periodically subjecting households to periods of income deficit. Income deficits force households to choose between present and future consumption. The second pathway is through the households' anticipation of drought. High uncertainty in the weather could force some households to choose income sources that provide more stable, but less remunerative income streams, especially if those households have already drawn down their assets to critical levels. If drought forces a household to dip into its productive asset base or to make more conservative income choices, it compromises the household's future productivity. With low productivity, households have fewer assets and therefore a lower tolerance for income variability. The combination of the two effects can entrap some households in poverty.

Income deficits force households to sacrifice assets and consumption. If a household rations consumption, it may do so in order to avoid destabilizing productive assets. If a household draws down its asset base, it does so presumably for the purpose of protecting consumption. A large literature tests for this latter consumption-smoothing behavior. This literature is based predominantly on data from multi-year studies from south India, Zimbabwe, and Burkina Faso, where households rely primarily on agricultural income that is highly variable due uncertainty in the timing and quantity of rainfall. The general consensus is that consumption smoothing does take place to a limited extent, and that it is more prevalent among wealthier households (Kazianga and Udry, 2006; Morduch, 1995).

For households with few assets, further destabilization of those assets could come at a high price. In a review of studies of famine events in sub-Saharan Africa, Corbett (1988) notes that households first responded to income deficits by reducing consumption and disposing buffer assets. Only when such ‘lower-cost’ responses had been exhausted, or the cost of malnutrition became too high, did households sell productive assets. In a theoretical study of asset-smoothing behavior, Zimmerman and Carter (2003) use a simulation to show that poor agents will smooth assets rather than consumption when faced with a subsistence constraint and asset price risk. However, as Hoddinott (2006) points out, the distinction between asset smoothing and consumption smoothing is somewhat artificial and not altogether useful. He summarizes, “...household responses to adverse shocks are effectively changes in their asset portfolio, with a critical issue being the extent to which the draw down of a given asset has permanent consequences.”

Not only do households differ in their response to drought, they also prepare for it differently. We expect that households in riskier environments and/or those in precarious asset situations would choose their income activities in a way that protects the income stream from the vagaries of the weather. Such households can favor variability-reducing input and production techniques (e.g. field scattering as observed by Carter (1997)), postpone investments or planting until more uncertainty is resolved, and/or engage in off-farm work (Morduch, 1995). Work by Zimmerman and Carter (2003) suggests that asset price risk combined with subsistence constraints will induce poor households to adopt conservative portfolios. Dercon and Christiaensen’s (2007) empirical study concludes that households apply insufficient levels of fertilizer as a result of the associated downside income risk. Conversely, we expect households that can protect consumption without endangering their production base (due to large asset endowments, insurance, credit, or borrowing) to allocate assets among activities that maximize expected income. Rosenzweig and Binswanger (1993) find that households exposed to greater weather risk put their wealth into lower risk portfolios, but that this relationship is attenuated by wealth. That is, wealthier households are less concerned with smoothing income since they are more willing (lower risk aversion) and/or better positioned to deal with income shocks (wealth helps households to smooth consumption). In short, those households that smooth income may be those with little ability to buffer consumption and are close to a critical asset threshold below which leads to destitution.

Reduced income variability may come at the cost of profitability and consequently compromise long-term growth. Rosenzweig and Binswanger (1993) find that low-variability asset portfolios are less remunerative. Dercon and Christiaensen (2007) observe that insufficient fertilizer application due to downside risk aversion results in lower average crop productivity. Lower productivity keeps asset levels low; low asset levels may limit households' choices to low-risk/low-return income-generating activities, thus trapping some households in poverty. The same cycle can be initiated when households sacrifice productive assets after drought events, thereby reducing productivity.[1]

Wealth and assets play a large role in determining which households are permanently hurt by drought and which are not. Zimmerman and Carter's (2003) dynamic simulation model with subsistence constraints illustrates how initially wealthier households become wealthier by pursuing a strategy of high-risk/high investments, and initially poorer households, forced to smooth income, become even poorer. Lybbert et al. (2004) identify a threshold level of livestock holdings above which pastoralists in southern Ethiopia can enjoy a more opportunistic form of pastoralism and are robust to moderate adverse shocks. Kinsey et al. (1998) observe that some households in their sample from Zimbabwe persistently had no livestock, even while most others were able to amass sizeable herds despite periodic drought-related liquidation. We can therefore expect another consequence of drought to be increased long-term inequality. Reardon and Taylor (1996) find that droughts increase poverty for the poor disproportionately, as they rely more heavily on crop income; the resulting liquidation of assets, however, makes them more vulnerable to future droughts.

III. Drought and Coping Strategies in Morocco

Periodic drought is a key feature of Moroccan agriculture, and given that 90% of agricultural land is not irrigated, it poses the single greatest hazard (Skees, 2001; Swearingen and Bencherifa, 2000). Historically, households have adapted to irregular rainfall quantity and timing by stockpiling grain and fodder from good years, scattering fields, moving herds in search of better forage, planting late crops such as lentils (after late rains), and liquidating animals to a minimum reproductive herd that requires less fodder (Swearingen and Bencherifa). Additionally,

[1] In a unique theoretical study, Elbers et al. (2007) decompose these two effects.

certain general adaptations to aridity, such as the planting of barley[2] and the use of fallow[3], have also made households more resilient to droughts in the past (Swearingen and Bencherifa).

The last three decades have seen increased volatility in national agricultural income (Azzam and Sekkat, 2005). Several factors are to blame, the most obvious among them being a permanent change in the general precipitation pattern. Since 1980, Morocco has experienced a 25% decrease in average rainfall, accompanied by an increase in the frequency and severity of droughts (Azzam and Sekkat, 2005; Barakat and Handoufe, 1998; Skees, 2001). Around the same period, in an effort to boost production, the Moroccan government raised its fixed producer price for cereals and other basic food crops from well below- to well above world prices. By the mid-1980s, producer prices for barley and wheat were approximately twice world levels (Swearingen and Bencherifa, 2000). Predictably, farmers responded with increased production. While higher yields played a part in increasing cereal output, another significant part was enabled by an expansion in the land under cultivation (Swearingen and Bencherifa, 2000; Azzam and Sekkat, 2005). Farmers increased cropland by reducing the acreage left in fallow and by encroaching onto low-rainfall grazing lands. The government's promotion of mechanization facilitated this expansion into marginal areas (Swearingen and Bencherifa, 2000). Finally, France's colonial policy of promoting wheat over barley changed Moroccan consumer preferences; wheat replaced barley as the predominant native cereal (Swearingen and Bencherifa, 2000). At the same time that droughts have become more severe, households have abandoned many traditions that have helped keep them resilient historically.

As traditional adaptations lose their effectiveness, many farmers have developed new ones. Swearingen and Bencherifa (2000) report that farmers increasingly use mechanization, nitrogen fertilizer, and irrigation to deal with drought. Arguably the single most important drought-coping mechanism is mechanized plowing. Mechanized plowing affords greater flexibility in both the area planted and the timing of planting, because it can be done far faster than animal plowing and does not require that the first rains first soften the soil. Farmers can therefore get a better sense of the season to come before breaking the soil. Nitrogen fertilizer is also used to increase production during good years so that it may be stockpiled in preparation for drought years. And to a lesser extent, households have attempted to develop irrigation systems

[2] Barley is more drought tolerant than wheat; it also ripens earlier, reducing the effects of late-season drought.

[3] Fallow, the practice of leaving a field uncultivated, lets moisture and nutrients accumulate in the soil. This leads to increased yields when the fields are cultivated again. In Morocco, fallowed fields also provide a source of fodder for livestock.

by digging new wells, diverting surface water onto fields, and using motorized pumps. In sum, agriculture has become a higher-risk, higher-stakes game. At the same time, however, households are relying less on the farm for income (Swearingen and Bencherifa, 2000)

IV. Drought-Coping Strategies as a Function of Income Shock and Asset Composition

Households mitigate income deficits by reallocating assets. In deciding which asset to sell or consume, households weigh the foregone losses in long-term productivity of each. We begin with Zimmerman and Carter's (2003) inter-temporal expected utility maximization problem with a productive and non-productive asset. Households receive utility from consumption today and expected consumption in the future. Consumption in any period cannot exceed income (*I*) in that period plus the value of assets drawn down at that time. There are two assets: a non-productive asset *N* and a productive asset *P*. ρ is the price of the productive asset and the numéraire the price of non-productive asset. This model does not allow borrowing.

$$c_t \leq I_t + \rho p_t + n_t \tag{1}$$

Assets evolve such that

$$\begin{aligned} N_{t+1} &= N_t - n_t \\ P_{t+1} &= P_t - p_t \end{aligned} \tag{2}$$

Income in every period is a function of the level of the productive asset, the covariate random shock parameter θ_t, and a household-specific shock parameter θ_i.

$$I_{it} = \theta_t \theta_i f_i(P_{it}) \tag{3}$$

In each period, income is revealed and the household reallocates its resources between consumption, savings, and investment. The household's problem is to choose consumption and asset levels in each period to maximize utility today plus the expected sum of all future utility. Future utility is discounted by factor δ. The marginal utility of consumption is decreasing. The household is also faced with a subsistence constraint: if consumption falls below a minimum threshold, utility in that period and all subsequent periods is 0.

$$\max_{\{\underline{c}_0, \underline{N}_1, \underline{P}_1\}} E_0 \left\{ \sum_{t=0}^{\infty} \delta^t u(c_t) \right\} \tag{4}$$

$$\begin{aligned} \underline{c}_s &= \{c_s, c_{s+1}, c_{s+2}, \ldots\} \\ \underline{N}_s &= \{N_s, N_{s+1}, N_{s+2}, \ldots\} \\ \underline{P}_s &= \{P_s, P_{s+1}, P_{s+2}, \ldots\} \end{aligned}$$

The utility today of all expected future consumption can be expressed as the value of the problem in the future, discounted by one period. This allows the problem to be rewritten as

$$\max_{\{c_0,N_1,P_1,L_1\}} \left\{ u(c_0) + \delta L_1 \cdot E_0 \left\{ \max_{\{\underline{c}_1,\underline{N}_2,\underline{P}_2,\underline{L}_2\}} \left\{ \sum_{t=1}^{\infty} \delta^t u(c_t) \right\} \right\} \right\} \quad (5)$$

or

$$\max_{\{c_0,N_1,P_1,L_1\}} \{ u(c_0) + \delta J^*(N_1,P_1,L_1) \} \quad (6)$$

where the state variable L takes the value of 1 as long as consumption in the present period stays above the subsistence level.

Productive assets can take many forms, and each can have characteristics that tie the marginal future productivity of that asset to its level. Intuitively, most assets will have diminishing marginal productivity, especially if other co-factors of production are limited. On the other hand, too little of an asset can also cause lower productivity. In the case of livestock, studies suggest the existence of critical herd size thresholds, below which the marginal productivity of an animal falls sharply. Some examples are a span of oxen for plowing (Hoddinott (2006)), or a minimum herd size required for transhumant foraging (Lybbert et al. 2004). Finally, for credit-constrained households, many productive assets can be difficult to recoup, especially if doing so requires large sums of capital. Dercon's (1998) simulation shows how the 'lumpy' capital requirement for acquiring cattle, combined with credit constraints and safety-first behavior can bar some Tanzanian smallholders from entering into the relatively remunerative cattle rearing.

We consider two extensions to the model above to reflect minimum productive threshold effects and investment lumpiness. The first is a minimum productive asset threshold, similar to the subsistence constraint. If the productive asset falls below this threshold, it is no longer productive. We modify equation 2 such that

$$I_{it} = \begin{cases} \theta_t \theta_i f_i(P_{it}) & \text{if } P_{it} > \underline{P} \\ w_i & \text{otherwise} \end{cases} \quad (7)$$

where $w_i < \theta_t \theta_i f_i(P_{it})$. Such a situation could arise if the productive asset is land, and landholdings become too small to profitably farm. While income from the asset itself could be 0 in such a situation, for modeling purposes we keep $w_i > 0$.

Next we incorporate a lumpiness constraint proposed by Dercon (1998). Whereas in the original problem both productive and non-productive assets were liquid, now only the non-productive asset is perfectly liquid. Restricting the productive asset to take only integer values increases the cost of recouping productive assets after they are consumed. Both modifications can increase the cost of current consumption in terms of future expected productivity, and this relationship will depend on the proximity of productive asset levels to critical minimum thresholds, and on the level of non-productive assets.

V. Study Area and Data Description

In the summer of 2007, and again in 2008, a collaborative team comprising researchers from the Moroccan National Institute of Agronomic Research, ICARDA, CIMMYT, and UC Davis implemented a survey of wheat-growing households in the Meknes-Tafilalet administrative region. The sampled 250 households represented four rural districts: Ain Jemaa, Sidi Slimane, Ait Ouikhalféne/Sebt Jahjouh, and Ben Smim. Together, they form an altitudinal transect running northwest-southeast through the jurisdiction of the Meknès Regional Agricultural Research Center, our Moroccan partner institution. We characterize the four districts, respectively, as lowlands (300 to 400 masl), plateau (500 to 600 masl), foothills (700 to 900 masl), and mountains (1,200 to 1,500 masl). Households in our sample areas depend on income from rain-fed annual crops (bread wheat, durum wheat, barley, oats, pulses), livestock, wage labor, and remittances. As shown in Table 1, the relative importance of each source differs widely between the rural districts, reflecting differences in altitude, terrain, rainfall and proximity to urban centers. For example, the districts of Sidi Slimane and Ben Smim are located closer to urban centers; in these areas more households report relying on off-farm income sources.

We designed the surveys with a two-fold objective: to ascertain the relative importance of various income sources, and to understand drought as perceived and felt by farmers. Both 2007 and 2008 surveys included detailed questions about crop production, livestock holdings, fruit and olive production, off-farm income sources and remittances from household migrants. The 2007 survey included a module in which farmers ranked various income sources in terms of risk, and then broke down their own household income in terms of the listed income sources. Additionally, the 2007 survey was accompanied by a game in which farmers stated their willingness to pay for hypothetical wheat varieties with varying yield distributions. The 2008 survey featured a module in which farmers stated the relative frequencies with which they experienced a ‘severe drought’ year, a ‘mild drought’ year, an ‘average’ year, and a ‘good’ year and then for each type of year, what wheat yields they could expect.

Table 1. Descriptive Statistics by Rural District				
	Ain Jemaa	**Sidi Slimane**	**Sebt Jehjouh**	**Ben Smim**
Altitude (masl)	300 to 400	500 to 600	700 to 900	1200 to 1500
Mean Annual Rainfall (mm)	459	425	445	686
Percent Cultivated Land in				
bread wheat	47.6	52.7	36.0	24.4
durum wheat	5.0	3.3	8.0	10.0
oats	1.4	7.8	24.6	18.9
barley	10.1	6.0	21.3	32.5
faba beans	8.0	0.6	7.7	4.5
chick peas	10.4	4.0	0.9	0.7
other pulses	1.1	2.5	0.8	6.7
sunflower	15.9	.	0.4	.
truck crops	0.5	23.2	0.2	2.3
Household demographics				
Mean Cultivated Area (ha)	8.84	2.66	12.24	5.68
Goat Ownership (%)	5.2	0.0	28.4	32.7
Mean Goats	9.5	.	31.5	29.5
Sheep Ownership (%)	64.9	39.7	87.7	74.5
Mean Sheep	19.5	12.2	74.9	150.7
Cattle Ownership (%)	85.7	79.4	90.1	60.0
Mean Cattle	3.5	3.5	4.4	5.3
Reporting Wage Labor (%)	24.6	40.3	17.2	40.0
Reporting Remittances (%)	16.8	20.9	11.1	7.2

VI. Income Sensitivity to Drought

The two-year study period coincided with a drought year (2006-2007 crop year), followed by a ‘recovery’ year (2007-2008 crop year). Total revenue from the drought year fell for most households. Table 2 shows average revenue by income source for each rural district. Of the multiple types of income upon which households depend, crop income is arguably the most sensitive to drought. We calculate the deficit in crop income from the 2007 harvest using 2008 crop income as a baseline. By this measure, households in Ain Jemaa were dealt nearly 40% less crop income in 2007 than in 2008, and in Sebt Jehjouh, the deficit was approximately 30%. Because crops take several months to mature, the harvest outcome is unknown to the farmer at the time of planting and the application of most inputs. Unless the farmer’s expectations change, cropping choices, inputs, and practices would not change on a yearly basis. Change in crop income is therefore a comparatively straightforward measure of the effect of a drought event. In addition to crop revenue, Table 2 shows livestock revenue, off-farm income, and remittances for both years. Changes in income from these other sources, however, must be interpreted with caution as they can reflect *responses* to the crop income shock as well as the shock itself. For example, 2007-2008 saw significantly higher livestock revenue in all districts except Sebt Jehjouh. As will be discussed in the next section, some livestock sales in 2007/2008 were a direct result of the drought in 2006/2007.

Table 2. Mean Gross Income by Source

		Ain Jemaa	**Sidi Slimane**	**Sebt Jehjouh**	**Ben Smim**
Crop Income	*2006/2007*	11626	19636	7706	17132
	2007/2008	25035	29279	12743	19914
Change in Crop Income		13409	9643	5037	2783
		(5.36)	(1.20)	(4.07)	(1.29)
Change as Percentage of		36.86%	-6.37%	31.59%	-0.14%
2007/2008 Crop Income		(6.41)	(-0.36)	(3.61)	(-0.01)
Off-farm Income	*2006/2007*	2812	7005	3723	11377
	2007/2008	4698	8593	581	2097
Change in Off-farm Income		1886	1588	-3142	-9280
		(1.63)	(0.66)	(-1.62)	(-2.03)
Remittance Income	*2006/2007*	2058	6632	782	857
	2007/2008	575	4353	1040	1004
Change in Remittance Income		-1483	-2279	258	147
		(-1.26)	(-0.78)	(0.58)	(0.50)
Total Income	*2006/2007*	16496	33274	12210	29366
	2007/2008	30308	42225	14364	23016
Change in Total Income		13812	8951	2153	-6350
		(4.79)	(1.09)	(0.88)	(-1.17)
Change as Percentage of		27.35%	-102.81%	-8.62%	-109.05%
Total 2007/2008 Income		(2.32)	(-1.26)	(-0.29)	(-1.66)
Observations		59	34	50	28

t-statistics given in parentheses

Households rely on multiple activities and differ in the extent to which they rely on each. The short study period, however, precludes the estimation of the relative importance of the various activities. We therefore employ the results of the 2007 survey module in which farmers state the degree of risk that they associate with cereal income, non-cereal crop income, revenue from olives and fruit, livestock sales, and non-agricultural income, and then indicate the percentage contribution of each to total household income in an 'average' year. A risk rating of 1 indicates that the farmer considers the activity 'very risky' and 4 indicates that the farmer associates no risk whatsoever with the activity. By weighing the risk ratings given to each category by the relative importance of each, we generate for each household a stated total income risk index. Table 3 summarizes households' responses by district. Farmers' subjective responses show that agricultural activities, particularly cereal crops, are the most risky (district means range from 1.24 to 1.62) and that non-agricultural income is the least risky (district means range from 3.28 to 3.77). The responses are consistent with the assumption that drought poses the most significant hazard to rural incomes.

Table 3. Perceived Risk and Contribution of Income Categories by District

		Sidi Slimane	**Ain Jemaa**	**Sebt Jehjouh**	**Ben Smim**
Cereal Crops	*perceived risk*	1.58	1.42	1.24	1.62
	contribution (%)	32	46	39	18
Non-cereal Crops	*perceived risk*	2.35	1.97	1.73	2.09
	contribution (%)	19	24	11	12
Olives/Orchards	*perceived risk*	3.03	2.75	2.37	1.89
	contribution (%)	13	6	5	9
Livestock	*perceived risk*	2.64	2.42	2.21	2.20
	contribution (%)	23	20	43	47
Non-agricultural	*perceived risk*	3.33	3.77	3.36	3.28
	contribution (%)	12	4	3	14
Total Income	*perceived risk*	2.37	1.95	1.84	2.15
N		66	77	80	54

This module also illustrates the wide variation in income composition among the sampled households. At the district level, households in Ain Jemaa and Sebt Jehjouh rely the most on cereal income, and in Ben Smim, livestock is stated as the single most important income source. Households in Sidi Slimane and Ben Smim derive a non-trivial portion of income from non-agricultural labor. Within each district, the coefficient of variation on the stated income contribution ranges across the four districts from .42 to .96 for cereals, .66 to 1.75 for non cereals, 1.39 to 2.16 for olives/orchards, .57 to 1.01 for livestock, and 1.70 to 3.13 for non-agricultural income. Meanwhile, the coefficients of variation for perceived risk for all categories within each district stay in the range of .15 to .43.

VII. Drought Coping Strategies

The 2008 survey presented each farmer with a list of common drought coping mechanisms and asked if he had had to rely on any as a direct result of the 2006-2007 drought. The list began with reversible, 'lower-cost' responses such as drawing down stores of cereals, and ended with drastic responses that would have indicated desperation on the part of households [Table 4]. The most commonly reported drought responses are drawing down stores of agricultural products, selling sheep, selling cattle, beginning or increasing off-farm work, and informal loans.

Table 4. Reported Drought Responses

Percentage of households responding 'yes' to having...		
Sold more stored production than usual	4.0	
Consumed more stored production than usual	16.3	
Sold more feeder sheep than usual	27.9	*
Sold more feeder goats than usual	2.6	*
Sold more feeder cattle than usual	9.5	*
Sold more reproductive sheep than usual	16.3	*
Sold more reproductive goats than usual	5.1	*
Sold more reproductive cattle than usual	12.4	*
Sold gold	0.4	
Sold household goods	1.2	
Began or increased off-farm agricultural work	10.2	
Began or increased non-agricultural work	8.6	
Borrowed money from family or friends	19.1	
Asked for money from family or friends	4.3	
Borrowed money from someone else	2.7	
Installed irrigation	2.4	
Sharecropped in a plot	9.4	
Sharecropped out a plot	3.1	
Rented in a plot	9.8	
Rented out a plot	3.9	
Sold a parcel	0.0	

*percentages taken over households owning sheep (goats, or cattle)

Households typically report employing multiple responses. We use Principal Components Analysis over the pooled sample to identify the responses that are most commonly observed together. This allows the characterization of households not in terms of individual responses, but in terms of strategies [Table 5]. Strategy 1 entails the drawing down of stored grain and the sale of sheep or goats. Strategy 2 is a combination of seeking or increasing off-farm work and borrowing money. Strategy 3 comprises selling off cattle and renting out land. Strategy 4 also involves selling off cattle, but households avoid renting out land.

Table 5. Commonly Observed Coping Strategies

	Strategy 1	*Strategy 2*	*Strategy 3*	*Strategy 4*
Sell/Use Stored Grain (Dh.)	0.61	-0.19	0.25	-0.08
Small Stock Sales (Dh.)	0.66	-0.05	0.17	-0.06
Off-Farm Earnings (Dh.)	-0.06	0.72	0.01	0.06
Take Out Loan (Dh.)	0.33	0.61	0.07	0.29
Large Stock Sales (Dh.)	-0.21	-0.18	0.67	0.68
Rent Out Land (ha)	-0.22	0.19	0.68	-0.66
Eigenvalue	1.41	1.32	1.01	0.94

Coping Strategy Correlates

	Strategy 1	*Strategy 2*	*Strategy 3*	*Strategy 4*
Small Stock	0.25	-0.02	0.01	-0.12
Large Stock	0.06	0.06	0.16	-0.18
Land	0.24	-0.18	-0.04	-0.03
Labor	0.09	0.06	0.05	0.03
Non-Agricultural Wealth	0.05	0.06	0.11	0.11
% Income Deficit	0.03	-0.05	-0.02	0.03
Income Deficit	0.09	-0.05	0.06	0.00
Stated Total Income Risk	-0.07	0.03	-0.01	-0.06

The pattern of clustering in the reported drought responses could imply a set sequence of actions that all households may take depending on their level of desperation as suggested by Corbett (1988). However, it could also indicate the existence of distinct households 'types.' Strategies 1 and 5 involve the sale or consumption of stored grain and/or small stock, both of which may be thought of as non-productive assets. Strategies 3 and 4 involve the sale of cattle and/or the renting out of land, strategies that may be more costly in terms of longer-term productivity. Strategy 2 describes a response in which household borrow money and seek work off-farm. This strategy could indicate a paucity of on-farm assets to sell or consume.

The bottom half of Table 5 shows the correlations between each household's five predicted strategy scores and some basic asset indices. *Small stock* aggregates reported sheep and goat numbers, and *large stock* gives the reported head of cattle[4]. *Land* is the total area, in

[4] We use herd sizes reported in the 2007 survey so that the numbers do not yet reflect responses to the harvest deficit.

hectares, that households reported owning; and *labor* counts the number of men of age between 15 and 55 in each household. Unsurprisingly, households with a high score for strategy 1 (sell small stock, sell/consume stored grain) are those with more sheep or goats and land. Scores for strategy 2 (borrowing money, seeking off-farm work) are negatively correlated with land ownership. Households scoring high for strategy 3 (sell large stock, rent out land) appear to be those with larger herds of cattle. Strategy 4 (sell large stock, do not rent out land), however, shows an equally negative correlation with cattle ownership.

A priori we expect to see 'higher-cost' strategies associated with larger income deficits. We use three measures of the drought shock: the value of each household's 2008 harvest minus the value of its 2007 harvest (Income Deficit), the deficit as a percentage of the 2008 harvest value (% Income Deficit), and each household's stated measure of income risk (where 1=very risky and 4=no risk at all). Weak correlations between coping strategies and measure of the drought shock do not allow any inference in this respect.

VII. Conclusion

This study uses a combination of estimated and stated measures of income sensitivity to drought to identify households whose income streams are most exposed. Consistent with conventional wisdom, farmers who rely the most on crop income are the ones with the greatest income deficits. Cursory analysis of coping strategies shows that households that rely on distress sales are those with larger herds, and that seeking loans and off-farm work are the responses of those households with little land. The identification of vulnerable households, however, requires deeper analysis since the same households that are the most exposed to drought may also be those best able to deal with the resultant income shocks.

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