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Individual and Collective Rationality in Pastoral Production: Evidence From Northern Kenya

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This study explores the individual and collective rationality of livestock accumulation in pastoral production using data gathered in northern Kenya. Results suggest accumulating wealth in livestock even when facing the prospect of sudden dramatic loss makes sense at the household level, and that there is limited empirical support to the contention that herd accumulation at the household level imposes a cost on other households. I conclude by arguing the record of failure in pastoral development may be at least partially due to a faulty conceptual foundation, and suggest facilitating herd accumulation may offer more promise than discouraging it.

KEY WORDS: herd accumulation; risk management; negative externalities; common property; pastoralism.

INTRODUCTION

This study uses data gathered from pastoral herders in northern Kenya to develop an understanding of pastoral production in arid and semiarid African rangelands. The findings shed light on the historical failure of pastoral development efforts and suggest directions for future research and development efforts in pastoral rangelands. I take as a starting point the boom-and-bust cycles of livestock populations in the pastoral rangelands of Africa noted by many observers (Coppock, 1994; Fafchamps, 1998; Livingstone, 1986). Herd size grows steadily over a period of years in a boom phase, only to have these gains erased during a short bust phase. I first consider the question of individual rationality in such an environment.

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Incentives inducing herd accumulation have been described as originating in the common property nature of tenure arrangements in pastoral rangelands (Jarvis, 1980; Hardin, 1968), from cultural norms that confer status and prestige to large herd owners (Doran *et al.*, 1979; Herskovits, 1926), and in response to the highly variable nature of livestock production in semiarid and arid areas (Sanford, 1983). I focus attention on the extent to which livestock accumulation can be empirically identified as an individually rational strategy to adopt in the variable production environment facing Gabra pastoralists in northern Kenya. If herd accumulation is occurring primarily in response to uncertainty about future exogenous variables such as rainfall and disease, efforts to influence cultural norms or land tenure patterns that do not reduce uncertainty will have limited impact.

In section three of this study I present evidence on the rationality at the household level of livestock accumulation when it is almost certain that sudden, massive herd losses will occur with some frequency. I analyze the incentives to accumulate livestock in terms of how accumulation affects household income, how the returns to wealth kept in livestock compare to a formal savings alternative, and how accumulation serves as an ex ante self-insurance strategy. Overall, I conclude that herd accumulation makes a great deal of sense as a response to the highly risky production environment of the study area. This limits the effectiveness, and calls into question the usefulness, of efforts to discourage accumulation through modifying the land tenure system or cultural values in the absence of efforts to decrease production risk. Even if one accepts the contention that livestock accumulation is individually rational, this leaves unanswered the charge that such accumulation is collectively irrational. Previous studies describe three interrelated manifestations of the collective irrationality of herd accumulation: grazing-induced environmental degradation, endogenously triggered livestock population, cycles, and lowered productivity of animals.

Pastoral production has been described as ecologically destructive due to the long-term impact of larger than optimal herd size on a given pasture resource (Brown, 1971; Hu *et al.*, 1997; Lamprey, 1983). Doran *et al.* (1979) argue "the tendency to retain or increase cattle numbers even under adverse environmental conditions is a widespread and characteristic feature of many African societies. The observation that Africa is now perhaps the classic example of a continent suffering soil erosion caused by overgrazing is a reflection of the nature and extent of the problem" (p. 41). Preventing or reversing environmental degradation requires a transformation of pastoral land use patterns and cultural attitudes through extension and education, land tenure reform, or external regulation as a second best option. Barnes (1979) argues "The future of large tracts of Africa thus depends, in the first instance, on drastic changes in traditional attitudes towards land use among relatively unsophisticated and uneducated indigenous peoples. This can only be brought about by concerted and well-planned programs of rural reform and education . . ." (p. 51). Doran *et al.* find ". . . it will be necessary either to implement measures that will induce stockowners to sell more cattle or, alternatively, to enforce control of cattle numbers" (1979, p. 45). Jarvis (1980), in response, suggests "the principal production problem . . . would seem to be the communal grazing system . . . The subdivision of the range for private use is the economically preferred policy . . . the implementation of direct controls on the number of animals which herders will be permitted to graze is the next best solution" (pp. 611–613).

Another concern raised in the literature is that sudden herd die-offs result from an interaction between aggregate stocking pressure and pasture availability. The individual's goal of livestock accumulation leads to the collectively irrational outcome that either growth is slowed in normal years or a sudden die-off of animals is made more likely in drought years, or both. Fafchamps (1998) argues "it is generally agreed that the overexploitation of the available pasture is at the root of livestock cycles, and that this overexploitation—or overgrazing—is the result of common or open access." He notes that although the timing of the bust phase of a boom-and-bust cycle may depend on exogenous rainfall shocks, "it fundamentally results from the accumulation of animals beyond the carrying capacity of the range." This view assumes the sudden losses of a bust phase are triggered by aggregate herd size exceeding forage availability. Desta and Coppock (2002) present a variation on this theme, suggesting that certain combinations of stocking pressure and rainfall deficits can trigger livestock population drops.

Finally, recent theoretical studies focus on how livestock accumulation by one household impacts the production of other households in commonly held rangelands (Fafchamps, 1998; Goodhue and McCarthy, 2000; McCarthy, 2000). These studies suggest that growth in the individual household's herd decreases production per animal in the herds of other users of the rangeland. Herren (1991) postulates that in the Maasai setting he is investigating "[h]igher stocking rates may have resulted in a decrease of productivity per animal, resulting in a lower food output from a family herd of a given number . . ." (p. 99). Given that pasture is limited, each user of a common rangeland makes decisions that have an impact on other users in terms of current period benefits such as herd weight gain or milk production.

The policy response to each type of collective irrationality is to discourage herd accumulation due to the negative externalities it generates.[2] The

[2]An externality occurs when the actions of one agent directly affect the environment of another through a mechanism other than market prices (Varian, 1992). A negative externality

logical foundation of such policies is that herders will be made better off if they can somehow be restrained from collectively engaging in irrational behavior. Recent studies adopting the "new range ecology" approach are critical of such policies, and challenge the assumption that herd accumulation at the household level is collectively irrational in arid and semiarid areas (Hellden, 1991; Homewood and Rogers, 1987; McCabe and Ellis, 1987). It is argued that under the climatic conditions characterizing these areas,[3] frequent droughts ensure livestock populations rarely reach levels where negative environmental externalities are generated (Abel, 1993; Biot, 1993; Ellis and Swift, 1988; Sanford, 1983; Scoones, 1993; Westoby *et al.*, 1989).

This study shares the skepticism about the presence of negative externalities in pastoral production with the new range ecology approach. However, I here consider not only environmental externalities, but investigate empirically a variety of different externalities that have been proposed in the literature on pastoralism. I also suggest that the focus of the new range ecology approach on aggregate stocking rates on a rangeland can overlook critical issues of spatial distribution of these animals. Overall, I find there is little evidence to suggest that the welfare of pastoralists will be improved by policies that discourage herd accumulation. I do find that efforts to combine herd accumulation with efforts to support spatial mobility offer a foundation for development efforts in this area. In conclusion, I suggest that the overwhelming failure of development efforts in pastoral areas is at least partially due to the flawed conceptual foundation of past efforts, and argue that future policies based on careful empirical research offer some hope for a more optimistic future for development in pastoral areas.

DESCRIPTION OF THE STUDY AREA AND DATA

This study uses data gathered in two areas of Marsabit District, Kenya, occupied by Gabra pastoralists: the Chalbi area and the Dukana area. Gabra inhabit the arid rangelands of the Kenya–Ethiopia frontier.[4] Gabra

means that the actions of one individual impose a cost on another individual, and the individual who imposes this cost is not required to compensate the individual who bears the brunt of this cost. It is also possible for an externality to be positive. In the pastoral setting considered in this study, an example of a positive externality is increased security brought about by collective decisions by households to migrate together for mutual protection. We will only focus here on the presence or absence of a negative externality.

[3]Specifically, it is argued that in areas with mean annual rainfall levels below 400 mm per year and coefficients of variation for rainfall greater than 30 (Coppock, 1994), production conditions make it unlikely that animal populations are the fundamental cause of changes in rangeland productivity.

[4]The Gabra in this area are Gabra Malbe, as distinct from the Gabra Miigo who live mainly in Ethiopia (Tablino, 1999).

are a Cushitic-speaking group who share a language with the cattle-keeping Boran and share many cultural practices and clans with the neighboring camel-keeping Rendille and Somali (Schlee, 1989).

Gabra society is divided into two moieties and five sections[5] (Torry, 1973). The highest level of political and social organization is the section, which is led by a group of elders in a ritually important village called a *yaa*. Sections are associated with particular broadly defined geographical areas, but there is no exclusive right to graze animals in an area associated with membership in a particular section (O'Leary, 1985). Each household has the right to migrate and graze anywhere in "Gabraland."[6] The majority of households in the Chalbi sample belong to the *Algana* section while the majority of households in the Dukana sample belong to the *Gara* section.

The unit of analysis for this study is the Gabra household. Torry (1973) and O'Leary (1985) present detailed household-level analysis of Gabra, and I follow their convention of defining a Gabra household as a herd-owning unit residing in a single dwelling. As women are not allowed to own animals, a household is centered on a husband or in the absence of a husband, an eldest son supervised by his uncles. A household has at least some members resident in a base camp throughout the year. The base camp is centered on a moveable hut that is approximately four meters in diameter and surrounded by night enclosures constructed of thorny branches for animals. Women and children tend to be permanent residents of the base camp, which is moved every few months. Often groups of households move together from one site to another for a short time, but these groups are not stable over longer time periods. Gabra households also use satellite camps, where animals are sent to remote grazing areas away from the base camp. Young men tend to be the residents of these temporary and highly mobile satellite camps.

Gabra society has experienced rapid change in the past few decades. In particular, Gabra are increasingly influenced by national and international political and economic forces (KHRC, 2000; O'Leary, 1985; Tablino, 1999, 1996) which present both new challenges and opportunities. Many of the issues described by Fratkin (1991) for the neighboring Ariaal hold true for Gabra—a new constellation of government agencies, nongovernmental organizations, and mission activities presents new challenges and opportunities that need to be reconciled with traditional structures and rules. As is the case throughout northern Kenya, a profound change over the past 40 years has been the rapid growth of settled populations in small market towns.

[5]Torry (1973) uses the term phratries to describe what is here termed a section.

[6]Gabra property rights have not changed in the ways Ensminger (1992) documents for the linguistically related Orma in Kenya. It should be noted that efforts currently under way to introduce environmental management committees in this area may lead to a situation similar to that identified by Ensminger.

While by no means denying the importance of these new developments, I wish in this study to emphasize the economic conditions facing pastoralists who have not settled in towns and who continue to migrate with their herds in the Gabra rangelands.

This study is based on interviews with 39 households in the Chalbi area and 49 households in the Dukana area conducted in 1997–1998. The Chalbi area borders the Chalbi desert and is an extremely arid production environment. The Dukana area lies approximately 100 km to the north of the Chalbi area and is slightly less arid but has fewer watering points. The questionnaire was retrospective in nature, recording information for four time periods per year for each of the years 1993–1997. The four time periods, each roughly 3 months, correspond to the bimodal rainfall pattern of the area: the long rains, the dry season following these rains, the short rains, and the dry season following these rains. This approach provided multiple data points for a given household (from 16 to 20 data points per household depending on when the household was interviewed).[7] The sampling method chosen was based on the idea of a transect, as no list of pastoral households existed for this area. Enumerators moved between the main towns of the study area (Kalacha and North Horr in Chalbi, and Sabarei and Dukana in the Dukana area) interviewing herders they encountered at nomadic camps along the way.[8]

Respondents were asked to report the following variables for each time period[9] ages of household members; household size[10]; household herd size

[7]The dataset is not longitudinal in the sense that there are repeated observations by an interviewer of a single household over time gathered during multiple visits. However, it is longitudinal in the sense that the interviewer recorded repeated observations made by the household over time, but did so during a single interview.

[8]The definition of this sample did not include former herders who have moved to the small towns of the study area, either in search of economic opportunities or due to the loss of their herd. Issues of selection bias are possible if herders who lost their animals between 1992 and 1997 were systematically overlooked due to the sampling method based on the outcome of herders still residing in the grazing areas. However, discussion with both nomads and town residents indicated this was not likely to be a major issue as there was not a significant population flow from the rangelands into the towns during this time period, and very few households were forced out of pastoralism due to the herd losses experienced in 1996.

[9]Respondents appeared to have little difficulty in recalling season-specific information over the 4-year time period covered in this study. This was likely aided by the fact that widespread herd losses in 1992 served as a notable starting period. In addition, herd genealogies were constructed for camels and cattle to record livestock production information, and served as the foundation for other questions (for a discussion of this methodology, see Grandin, 1983, and Turner, 2003). In a society where records are not written, information in herders' memories serves a critical function in herd management decisions. Knowledge of complicated genealogy structures and historical events is critical for both Gabra society and for herd management decisions (Robinson, 1985; Tablino, 1999; Torry, 1973). While repeated observations would be preferable for construction of a longitudinal data set, the recall data in this study are internally consistent, and are in my judgment reliable enough to analyze empirically.

[10]Household size is reported in adult equivalents using the scale reported in Martin (1985).

and species composition; sales from the household herd, and characteristics and price per animal sold; slaughters from the household herd, and characteristics of animals slaughtered; transfers into and out of the herd and characteristics of animals transferred; milk production and milk sales; and other sources of household income. Stock variables are recorded at opening period levels, flow variables recorded for within period levels. Variables relating to livestock are recorded in total livestock units (TLU), where 1 livestock unit = 10 sheep or goats = 1 head of cattle = 0.7 camels (Schwartz *et al.*, 1991).

Household heads were also asked to rank on a scale of one to five the following variables for each rainy season—dry season pair: pasture availability, forage production, and stocking pressure. Pasture availability was described as a measure of how easy it was for the animals to become satisfied, forage production as a measure of the amount of animal feed produced, and stocking pressure the number of animals using the rangeland. Herders were asked to provide these subjective rankings for two different areas for each time period—the area within a five-hour walk from town and the area more than a five-hour walk from town. A rainy season–dry season pair lasts 6 months, in contrast to the 3-month periods described above.

Variables exogenous to the household are also recorded in the data set for each 3-month time period. The average price received for male goats is recorded and was computed from the age-adjusted average of all observations in the sample for that time period. A variable records the tons of food aid delivered to the towns of the study area in a given time period based on information obtained from the distribution agencies. Four variables are used to record rainfall characteristics of a given time period; one measures total rainfall over the past 6 months; a second measure indicates the fraction of the 6-month total that fell in the current 3-month season; and the other two are dummy variables that record whether the period in question is one of the two annual rainy seasons. Rainfall information was gathered at the North Horr Catholic mission and the Kalacha African Inland Church mission. Table I presents summary statistics of variables used in later regressions.

HOUSEHOLD LEVEL RATIONALITY AND LIVESTOCK ACCUMULATION

Income Production

Gabra rangelands are the most arid in all of east Africa (FAO, 1971). Robinson (1985) describes the environment as "... one of rugged

Table I. Descriptive Statistics of Variables Used in this Study

	Average	Standard deviation
Income per person per day (shillings)	26.63	19.95
Herd Size (TLU)	29.06	25.27
Smallstock fraction	0.34	0.18
Age of oldest male	50.62	13.38
Age of oldest female	36.57	11.48
Household size in adult equivalents	4.51	1.66
Chalbi dummy	0.42	0.49
Price of male goat (shillings)	869.58	237.25
Rainfall over 6 month period (mm)	56.82	38.27
Fraction of rainfall in current period	0.54	0.44
Long rains dummy	0.26	0.44
Short rains dummy	0.26	0.44
Food aid deliveries in tons per period	71.32	88.09
Herd size in mid 1996	55.33	43.14
Herd size in early 1997	26.51	18.14
Smallstock fraction in 1996	0.55	0.17
Sales up to 1996	6.86	4.72
Slaughters up to 1996	4.49	2.71
Milk (L)	4.44	3.58
Milk per TLU	0.21	0.13
Herd size change (TLU)	0.53	4.68
Herd size (change per TLU)	0.03	0.13
Herd size of others	28.59	13.89
Pasture availability around town	1.82	0.99
Feed production around town	2.37	0.88
Stocking pressure around town	2.72	0.85
Pasture availability away from town	3.28	0.89
Feed production away from town	3.55	0.87
Stocking pressure away from town	4.17	0.73

desolation; searing winds and unrelenting sun" (p. 43). Mean annual rainfall is below 300 mm for the vast majority of Gabra rangelands, making rainfed cultivation impossible (Schwartz *et al.*, 1991). Rainfall is highly variable temporally. Figure 1 presents the annual rainfall level recorded at the North Horr Catholic mission from 1977–2000. The coefficient of variation for annual rainfall in North Horr for the period 1977–2000 is 55. In addition, the intra-annual variation in rainfall is shown in Fig. 2, which reports average rainfall by month when averages are calculated for the period 1977–2000 using the North Horr data.

Rainfall is also highly variable spatially. Monthly rainfall totals for the two rainfall stations in the Chalbi area (North Horr and Kalacha) from January 1993 to May 1997 are presented in Fig. 3. Although these sites are only 50 km apart, the correlation in monthly rainfall is only 0.66 for the 53 months for which we have data for both sites. Further, there are multiple occurrences of one site recording rainfall while the other site records zero

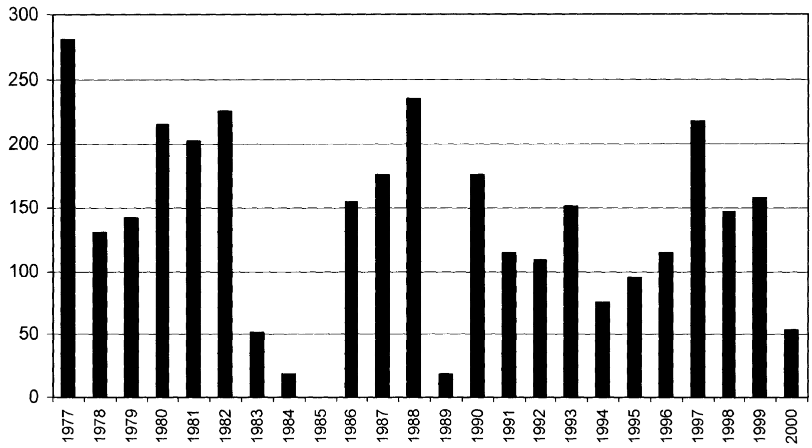

Fig. 1. Annual millimeters of rainfall in North Horr, 1977–2000.

rainfall. Clearly, spatial mobility is a critical element of production when rainfall is so spatially variable.

In addition to variability in rainfall, households must confront variability in herd size over time. The historical record suggests herd losses are frequent in this area. In the post-independence era, widespread herd losses are reported in 1965, 1970–71, 1975–76, 1980, 1983, 1991–92, and 1996 (O'Leary, 1987; Robinson, 1985; Tablino, 1999) and continue, as evidenced by losses in 2000. The data set contains season-specific information on households starting in early 1993 and ending in 1997, beginning after widespread herd losses in 1991–1992. The livestock population in 1993 was

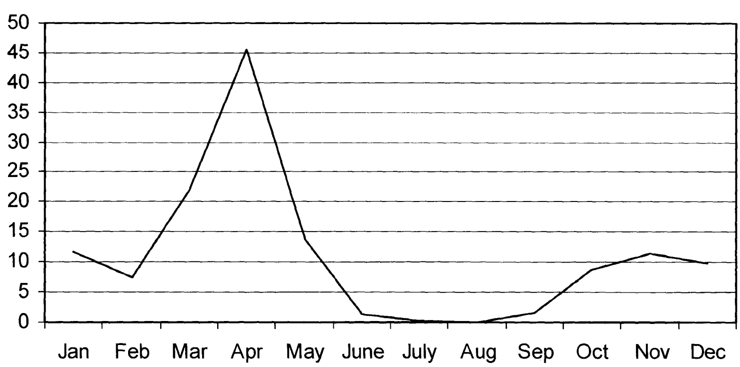

Fig. 2. Average millimeters of rainfall in North Horr by month, 1977–2000.

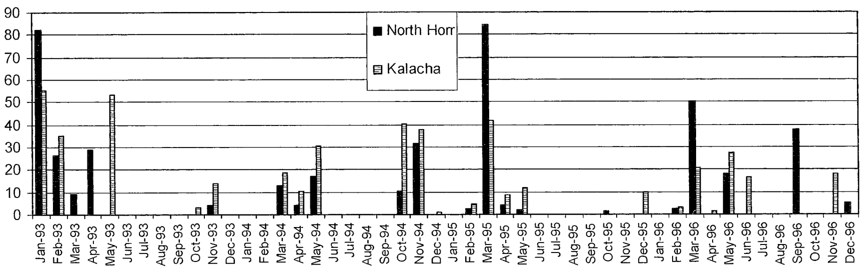

Fig. 3. Millimeters of rainfall in Kalacha and North Horr by month, 01/93–12/96.

51% of the 1991 livestock population (figures provided by the District Livestock Office in Marsabit). Returning to the sample gathered for this study, by mid-1996 the size of the average Chalbi herd had increased by an average of 68% and in Dukana by 33% when herds are measured in total livestock units (TLUs). However, in late 1996, Chalbi households experienced sudden herd loss. Between the middle of 1996 and early 1997, the average household herd in Chalbi decreased by 50%. This decline was almost entirely due to mortality, rather than sales or slaughters (Fig. 4).

Household food security can be threatened by such losses as households derive their livelihoods from herds of camels, cattle, sheep, and goats (hereafter, sheep and goats will be grouped into a single category termed "smallstock"). The data indicate households depend almost entirely on livestock and livestock products for the generation of income. Assigning

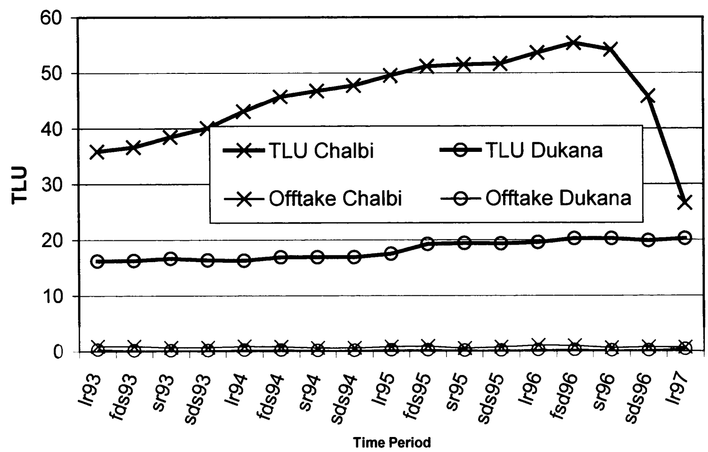

Fig. 4. Average herd size and offtake by site, early 1993–early 1997, reported in McPeak, 2004.

market values to home-consumed goods reveals that, on average, 72% of total income is obtained from milk produced by the household herd; 14% is obtained by the sale of animals; 13% is obtained by home consumption of slaughtered animals; and 1% is obtained by skin and hide sales, gifts, and remittances. This derived income measure indicates average income per adult equivalent per day is $0.61 in Chalbi and $0.38 in Dukana, using the exchange rate provided in World Bank tables (2002). Not only is average income low, there is also a great deal of variability around these averages over time at the household level. The average household level coefficient of variation for the income measure over the different time periods recorded for each household is 45 in Chalbi and 51 in Dukana. Since the great majority of income is directly consumed by the household, this suggests a high degree of temporal variability in household consumption. Not only are households poor on average, but they also face highly uncertain income over time.[11]

Given the reliance of Gabra pastoralists on their livestock for income, and the dependence of these livestock on rain-fed pasture for sustenance, income is likely to be influenced by both changes in herd size and changes in rainfall conditions. To investigate the importance of different variables on household income over time, income per person per day is estimated as a function of household herd size, herd composition as measured by the fraction of herd TLU accounted for by smallstock, and household characteristics such as age of the oldest male, age of the oldest female, and household size as measured in adult equivalents. The estimate also includes as regressors variables exogenous to the household, recording rainfall over the past 6 months, the fraction of 6-month rainfall that fell in the current period, whether the period is supposed to be a rainy season, the average price of a male goat, food aid deliveries, year dummies, and a time trend by period. The estimate controls for household specific fixed effects, as all time period specific household variables are differenced from their household specific mean for all periods (Table II).

Results indicate that herders seek to accumulate animals because more animals mean increased income. While this finding is perhaps somewhat obvious, it merits note for two reasons. First, it clearly demonstrates that viewing herd accumulation solely as a result of cultural attitudes, say in order to gain prestige, is inadequate. As households accumulate animals, their income increases. Second, it clearly demonstrates that the direct impact of policy measures that reduce animals at the household level is to reduce

[11]The data set provides some evidence that variability in income is particularly pronounced for the poor, as the correlation between household average income and the coefficient of variation is negative, (−0.24), suggesting lower average income households are also subject to greater variability in income levels over time.

Table II. First Difference and Average Income Per-Person Per-Day (Heteroskedastic consistent standard errors in parentheses)

	First difference income
Herd size (TLU)	0.7857*** (0.0853)
Herd Size^2 in TLU ($\times 10^{-2}$)	−0.2289*** (0.0358)
Smallstock fraction of herd	−0.3971 (4.1630)
Age of the oldest male	−0.4151 (1.0700)
Age of the oldest male^2	0.0092 (0.0084)
Age of the oldest female	−2.2216** (1.1230)
Age of the oldest female^2	0.0231** (0.0105)
Household Size in Adult Equivalents	−7.5383*** (1.284)
Price of a male goat ($\times 10^{-2}$)	−0.0754 (0.1261)
Fraction of 6 month rainfall in current period	5.1307** (2.0170)
Rainfall in 6 month period	0.0699** (0.0309)
Rainfall in 6 month period^2 ($\times 10^{-2}$)	−0.0175 (0.0165)
Long rains dummy	1.9848 (2.5300)
Short rains dummy	−0.7819 (1.6710)
Food aid deliveries	−0.0031 (0.0081)
$\chi^2_{(2)}$ own herd	87.9***
$\chi^2_{(2)}$ male age	1.9
$\chi^2_{(2)}$ female age	4.9*
$\chi^2_{(2)}$ 6 month rain	11.2***
$\chi^2_{(2)}$ time period	22.2***
$\chi^2_{(5)}$ year dummies	35.8***
R^2	0.27
Number of observations	1686

*Indicates significant at the 10% level.
**Indicates significant at the 5% level.
***Indicates significant at the 1% level.

income. While such measures can lead to overall benefits if there are in fact negative externalities that they address, the direct effect is the only effect if no such externalities exist—that is to say the policies reduce household income.

We simulate these results to compare income levels using the average herd size in mid-1996 compared to average herd size in early 1993 and hold all else constant. Estimated income per person per day using the 1996 average herd size is 26% greater than the value obtained using the 1993 average herd size, all else held constant. If we consider the negative impact of the herd losses of late 1996, income per person per day decreases 34% due to the average herd loss from mid-1996 to early 1997. The results also illustrate that households are exposed to risk through rainfall failure. A total rainfall failure implies a 13% reduction in income from the mean value of rainfall, all else held constant. Results also indicate that income level is not significantly influenced by the price variable. Even though there is a high degree of unpredictability in livestock pricing in this area (Barrett *et al.*, 2003), it appears households have developed effective *ex post facto* coping mechanisms to deal with such unpredictability. In addition, the variable recording food aid deliveries to the study area is not significantly related to changes in household income.[12] If food aid deliveries were effective in responding to temporary low income crises or if households reduced income generation activities in response to free food aid, we would expect a negative relationship between income and food aid deliveries. This finding suggests that food aid is either very small in quantity or is not well-timed as a relief measure.

Herd Growth

While accumulation of livestock is clearly related to increased income, a different perspective on livestock accumulation can be obtained by considering the rates of return to capital held in livestock. While the data above indicated it is sensible for households to accumulate livestock to increase income, it also indicated that livestock assets can be suddenly lost, leading to the possibility of a household food security crisis. Would it not be prudent for households to convert some of their inherently risky livestock wealth into less risky formal savings that can be used to prevent a food security crisis in the future or to restock through markets after the crisis has passed?

To address this question I first consider rates of return to capital held in the form of livestock, excluding the income generation benefits discussed in the previous section. I begin by noting the differences between herd composition and rates of change in the two study areas. The average composition of the early 1993 Chalbi herd (measured in TLU) was 51% smallstock, 36% camels, and 13% cattle. In Dukana, the figures are 47% smallstock, 30% camels, and 23% cattle. Table III presents information on herd growth rates over a 3.5 year period for each species in each area. Particularly notable is the rapid increase in Chalbi livestock over the 3.5 year period followed by the rapid decline over the following 6-month period.

Table III shows changes in herd size stocks over time but does not reflect the rate of return to livestock capital fully, as it does not include measures of cumulative flows of livestock during the period. If the cumulative record of sales,[13] slaughters, and net transfers over the 1993–1996 period are added to the stock variable of early 1997 herd size used in the previous growth calculations, it is found that Chalbi herds measured in TLU terms returned an average annual rate of 6% from early 1993 and

[12]The food aid measure is not included in the computation of household income per person per day.

[13]There were no purchases of animals recorded for any household in the dataset.

Table III. Herd Growth and Herd Loss

Area and species (starting share)	Number of sample households with this species	% change 1993-mid 1996	% change mid 1996-early 1997
Chalbi camels (36%)	38	40	−22
Chalbi cattle (13%)	22	43	−16
Chalbi goats and sheep (51%)	39	118	−70
Dukana camels (30%)	40	80	0
Dukana cattle (23%)	44	81	8
Dukana goats and sheep (47%)	49	9	−2

early 1997 (standard deviation 0.11, 28% of households experienced negative rates), while Dukana herds averaged 15% annualized livestock rates of return over the same period (standard deviation of 0.15, 12% of households experienced negative rates).[14]

Development programs in this area have for many years emphasized the positive opportunity offered by formal savings, yet participation rates in formal savings are extremely low (Osterloh, 2001; Lusigi, 1984). Contrasting these livestock rates of return with the returns to formal savings illustrates why it may require more than extension efforts to persuade herders to convert capital held as livestock into formal savings in this area. Given current banking regulations at the nearest formal bank in the district capital, a cash deposit the equivalent of roughly 25 goats or more would return approximately 2% per year over a 4-year period, between 18 and 25 goats would yield a return of −44 %, and an account of lower value than 18 goats would be completely dissipated by service charges over 4 years, earning a rate of return of −100%. The positive rate of return threshold herd of 25 goats is roughly 10% of average household herd size, and is equivalent to more than half of the average household's total livestock sales over the 4-year study period. Even including the losses of late 1996, and excluding the benefits of income generation and the costs associated with accessing savings in the district capital, livestock raising offers a higher average rate of return than savings. While it could be argued that formal banking may still be attractive in terms of reduced variance in return, discussions with herders suggest viewing bank savings as low risk may not be appropriate as herders express doubts about the safety of money placed in banks.[15]

Even if formal savings returns are improved, the use of financial savings to self-restock may be of limited effectiveness due to the nature of the

[14]The average annualized growth rate in Chalbi before the losses of 1996 was 34%.

[15]In general, herders attribute this uncertainty to a lack of confidence in the ethical behavior of bank staff, although it is possible that this uncertainty arises from a lack of clarity about service charges leading to savings dissipation of the kind described above which is then blamed on bank staff.

livestock markets in this area, which are designed for the export of male animals from the pastoral area to the Nairobi market (Schwartz *et al.*, 1991). Analysis of sales data at the district level suggests female animals account for less than 33% of animals sold in the market (Barrett *et al.*, 2003), which is consistent with information on the characteristics of animals sold at the household level. The data gathered for this study also indicate that marketed female animals are on average older than marketed male animals. Herders contend that even when they do find female animals in markets that can be used for restocking, they are apprehensive about buying such animals due to their limited information on animal reproductive status and potential. The current livestock market structure in the study area is not well-suited to the role of allowing self-restocking through market mechanisms. This provides further insight into why households chose to self-insure through livestock accumulation.

Finally, a direct assessment of the effectiveness of household-level herd accumulation as a risk management strategy can be made by analyzing information on livestock losses during the crisis period in Chalbi in late 1996 (Fig. 1). Postcrisis early 1997 household herd size is regressed on the following variables: household herd size in early 1996 and its square; the fraction of early 1996 household herd TLU that is accounted for by smallstock; early 1996 household size in adult equivalents; and the total household specific TLU value of sales and the total TLU value of slaughters from early 1993 to early 1996. The final two variables are included to see whether offtake can decrease herd loss by culling weaker animals or by allowing access to cash from sales revenue for the purchase of veterinary inputs or feed supplements. The results of this regression are presented in Table IV.

As is reported in a variety of other studies (Ensminger, 1992; Herren, 1991; Fratkin and Roth, 1990), the results indicate that larger precrisis herd size is correlated with larger postcrisis herd size up to 238 TLU. Only one

Table IV. Herd Size in Early 1997 as a Function of Mid 1996 Characteristics

	TLU herd size in early 1997
Herd size in mid 1996 (TLU)	0.6981*** (0.1549)
Herd size^2 in mid 1996 (TLU* 10^{-3})	−1.4694*** (0.5107)
Smallstock fraction of total herd	−0.2336** (0.1155)
Household size in adult equivalents	1.6316 (1.0130)
Cumulative sales (TLU)	0.3744 (0.6405)
Cumulative slaughters (TLU)	−1.3464 (1.3126)
Constant	2.7825 (10.3514)
R^2	0.69
Number of observations	39

*Indicates significant at the 10% level.
**Indicates significant at the 5% level.
***Indicates significant at the 1% level.

household had a herd larger than this critical point in early 1996. The more animals one has going into a crisis period, the more one can expect to have once the crisis has passed. However, the predicted increase of early 1997 herd size brought about by a 1 TLU increase over mean early 1996 herd size is 0.52. This is in agreement with the finding of McPeak and Barrett (2001) that livestock accumulation in this area is an effective, albeit costly, means of self-insurance. The fraction of a herd held in the form of small-stock has a negative influence on post-crisis herd size (see Table II). Finally, the coefficients for cumulative sales and slaughters indicate that past offtake behavior has no significant influence on postcrisis herd size. This indicates that sold and slaughtered animals were not selected for offtake due to their weakness and that those who sell more animals before the crisis period were not able to lower their losses through mitigation methods.

LIVESTOCK ACCUMULATION AND NEGATIVE EXTERNALITIES

Environmental Degradation

There has been long-standing concern over grazing-induced environmental degradation in Marsabit District, where the Gabra reside. Sobania (1979) quotes colonial era documents from the 1930s arguing that since pastoralists in northern Kenya own far too many animals from an environmental point of view, veterinary programs will be counterproductive. Rather, the document suggests "... a bit of disease now and then is to be encouraged in their stock provided it doesn't reach epidemic form" (p. 180). Lipscomb (1955) summarizes the problems of the pastoral livestock sector of Kenya in one word—overstocking—and describes controlled grazing schemes to address this problem.

The UN-funded project Integrated Project in Arid Lands (IPAL) was active in this area from 1976 to 1984. The project was established with a focus on "the arid lands of Kenya both for the support of their indigenous people and in the economy of the country as a whole, and because these lands were gravely threatened by desertification through misuse" (Lusigi, 1981, p. 7). Identifying this desertification and the associated misuse proved more nuanced than the project originally anticipated. Little (1994) writes "while IPAL's environmental studies rate much of Marsabit District as degraded or under the threat of degradation, the project's data show that most of the degradation has been in the vicinity of a few large settlements ... even in the case of these settlements, IPAL admits much of the damage is probably reversible" (p. 232). O'Leary, a former member of the IPAL research team, states that in the final analysis "IPAL range and livestock scientists calculated that generally at the macrolevel, the range sources could support current livestock populations. Range degradation is confined to areas surrounding trading centers and permanent water; but this is compensated for by vast areas which are underutilized" (1985, p. 65).

O'Leary's assessment is consistent with a 1988 evaluation of the District's rangelands reported in the Range Management Handbook of Kenya. This evaluation categorizes 80% of the rangeland areas as good (not degraded), 18% as fair (showing impact of use by livestock below a level seriously impairing livestock productivity), and 2% as poor (exhibiting significant decreases in productivity attributable to overuse). These overused areas almost entirely correspond to rangelands within a five-hour walk radius of the small market towns in the District.

I have compared the estimated rangeland carrying capacity reported in the Range Management Handbook with government livestock population figures (see McPeak, 2003). I found that at no point in the period 1963–1988 for which data are available were the rangelands of Marsabit District overstocked when taken as a whole. The environmental problem in this area is thus not one of larger than optimal aggregate herd size. Rather it is suboptimal spatial distribution of stocking pressure. This is an important distinction for two reasons. First, it indicates caution should be exercised in interpreting the implications of the "new range ecology" approach. Aggregate stocking pressure below overall environmental carrying capacity is a necessary rather than sufficient condition for the prevention of environmental degradation. Second, policies based on the "tragedy of the commons" premise that reducing aggregate herd size prevents degradation in such a setting are of limited effectiveness, or even counterproductive,[16] because households with larger herds are more likely to use the extensive grazing areas that are currently underused. Policies that reduce herd sizes can actually increase use of degraded areas. In such a setting, attempts to discourage herd accumulation by modifying societal values, land tenure, or imposing household herd size limits are not effective in addressing rangeland degradation. A focus on such measures overlooks policy measures that encourage herders to move animals from overutilized areas to underutilized areas, which can effectively combat degradation and improve security in currently underutilized areas, or measures to modify the current town-based food aid distribution system.

[16]The distinction between larger than optimal aggregate herd size and suboptimal distribution of animals is also important to understand. While aggregate stocking rates below ecological carrying capacity are sufficient to prevent widespread degradation, they are not sufficient to prevent localized degradation.

Herd Size Change

A second consequence of larger than optimal herd size identified in the literature is that a larger aggregate livestock population negatively influences household-level herd growth and make livestock losses more likely. Sobania (1979) quotes a 1928 Kenyan provincial administration report for Marsabit District: "It is the old story of the vicious circle. The natives amass stock until the country will no longer carry it, a period of drought or disease occurs, heavy losses are incurred and the process of amassing stock again commences" (p. 179).

To explore this proposition fully, data are required on multiple boom-and-bust cycles.[17] Unfortunately, such data are extremely rare. To my knowledge, only Scoones (1993) and Lybbert *et al.* (2001) have analyzed data sets containing information on multiple bust periods. Scoones analyzes cattle population data for six areas in Zimbabwe. He divides his analysis into two forms; stress years and normal years. He finds that during stress years, there is no evidence that aggregate herd size is associated with larger decreases in herd size. However, in nonstress years, herd growth through births and herd loss through deaths are impacted by aggregate herd size. Larger aggregate herds lead to lower growth rates.

There is some ambiguity to this finding though, as the area and time-specific data he uses are unable to differentiate between the summing of a concave herd growth function at the household level and a negative externality in the household herd growth function. Lybbert *et al.* (2001) address this issue directly in their investigation of household-level mortality over a 20-year period in southern Ethiopia that contains two different boom-and-bust cycles. They report that the size of the herd belonging to other herders does not have a significant impact on the mortality experience of a given household, although births in the herd do exhibit decreasing marginal returns to total herd size.

This study adopts the methodology of Lybbert *et al.* (2001) to empirically investigate the relationship between the size of the herd belonging to other herders and herd size change at the household level. A measure of the herd size of other herders is constructed by summing the herd size of all other herders in a given herder's area (Chalbi or Dukana) for each point in time covered by the data set and dividing by the number of observations used in this calculation. In simple terms, it is the average herd size for the area without including the herd size of the household in question. This

[17]Data on multiple drought periods allow testing of the hypothesis that higher stocking rates predrought lead to lower postdrought herd sizes all else equal. This would be along the lines of the regression conducted above, but for aggregate herd size and including rainfall variables.

captures the essence of the negative externality posited for pastoral areas: the herd size of other herders exerts a negative influence on the production of the household herd, holding all other variables constant. This measure is included as a regressor in this section to explore whether herd size change is negatively influenced by the stocking levels of other pasture users, holding own herd size constant.

Herd growth is calculated by subtracting herd size at the start of period t from herd size at the start of period $t + 1$, and adding to the resulting figure sales, slaughters, and net transfers that occurred during period t. Data limitations do not allow us to estimate herd births separately from herd deaths. Estimation is conducted by differencing time period specific observations for household variables from their means over all time periods. Two measures of herd growth are used as dependent variables. The first is defined as the TLU change per period in the household herd. The second divides this measure of change by the herd size at the start of the period to define a rate of herd size change. Results are presented in Table V.

As a household herd's size increases, there is a significant and negative impact on expected herd growth. Importantly for the purposes of this study, the size other households' herds does not have a significant impact on herd growth, indicating the contention that herd accumulation at the household level imposes a negative externality on other herders using the same rangeland is not supported by the data. However, is should be noted that the information in the data set is largely reflective of the process of herd growth and loss over one boom-and-bust phase. An area of further research is to analyze data sets containing information on multiple bust phases to further our understanding of what impact, if any, aggregate herd size has on herd losses in multiple bust phases.

Milk Production

A different argument about the nature of the negative externality-imposed production in common property settings focuses on production externalities. Specifically, it is argued that an increase in the household herd imposes a cost in decreased productivity in other household herds. We investigate this possibility empirically by investigating the relationship between the size of the herd owned by other herders and milk production at the household level.

We again use first difference estimation to explore the issue of milk production externalities. We use as dependent variables the total milk produced per day from the household herd and this measure divided by the total TLU in the herd. We use the same variables in these estimations as

Table V. First Difference Estimation of Milk Production and Herd Size Change

	Milk from herd (L)	Milk (L/TLU)	Herd size change (TLU)	(Herd size (change per TLU)
Herd size (TLU)	0.1177*** (0.0193)	−0.0020*** (0.0006)	−0.0524 (0.0452)	−0.0044*** (0.0009)
Herd size^2 (TLU 10^{-3})	−0.1612* (0.0958)	0.0040** (0.0017)	0.0914 (0.1595)	0.0109*** (0.0026)
Fraction of herd in goats and sheep	0.0715 (0.6532)	−0.0133 (0.0334)	−7.9931*** (1.942)	−0.2848*** (0.0547)
Average herd size of others (TLU)	−0.3651 (0.4324)	−0.0122 (0.0175)	0.7486 (0.9720)	0.0292 (0.0255)
Household size in adult equivalents	−0.2710 (0.2237)	0.0096 (0.0109)	−1.1940*** (0.4620)	−0.0246 (0.0182)
Age of the oldest male	0.0073 (0.1782)	0.0055 (0.0066)	−0.5936 (0.3810)	−0.0188 (0.0114)
Age of the oldest male^2 ($\times 10^{-2}$)	0.1799 (0.1636)	0.0072 (0.0074)	0.5140 (0.3810)	0.0206** (0.0102)
Age of the oldest female	−0.4978** (0.2161)	−0.0248*** (0.0079)	0.3830 (0.4504)	−0.0013 (0.0124)
Age of the oldest female^2 ($\times 10^{-2}$)	0.4923** (0.2142)	0.0267*** (0.0080)	−0.5556 (0.4485)	−0.0004(0.0125)
Rainfall in 6 month period ($\times 10^{-1}$)	0.1649*** (0.0576)	0.0068** (0.0029)	0.1414 (0.0983)	0.0072** (0.0029)
Rainfall in 6 month period^2 ($\times 10^{-3}$)	−0.0890** (0.0389)	−0.0039** (0.0020)	0.0710 (0.0773)	0.0003 (0.0023)
Fraction of 6 month rainfall in current period	0.4369 (0.3015)	0.0105 (0.0146)	3.8789*** (0.7400)	0.0781*** (0.0193)
Long rains dummy	1.3268*** (0.3562)	0.0806*** (0.0172)	−3.7890*** (0.9197)	−0.0626** (0.0241)
Short rains dummy	0.7496*** (0.2650)	0.0524*** (0.0127)	−3.1090*** (0.6259)	−0.0655*** (0.0158)
$\chi^2_{(2)}$ own herd	81.9***	19.6***	9.7***	23.2***
$\chi^2_{(2)}$ male age	1.5	3.4	2.2	4.8*
$\chi^2_{(2)}$ female age	5.4*	15.0***	9.5***	0.9
$\chi^2_{(2)}$ 6 month rain	9.0**	6.1**	20.2***	25.4***
$\chi^2_{(5)}$ year dummies	24.8***	25.5***	54.6***	46.1***
$\chi^2_{(2)}$ time period	13.3***	7.6**	37.6***	33.3***
R^2	0.32	0.24	0.22	0.23
Number of observations	1579	1579	1579	1579

Note. Heteroskedastic consistent standard errors in parentheses.
*Indicates significant at the 10% level.
**Indicates significant at the 5% level.
***Indicates significant at the 1% level.

were defined for the herd size change regressions. Results are presented in Table V.

Again, we find it is important to distinguish between the influence of an increase in the household herd and an increase in other households' herds. Milk production from the total herd and milk production per animal are significantly influenced by changes in household herd size. However, neither measure of milk production is significantly influenced by the size of the herd belonging to other herders. For both milk production and herd growth, we find the data do not support the hypothesis of negative production externalities brought about by other resource users increasing their herd size.

Herders' Perceptions

Finally, a direct approach to the negative externality question was defined in this study by asking herders about their perceptions of stocking externalities. As described above, herders were asked to report their subjective evaluation of pasture availability, feed production, and stocking pressure for each rainy season–dry season pair for the area around town and the area away from town. Table VI presents results of a regression of overall pasture availability on feed production and stocking pressure variables (and unreported household-specific dummies) for both the area around town and the area away from town.

Results are consistent with the existence of a stocking externality in the area around town. When herders were asked to aid in interpreting the stocking externality results, they reported that they reflect the greater labor expenditure required to make sure the animals are satisfied when stocking pressure is greater. They said they did not feel stocking pressure led to a significant decline in herd growth rates or milk production. They did agree that stocking pressure around town had led to negative changes in vegetation in these areas. Results indicate that there is no significant stocking

Table VI. Pasture Availability as a Function of Feed Production and Stocking Pressure

	Pasture availability around town	Pasture availability away from town
Feed production	0.6184*** (0.0273)	0.5654*** (0.0309)
Stocking pressure	−0.1118*** (0.0298)	0.0476 (0.0320)
R^2	0.66	0.42
Number of observations	843	843

*Indicates significant at the 10% level
**Indicates significant at the 5% level.
***Indicates significant at the 1% level.

externality in rangelands away from town. This may be reflective of the findings reported above that areas away from town are currently underutilized.

CONCLUSIONS

This study investigated whether livestock accumulation at the household level in pastoral systems is rational at both the household level and at the collective level and found that it is rational at the household level. First, income is directly related to herd size—as herds increase, household income increases. Second, wealth held in the form of livestock offers a higher rate of return over time than does wealth held in formal savings even if periodic herd losses are included in the calculations. In addition, accumulation at the household level is preferred to restocking through deploying formal savings in local livestock markets, as evidence suggests female animals are infrequently available in markets in the study area and herders indicate these animals are of questionable quality when they are available. Finally, herd size post-crisis is an increasing function of herd size pre-crisis, suggesting herd accumulation serves a self-insurance function.

With regard to collective irrationality, we find that there is limited evidence of negative externalities imposed by other herders on the individual household. Aggregate herd size has not exceeded ecological carrying capacity in any year for which records exist. Rangeland degradation is occurring, but it is restricted to areas around towns. Degradation results from a suboptimal distribution of animals, not larger than optimal herd size. Regression analysis finds that household level herd growth and milk production are not significantly influenced by the size of other households' herds. Analysis of subjective rankings of pasture availability finds there is some evidence of a localized negative labor externality brought about by other herders' stocking decisions.

The finding that herd accumulation appears to be economically rational at the household level and not detrimental at the collective level provides some measure of optimism for future pastoral development efforts. As noted in the introduction, many observers have described herd accumulation as irrational and due to cultural values or land tenure arrangements. These views have influenced policy. Sobania (1979) notes that a colonial era ranching scheme designed in northern Kenya was described as a means "to induce the Samburu to regard their fat steers as their means of livelihood rather than a joy to behold" (p. 54). Sandford (1996) describes how the view of pastoral land use as irrational led to policies designed to regulate livestock numbers, divide pastoral rangelands into self-sufficient blocks, and create private ranches. He also notes that provision of veterinary services and water point development have been discouraged, under the assumption that such interventions allow livestock populations to grow to the point where they destroy the environment.

The empirical record of such efforts in pastoral areas of Africa has been extremely disappointing (Brandstrom, 1985; de Haan, 1994; Goldschmidt, 1981; Lane, 1996). Scoones (1995) describes this failure in stark terms: "Millions of dollars have been spent with few obvious returns and not a little damage. Most commentators agree that the experience has been a disaster ..." (p. 3). Sanford offers a similar assessment, describing most previous efforts as "expensive failures" (1996, p. 180). The results of this study suggest that this record of failure may be partially explained by the fact that the conceptual underpinnings of development efforts in pastoral areas have been flawed.

Herd accumulation results from the economic logic of pastoral production in a risky environment. Whether herd accumulation also results from cultural values and tenure arrangements is somewhat irrelevant in this case. Herd accumulation at the household level does not appear to impose externalities on other households through rangeland degradation that cannot be addressed through policies influencing the spatial distribution of animals. In addition, efforts to reform cultural values or tenure arrangements in the hope of eliminating boom-and-bust cycles and thus improving pastoral welfare run the risk of severely reducing household welfare without achieving this goal because the underlying causes of these cycles are misdiagnosed. As suggested by this and previous studies, the factors that lead to sudden herd loss may be unrelated to stocking pressure.

Development efforts that attempt to eliminate the bust phase by discouraging livestock accumulation or actively imposing herd limits should first establish that aggregate herd size influences household-level losses in crisis periods. If bust phases are related to herd size externalities, limiting herd accumulation makes sense. If not, such policies reduce household welfare of an already largely poor population, as illustrated by the results of the income estimation, without providing any compensating benefit. A similar argument holds for policies that assume production from the aggregate herd can be increased by decreasing aggregate herd size. It is conceptually possible, but the evidence in this study indicates that empirical support should be provided before policies are formulated on this assumption.

To the extent that collective externalities exist, this study finds they result from suboptimal distribution of animals and may be compensated for by increased labor effort. The findings of this study suggest a way forward in pastoral development is to strengthen existing pastoral production systems. In the short to medium-term, herd accumulation in such environments should be facilitated, not hindered. Efforts that support mobility should be designed to reduce externalities resulting from suboptimal spatial distribution of accumulated animals.

In the longer term, a combination of formal insurance, higher rates of return to formal savings, and the development of livestock markets that allow self-restocking could reduce the economic incentive to accumulate animals. In addition, development of alternative income generation strategies other than livestock raising could offer households currently involved in pastoral production a greater possibility of smoothing income streams over time. These longer term efforts should build on the pastoral production system and attempt to strengthen it rather than displace it.

It is hoped that these findings will challenge other researchers to identify empirically in what domains and under what conditions stocking externalities exist. Such research is critical. Policymakers should note that the findings of this study may not be applicable to other pastoral areas,[18] and may be viewed with some skepticism since they are based on recall data. I realize that it is as dangerous to base policy in pastoral areas on the assumption that externalities do not exist as it is to base them on the assumption that they do exist. However, I hope that these findings encourage researchers and policymakers to consider the irrationality of herd accumulation and the existence of negative externalities in pastoral production as hypotheses to be tested rather than certainties on which policy can be based. The empirical foundation that such research will provide to pastoral development programs will help ensure that the record of failure characterizing past efforts need not characterize the future.

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[18]Many of the findings of this study may be specific to the study area, as it is one of the most arid used for livestock production, and herders in this area are still among the most mobile in Africa.

The opinions expressed do not necessarily reflect the views of the US Agency for International Development.

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