Rainfall Variability, Traditional and Commercial Rangelands Management, and the Drought Cycle: Some Theoretical Considerations and Empirical Evidence from Ethiopia

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Abstract:

Extensive livestock production is practiced in arid and semi-arid areas all over the world, and is particularly important in sub-Saharan Africa. Because land is marginal and rainfall patterns are erratic, returns per hectare are generally low and variability of returns is quite high, both seasonally and inter-annually. It has been hypothesized by a number of researchers studying rangelands management under these conditions that 1) returns to traditional commonly accessed pastures compare favorably with returns to commercial ranches in similar environments, 2) it is individually rational to accumulate animals in anticipation of a drought, so as to come out of a drought with more animals, and thus that 3) the use and management of traditional rangelands show little evidence of "tragedy of the commons" – type problems. Policy recommendations thus include devolving resource management to communities, and structuring long-term development and short-term crises interventions to mitigate stock losses during a drought.

These policy conclusions seem premature, however, since there is very little in the way of formal theoretical modeling of these systems, and empirical evidence seems to have been chosen to illustrate pieces of the system, rather than giving as complete a picture as possible, even with scanty evidence available. In this paper, we review existing information on commercial ranches and traditional pastures and show that one of the most crucial differences between the systems is the fact that commercial systems exhibit much less variability in production; in fact, returns in the traditional sector may even be greater than commercial returns in good years, but are much lower in drought years. Thus, production in the traditional sector is much more volatile and risky, even in areas where both production systems face the same underlying environmental conditions. Results from a simple one-period, common-pool resource model with production variability are presented, and used to contrast the outcomes from optimal management versus those stemming from a non-cooperative game. This model yields results consistent with observed empirical behaviour, namely that a traditional system relying on unmanaged (or imperfectly managed) common pastures exhibit the following: 1) relatively high profits in years with good and average rainfall, 2) much lower profits in poor rainfall years, and 3) greater variability in returns. We then argue that other factors

affecting the outcomes of the two systems -- such as differential access to credit, input and output markets, and perhaps different incentives to undertake precautionary savings – alone cannot explain the much higher volatility of stock levels and output under the traditional system. Empirical results are then presented from a community-level survey undertaken on the Borana Plateau of southern Ethiopia specifically designed to examine the impact of rainfall variability on stock levels and the level of cooperation observed in study communities. These results provide evidence that higher variability is in fact associated with lower stocking densities, and that non-cooperation leads to higher stocking densities implying that there remain 'commons' problems. In the conclusion, we argue that well-intended policies to mitigate the down-side of a drought – such as drought feed subsidies – are likely to exacerbate the severity and frequency of the drought cycle, and that policies based on the assumption that communities currently have adequate management institutions could quite possibly lead to results opposite to those intended.

I. Introduction

Livestock production is one of few options available to millions of impoverished people who live in arid and semi-arid areas of sub-Saharan Africa (SSA). Livestock are flexible; they can be moved in response to variable rainfall conditions and can be purchased or sold in response to variable market conditions. Livestock can supply animal traction and play key roles in the transfer and cycling of nutrients for crop production. While often lauded for these multiple roles, the African livestock sector is also associated with low productivity, low offtake, land degradation, and resource conflicts among pastoral groups and between pastoralists and farmers (Swallow, 1997).

Early attempts at resolving the problems of African livestock production concentrated on the perceived problems associated with common property or open access rangelands. Low productivity and land degradation were assumed to stem from a 'tragedy of the commons.' Typical policies undertaken in the 1970s and 1980s included the appropriation of rangeland by the state and the creation of ranching schemes. These policies often led to encroachment by cultivators into pastoral areas, or to the replacement of common property by open access where both non-traditional and traditional herders competed for resources. Nonetheless, projects modeled on the ranch approach frequently generated negative rates of return, and have often been criticized on the grounds that they favor wealthier households (Swallow, 1996; Behnke and Scoones, 1993).

It is hypothesized that many of the problems associated with establishing raches are due to the lack of proper accounting for the temporal and spatial variability of rangeland production and the role of mobility in sustaining livestock production in those environments. Since the late 1980s and early 1990s, many range ecologists and animal scientists have focused on the variability of rangelands, the resilience of rangeland ecosystems, and the adaptability of pastoral societies. This led to a school of thought now known as the "new range ecology." The tenets of the new range ecology are that forage productivity is driven by climatic variables rather than stocking density; that semi-arid rangelands are in fact resilient and not fragile; that forage composition is patchy rather than evenly distributed spatially; and that an opportunistic, mobile grazing strategy is better suited to these environments than conservative, sedentary strategies. Common property is consistent with opportunistic grazing strategies that are held to be both efficient and equitable (Behnke and Scoones, 1993; Scoones, 1995).

The benefits to mobility have also been shown by economists (van den Brink et al., 1996; Wilson and Thompson, 1993), though the standard negative externalities stemming from use of unmanaged common property resources are excluded from these analyses. An additional factor, that of holding onto livestock during the relatively good years in anticipation of a drought (a precautionary savings-type motive), has been put forth by Livingstone (1992) as a rational individual response to the drought cycle when credit and insurance markets are thin or absent; his empirical observations are supported by a dynamic mathematical model developed by Fafchamps (1997). Nonetheless, whereas it may be individually rational to hold on to more animals going into a drought to be assured of having more coming out, no attention is paid to potential additional effects when pastures are used in common.

There is also a small body of empirical evidence that supports the hypothesis that returns to traditional systems compare favorably to commercial ranching – at least in terms of returns per hectare. Pratt & Gwynne (1977) estimate that returns per hectare in the commercial system were close to those in the traditional Massai pastoral areas of Kenya, when valuing all products (i.e. offtake only in the commercial system, offtake plus milk in the traditional sector). Other studies showing favorable returns per hectare include Breman and de Wit (1983) for the west African Sahel, Western (1982) for east Africa, and Scoones (1994) for southern Africa. Pratt & Gwynne (1977) state that the two major differences between commercial production and traditional pastoral production are the level of capital investments and yearly recurrent costs for disease control, and management through the drought cycle. In the remainder of this paper, we focus on comparing the management of the two systems through the drought cycle.

It would appear, given all of the above evidence – theoretical as well as empirical, economic as well as ecological and anthropological – that policymakers should just proceed to implement recommended policies to promote mobility, devolve resource management to the community level, and minimize drought losses through such programs as feed subsidies. However, none of the research to date considers the impacts of both risk and reliance on common-pool resources on producer behaviour, and thus the conceptual framework used for the aforementioned analyses is potentially missing key components. To close this gap, we quickly review the different management strategies in the commercial and traditional sectors, highlight the main difference between the sectors, and examine potential theoretical explanations for the observed difference in behaviour and outcomes. We then present some empirical results from Ethiopia. In the concluding section, we reiterate the need to consider both internal and external factors affecting management of common property resources as well as the impact of risk on management and use rates before drawing policy conclusions.

II. Managing through the Drought

Commercial Ranches:

Heath (1999) maintains that commercial ranchers in Kenya set stock levels to mitigate impacts of dry to drought years; "conservative" stocking rates are also observed on commercial ranches found in many south African countries (Scoones, 1993). The rationale is that if the rainy season turns out to be quite good, ranchers increase stock levels somewhat to take advantage of higher returns; in average years, stock levels remain conservative to give certain areas a chance to rest. In a single poor rainfall year, stock levels are maintained with some gains in weight per animal but no mortality losses, and in drought conditions, ranchers increase culling to avoid mortality losses. In good years, then, ranches are generally under-stocked; in bad years, however, they can still realize some gains and at the very least, avoid mortalities. Unfortunately, most studies comparing commercial ranches to traditional pastoral areas are undertaken in average to good years which may account for the small difference between systems in terms of returns per hectare. This is somewhat unsatisfying, however, since the bigger difference will be performance under poor rainfall conditions, which large ranches are likely to weather in much better shape.

Traditional Pastoral Areas:

Toulmin describes traditional pastoral strategies during the drought cycle for four stages – 1) dry year , leading to 2) drought year, 3) recovery stage, and 4) "normal" conditions stage. She maintains that herders first attempt to increase their mobility, and perhaps to increase the diversification of species, and then to rely on wealthier kin or clan members. As conditions worsen, some herders attempt to sell certain animals, but by this time, prices have generally dropped and animals are generally in poor condition; some families may try and send members in search of wage work, and some to famine relief camps if these exist. As the drought ends, those with stock remaining attempt to recover as quickly as possible meaning that offtake is likely to be at its lowest; also, prices will rise during this period. This is followed by the "normal" period, where herd sizes increase, and there is also increased (but still relatively low) offtake.

In terms of production, there is evidence that the two systems differ, but differences in stock levels and returns per hectare are greatest during the drought stage, reflecting the different management of stock densities through the drought cycle. Information provided in Pratt and Gynne (1977) and Bekure et.al. (1984) (both on Masailand), show that average incomes and asset values between the communal areas and commercial ranches are roughly similar during average and good rainfall years, but strongly lower for the communal areas during a drought. This implies that the variance in income/asset values will be higher in communal areas vis-à-vis the private ranches. At the same time, Heath (1999) notes that commercial ranches in Kenya rarely sustained drought-related mortalities in 1984-84 or 1992-93.

Further evidence for communal systems in Kenya are found in Ellis et.al. (1986). This report contains a comparison of stock levels and reproduction and mortality rates in four regions in the Turkana district for the period 1978-1985. The authors give convincing evidence that areas with high stock levels going into the drought lost proportionately more animals than those areas that were moderately stocked before the drought. Thus, the two moderately-stocked areas lost proportionately (and absolutely) less animals, and herd recovery was much quicker in these areas. More "conservative" stocking rates were associated with lower mortality, quicker recovery, and thus overall lower variability.

Why the Different Strategies?

In this section, we discuss alternative hypotheses for explaining the stylized facts regarding the different strategies observed in the commercial vs. the traditional sector through the drought cycle. First, we outline the "tragedy of the commons" school of thought. This section is followed by a description of other possible hypotheses to explain the difference in the systems.

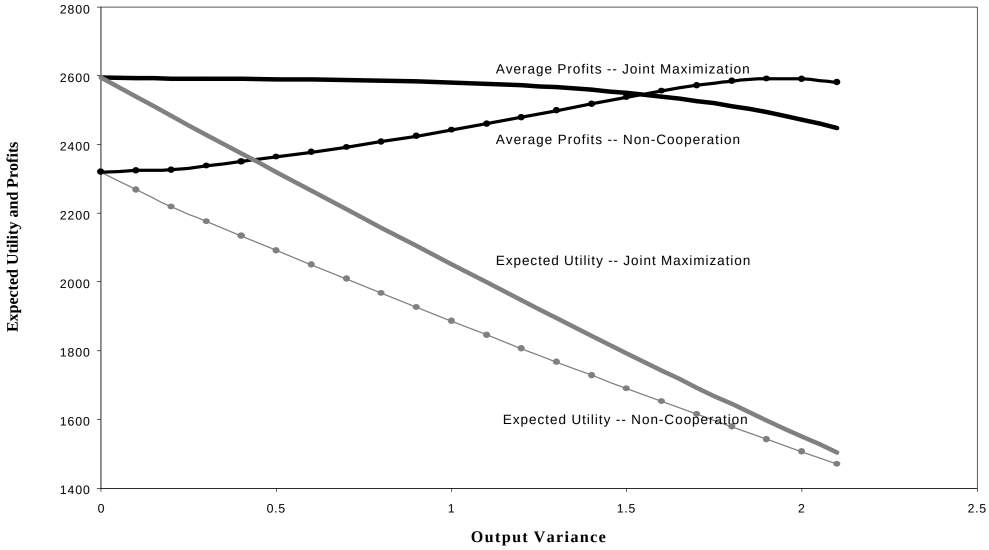
<u>Tragedy of the Commons</u>: There are at least four ways that a resource held in common may contribute to different management and use of pastoral resources than those that would occur under a socially "optimal" management system, or under a privatized ranching scheme (in terms of long-term productivity and profitability).

1. One-period loss in profits/production due to overgrazing this period (crowding externality).
2. Future losses to pasture productivity due to overgrazing over time (dynamic externality).
3. Under-Investments in improvements to the common-pool resource, in this case pasture land.
4. Over-generation of risk; i.e. higher stock densities leading to greater swings in animal productivity.

Many researchers, particularly range ecologists, have determined that point 2 – future losses in pasture potential – is not likely to be important in arid, and perhaps semi-arid areas (Sandford, 1983; Behnke and Scoones, 1993). Traditional crowding externalities alone cannot explain the pattern of differential returns throughout the drought cycle, since in this case, returns from the commons would always be lower than those from commercial ranches. Under-investment poses a problem that is difficult to address given available data. As stated above, in the more arid environments, climatic variables are likely to be the driving factor influencing rangeland productivity; limited evidence from commercial ranches in Kenya indicate very little investment in pasture productivity enhancing measures (Heath, 1999), with the exception of bush control. Nonetheless, this possible explanation deserves further theoretical and empirical research.

Finally, consider the addition of risk to the standard common property model. One of the few papers to address this is Sandler and Sterbenz (1993), who show that stock levels will decline as risk increases, which leads them to posit that the "tragedy of the commons" will be mitigated as risk increases. A simple model of m-players using a common pool resource developed by McCarthy (1999) incorporates risk into a utility maximization problem using a mean-variance specification. Here, it is also shown that risk reduces stock levels – but non-cooperative levels are still always greater than those resulting from joint maximization. The "tragedy" is mitigated only insofar as the basis of comparison is the no-risk, joint-maximization solution. Furthermore, total stock levels are increasing in the number of members, as is the case under certainty. As variability in production increases and stock levels decline, it is quite possible for profits accruing under the non-cooperative game to be greater than those under joint-maximization, though expected utility will always be lower, as depicted in Figure 1.

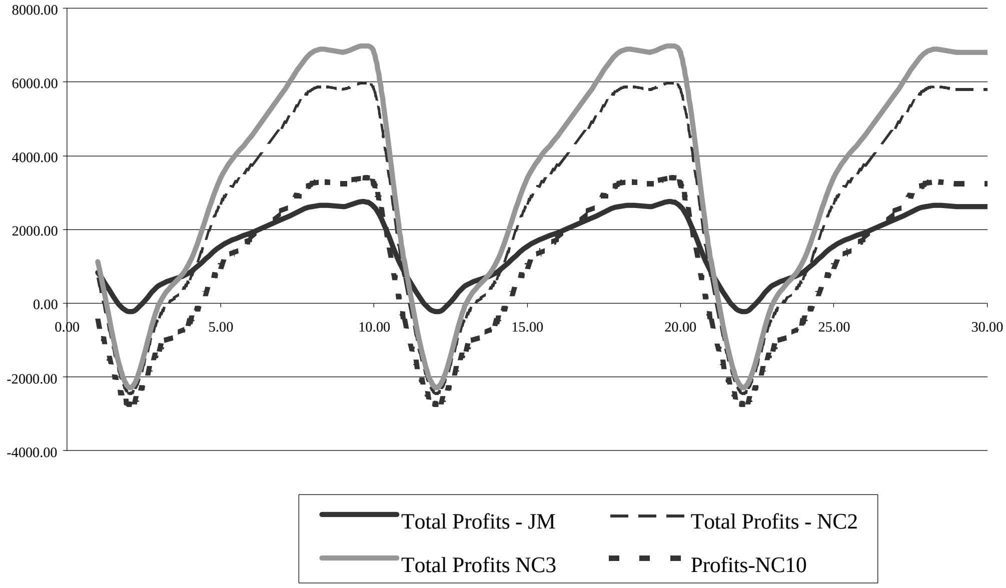
Figure 1: Expected Utility and Profits as Output Variance Increases:



To model the outcomes of the system through a drought cycle, a very simple model based on the assumption that producers are myopic was developed. The model indeed shows that profits and stock levels will all greater variability vis-à-vis the joint maximization case, and this variability increases with increases in the number of players, as depicted in Figure 2. Though it is easy to "eyeball" the graph and see that joint maximization exhibits the least variability, it is more difficult to tell that in fact the variance of profit and the coefficients of variation increase rather dramatically as the number of players increases. With the parameters used here[1], the standard deviation of profits goes from 990 under the joint maximization scenario, to 2070 under the case where there are 10 members exploiting the resource in a non-cooperative fashion. The coefficient of variation goes from .64 to 2.06.

[1] The numbers themselves are roughly based on pasture productivity estimates obtained by Swallow (1994) for Lesotho; prices and costs roughly follow those obtaining in Kenya in 1999 (Heath, 1999). The curvature properties of the profit function captured in the graph do not change with changes in parameters;

Figure 2: Profits through a Drought Cycle



This model can thus explain the empirical phenomena where returns to communal systems compare favorably with commercial returns in good years, but the communal system experiences very poor returns in bad rainfall years, and variability in returns and stock densities are much higher. It also suggests that large fluctuations may in part be due to "commons"-type management problems, and that comparing relative profits in good and average years in order to deduce the capacity of the community to manage its resources may be seriously misleading. Imagine that an effective drought feed subsidy program were put into place, substantially reducing down-side risk and overall output variability. In this case, it is quite possible that resulting incomes will be lower and stock levels substantially higher, though expected utility should also be higher. Nonetheless, results, especially profits, will be rather different than those expected from a well-managed system.

Finally, we consider the argument proposed by Livingstone (1992), among others, who posit that keeping large numbers of animals is rational because each individual increases

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though, when one-period externalities are much greater than the risk externality, the difference in variability between the systems is much less pronounced.

his/her chance of coming out of a drought with at least some animals in order to begin reconstituting the herd. It is fitting to note that there is little empirical evidence to back up this claim, even at the household level. Also, this model of precautionary holdings is not consistent with the much higher variability of the traditional system vis-à-vis the commercial ranches facing similar drought risks – the traditional system exhibits greater variability precisely because of stock levels chosen, and not vice versa. As noted above, one of the few empirical studies to examine this hypothesis was the Ellis et.al. study; to repeat, areas in Turkana with relatively moderate stocking densities (compared to calculated “carrying capacities”) suffered much lower mortality rates during the droughts of 1978-79 and 1984-85 than did areas with much higher densities to begin with – that is to say, those holding on to more, lost more *at the community level*, though not necessarily at the household level. Areas with moderate densities also recovered more quickly. There is also some limited anectdotal evidence of the same applying in the southwestern part of Zimbabwe (author’s personal observations) – holding onto more leads to greater losses, not less.

Empirical Evidence from Southern Ethiopia:

Empirical evidence on cooperation and stock densities at the community level was obtained from a survey of 40 villages undertaken on the Borana Plateau in southern Ethiopia during 1997. The region is semi-arid, livestock production is the major production activity, and cattle are the predominant livestock species. This period corresponded to the “upside” of the drought cycle; the last generalized drought occurred in 1991-1992; thus we should be able to determine if non-cooperation and rainfall variability affect stock densities at the community level. There are no private ranches in this area with which to compare results; however, we do test two of the main hypotheses from the existing literature: 1) whether or not cooperation at the level of the community has an impact on stock densities, and 2) whether rainfall variability leads to higher stock densities (consistent with the Livingstone/Fafchamps hypothesis), or rather to lower stock densities (consistent with the one-period risk-averse producer model). Though these are our two main hypothesis, we digress a bit to explain the empirical results more fully.

Estimations presented below are taken from Kamara & McCarthy (2000); we will not go in to a detailed derivation of the empirical model, but note that it was developed from a theoretical model of risk and use of common-pool resources (McCarthy, 1999). Monthly rainfall data was first collected at rainfall stations across the plateau, 12 stations which had at least 14 years of monthly data were identified. Rainfall was then stratified into four categories according to mean and variance in rainfall, and communities within a 25 km. radius of each station were randomly chosen. In the communities, information was collected on basic demographics, land size and allocation, rangeland productivity, water sources, numbers and types of livestock held, wealth ranking and distribution, seasonal migration of animals to other pastures and in-migration of other animals onto communities pastures, and on rules and regulations over various natural resources. Also, communities identified their primary markets for livestock and grain sales and purchases; distances to these markets were quantified, and then market price data was gathered at these markets.

First, a principal components analysis was performed on a number of indicators thought to represent the level of cooperation reached in a community. This was done since none of the communities had explicit rules on stock levels. It was hypothesized that factors such as the number of meetings and percentage of households attending, numbers of various rules regarding pasture, water, and other land uses, and violations of those rules would give an index of the level of cooperation at the community level. We used only the first factor, which was most easily interpretable as capturing an index of non-cooperation (NonCoop) (results of the factor analysis is presented in Appendix 1).

We then regress the index on factors hypothesized to affect cooperation. Total households and the square of households were used to test the hypothesis that cooperation is more difficult with relatively few households because of fixed costs and also more difficult with many households because of the increased costs of communication and coordination. Higher relative prices, better range quality, and shorter distance to markets are hypothesized to increase cooperation and thus be negatively related to an index of non-cooperation, since gains to cooperating should be greater than gains to not cooperating as prices and range quality increase and distance falls. Cooperation should also be greater where the coefficient of variation in rainfall is greater, since gains to cooperating should increase relative to gains from not cooperating the higher the variability in rainfall (McCarthy, 1999). Dummy variables indicating whether community members migrated to outside pastures for at least 1 month during the preceeding year and whether outsiders came in to use community pastures for at least 1 month are hypothesized to positively effect the index of non-cooperation. The percentage of members engaged in outside wage work is hypothesized to capture the opportunity cost of dedicating time to community activities and will thus increase non-cooperation; and finally, heterogeneity in wealth is also hypothesized to increase non-cooperation due to the fact that there will be fewer agreements mutually beneficial to all. Results from the regression of the non-cooperation index are presented below[2].

Dependent Variable: NonCoop	**Coefficient**	**t-value**
Total Households	.02*	1.89
Total Households^2	-.00008*	-1.98
Coefficient of Variation of Rainfall	-.90	-.09
Relative Livestock Price (in natural logs)	-1.40*	-2.06
Distance to Market (in natural logs)	.30	.88
Range Quality Index	-.19	-1.60
Dummy for In-migration of Animals	1.01*	2.00
Dummy for Community Animals out-migrating	-1.50**	-2.51
Percent of Members engaged in wage work	.008**	2.28
Heterogeneity in wealth	.32**	2.92

Adjusted R-squared: .52
N=39

The NonCoop index indeed seems to capture non-cooperation. However, non-cooperation is at first increasing and then decreasing in total households – contrary to the fixed cost/ increasing variable cost hypothesis. The total impact is always positive in survey communities, but begins to decline at 250 households; in our sample just three

[2] All estimations were performed using STATA 6.0; all used the cluster option to account for the clustering

communities are larger than 250. High prices lead to lower non-cooperation, though distances to market do not have any statistically significant affect. Range quality is also negative, but not quite significant at the 10% level. The rather crude measure for in-migration positively affects NonCoop; which gives support to the hypothesis that use of core community grazing resources by others reduces incentives for community members themselves to cooperate. At the same time, when community members use outside pastures, non-cooperation is reduced. Instead of capturing additional costs of monitoring and enforcing agreements within the community when members are absent, out migration may relieve stocking pressure on community grazing and water resources thereby contributing to easier management of those resources. The higher the percentage of members engaged in outside wage work and the greater the degree of heterogeneity in wealth, the higher is NonCoop, as hypothesized. Coefficient of variation in rainfall, however, has no effect. Overall, this regression has good explanatory power, and results coincide with the main hypothesis regarding factors influencing the degree of non-cooperation.

Next, we use the NonCoop factor as an explanatory variable in the regression of community-level stock densities; clearly we expect stock levels to increase as non-cooperation increases. Other factors hypothesized to affect stock densities include relative prices (positive), distance to market (negative) and total number of households. Even though there was little evidence of population density-driven intensification, we allow for an additional impact of greater number of people outside those associated with non-cooperation; we include the total number of households and a dummy variable for whether or not haymaking was practiced in the community. Finally, we include the coefficient of variation of rainfall. Because one of the hypothesis of the "new range ecology" is that the underlying ecology of pastures is fundamentally different where the coefficient of variation of rainfall is greater than approximately .33, we also allow for a different slope and intercept effect, by including a dummy for communities with coefficients of variation greater than .33, and by including an interaction term of the dummy* the coefficient of variation. Regression results are presented below. In the first

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of communities around rainfall stations.

set of results, we use the NonCoop variable; in the second we replace NonCoop with the exogenous factors hypothesized to affect NonCoop.

Dependent Variable: Stocking Density (natural logs; TLU per ha.)	**Coefficient**	**t-value**
Total Households (natural logs)	.54**	3.72
Dummy for Haymaking	.27	.80
Coefficient of Variation of Rainfall (CoV)	.80	.97
Dummy CoV > .33	-2.05*	-1.82
CoV*Dummy-CoV	-2.43**	-2.56
Relative Livestock Price (natural logs)	1.15*	1.87
Distance to Market (in natural logs)	-.13	-.83
Range Quality Index	.11*	2.06
NonCoop	.19**	2.62

Adjusted R-squared: .60
N=39

Dependent Variable: Stocking Density (natural logs; TLU per ha.)	**Coefficient**	**t-value**
Total Households (natural logs)	.63**	4.82
Dummy for Haymaking	-.28	-1.00
Coefficient of Variation of Rainfall (CoV)	2.24*	1.94
Dummy CoV > .33	-3.24*	-2.16
CoV*Dummy-CoV	-3.05**	-2.75
Relative Livestock Price (natural logs)	1.04*	2.08
Distance to Market (natural logs)	-.15	-1.15
Range Quality Index	.003	.05
Dummy for In-migration of Animals	.59*	1.87
Dummy for Community Animals out-migrating	.26	.65
Percent of Members engaged in wage work	-.004	-.54
Heterogeneity in wealth	.23**	2.60

Adjusted R-squared: .64
N=39

* significant at the 10% level; ** significant at the 5% level

In the first specification, NonCoop is positive and significant. This lends support to the notion that there are varying degrees of cooperation, and the level of cooperation reached affects total use rates, even where use rates are not subject to formal community rules. Total households, relative livestock prices, and range quality all had positive and significant coefficients as expected; while coefficients for distance to market and haymaking were not statistically significant. In this specification, the coefficient of variation is positive, but not statistically significant, whereas the coefficients allowing for intercept and slope differences above and below a coefficient of .33 indicate that there is a strong negative effect on stocking densities in environments with relatively high environmental variability[3]. This provides strong evidence that stocking rates are in fact lower, *ceteris paribus*, in areas with relatively high rainfall variability. These results support the hypothesis stemming from the one-period common pool resource model. They are not consistent with the “more-in, more-out” model of herd accumulation, as we would expect higher stocking densities in higher variability environments.

The second equation, where NonCoop is replaced by the exogenous variables expected to affect the level of cooperation reached, has somewhat greater explanatory power. All but the haymaking dummy variable have the same sign. Given that a number of variables are now hypothesized to be picking up both a direct effect on stocking and an indirect effect via cooperation, it is interesting to note that the coefficient on households increases whereas those on prices and range decrease, as expected; however, the range quality variable is not significant. Both in-migration and heterogeneity in wealth have a significant positive impact on stock densities; whereas out-migration and wage work have no significant effect. The major difference is that the regression coefficient on the coefficient of variation variable is greater and statistically significant, though the total effect on households in high rainfall areas remains negative.

[3] The new range ecology literature uses .33 as a rough cut-off point. In our data we have 12 separate observations on rainfall and variability; we tested the effects using various dummies constructed for

Conclusion:

Extensive livestock production still provides a livelihood for a large number of people in marginal areas of sub-Saharan Africa. Yet, few advances of any sort have been made over the last three decades, and these areas remain characterized by low productivity and extreme vulnerability to climatic fluctuations. The failed "ranching schemes" of the 1970's gave way to almost complete neglect by governments and donors. There is now renewed interest in these rangelands; a pessimist may claim this is because of the environmental implications more than livelihoods of the people dependent on them. Historically, it was claimed that traditional rangeland management failed because of common property problems; the response was "quasi"-privatized ranching schemes. Then it was claimed ranching schemes failed because of an inadequate accounting for rainfall variability and the importance of mobility and that there was no evidence of common property-type problems. Both analyses are likely to be partially right and partially wrong.

Comparing the limited empirical evidence from the traditional and the commercial sectors, it appears as if the major difference between the systems is the management of herd sizes through the drought cycle – in traditional systems, herders build up far greater stocks during an upturn, and suffer much greater losses in a downturn. The system is thus far more volatile. One possible explanation is that it is rational to build herds in anticipation of a drought; this explanation does not help to explain the contrast between private ranchers and traditional herders, nor is it consistent with evidence that herders' hold fewer animals, *ceteris paribus*, in environments with greater rainfall variability. Another possibility is that risk externalities arising from imperfect management of common resources lead to the greater observed variability on these rangelands. This explanation is consistent with empirical evidence.

To date, few policies or projects aimed at mitigating high livestock mortality rates during a drought have been undertaken at a large scale. However, drought mitigation programs aimed at offsetting losses during the drought may very well lead to dramatic increases of

observations above and below .25 to .38, and results were quite robust.

stock levels and lower profitability. They may also lead to much greater susceptibility to even small deviations below average rainfall, in turn leading to greater expenditures on the drought mitigation measure. This "vicious" cycle has been borne out in the pastoral systems operating on common pasture-lands in Morocco, Egypt and Syria; leading to enormous government expenditures, and to lower incomes per capita (Hazell, 1998). At the same time, it must be stressed that these rangelands support a large number of people, and that livestock mobility is likely to remain a key strategy for exploiting rangelands in semi-arid to arid regions. The message for policymakers is unfortunately somewhat complicated: To reduce high livestock mortalities during "droughts", it is not enough to put into place effective "crises" mitigation mechanisms, since these are likely to have an immediate impact on the use and management of the range resources, through all stages of the drought cycle. Policies to increase off-take during an upturn are potentially equally as important for decreasing variability of returns; and, a commitment to designing and implementing policy measures to improve (or at least not weaken) community-level management of these resources must accompany any such measures.

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