Chapter 4

Ecological and Economic Consequences of Reduced Mobility in Pastoral Livestock Production Systems

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1. INTRODUCTION

Nomadic livestock production with domestic ruminants, dromedaries and donkeys used to be the dominant economic activity in the dry lowlands of the Old World Dry Belt, extending from Mauritania to North-West India. Common to these areas are the low and erratic rainfall, the high risk of recurring droughts, the high rate of actual and potential evapo-transpiration and the general scarcity of permanent surface water. These result in low and seasonal biomass production of both the herbaceous and the woody vegetation, which in turn cause large seasonal changes of forage availability and of forage quality. Despite significant differences in the political and economic conditions in the countries of that large eco-region it is largely the similar ecological potential which determines the status, development and performance of livestock production in the dry lowlands. Migratory pastoral production systems, which have evolved under these marginal natural conditions, share a number of unique characteristics that are aimed at minimizing production shortfalls caused by large variations in forage productivity. One of the most prominent risk minimising system attributes relates to the mobility of pastoral livestock herds and households, allowing full exploitation of forage resources that are unequally distributed in space and time (Coughenour et al., 1985; Ellis & Swift, 1988). Orientation towards subsistence production, reliance upon a combination of different animal species, considerable sharing of

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resources and products within small groups, and an emphasis on milk rather than meat production are additional features contributing to risk avoidance in pastoral economies (Swift, 1982; Western, 1982).

Although abiotic and biotic conditions have not changed much in the past decades traditional, subsistence oriented, migratory pastoralism has virtually disappeared as a land use system throughout the Old World Dry Belt. In Saudi Arabia it was transformed into high input and mechanized long distance grazing systems (Ahmad, 2001), in Tunisia the Southern rangelands are largely depopulated because many pastoralists have opted for livelihood opportunities in other sectors of the economy, Somalia has experienced spontaneous and often violent privatization of formerly communal rangelands for sedentary forms of livestock production (Schwartz, 1993). In many other countries subsistence orientation has given way to market integration with an accompanying shift to specialization, i.e., meat production with sheep and goats as in Algeria or milk production with camels in the vicinity to urban markets as in Mauritania and Syria.

In Kenya pastoral production systems have remained remarkably stable for a long time. However, fundamental demographic, economic, and political changes have disrupted the delicate balances between human populations, livestock numbers, and rangeland resources in these socio-natural systems. These changes originated partly in programmes of the colonial administration aimed at raising productivity in the pastoral sector, which, subsequently, were taken over almost without interruption by the Kenyan government after independence (Oxby, 1975; Bennett, 1988). Attempts at restructuring pastoral production systems to increase their economic self-sufficiency and contribution to the national economy have almost always failed. Instead, such attempts have affected traditional land-use practices, have led to permanent differential access to basic productive resources, and to a substantial increase in income disparities among pastoral households (Hogg, 1986; Mayer et al., 1986).

Another, more serious influence on pastoral production systems relates to the constantly increasing human population in the semi-arid rangeland areas of Kenya, and to the accompanying conflict over land resources. The rapid population growth in neighbouring agricultural communities has led to an expansion of cultivation onto semi-arid rangelands. In particular the small pockets of high potential pastoral land which formerly served as dry season grazing reserves, are increasingly being occupied by agriculturalists. These losses have been aggravated by the establishment of commercial ranches and national parks on pastoral land (Schwartz & Schwartz, 1985). The increased competition for resources among different land use systems was also paralleled by a steady growth of the pastoral population, although at a slower rate than in other groups in Kenya, which further decreased the per capita availability of land for grazing (Swift, 1982).

The combined forces of demographic pressure, steady loss of rangeland to other sectors, and development interventions in pastoral economies have contributed to a rapid decrease in the mobility of pastoral herds and settlements throughout Kenyan rangelands (Grandin, 1988; Fratkin, 1992; Schwartz et al., 1995; Roth, 1996). Sedentary pastoralism in the vicinity of small towns, trade centres, famine relief stations, and mechanized water sources has become a widespread practice, especially among impoverished pastoral households (O'Leary, 1990). The transition to settled life, for long a primary objective of development policies aimed at pastoralists in Kenya, is likely to cause substantial ecological and economical problems. Schwartz et al. (1995), for instance, note that concentration areas are marked by severe and spreading degradation of vegetation and soils. This, in turn, lowers herd productivity, increases herd sizes required to meet household needs, and thus further accelerates environmental degradation and the likelihood of destitution.

To illustrate these complex processes some results of a case study on Rendille pastoralism carried out over many years in Marsabit District of Kenya are presented.

2. A CASE STUDY REVISITED—THE RENDILLE PASTORAL PRODUCTION SYSTEM

The Rendille of Marsabit District in Northern Kenya, a small ethnic group, numbering not more than 25,000 individuals, occupy a home range of approximately 15,000 km^2 in the Western half of the District. They practice a form of opportunistic, horizontal nomadic pastoralism with dromedaries, goats, sheep, and cattle. The small size of the group and the limited and well-defined home range were seen as positive conditions to carry out a study of the factors determining land use and migration patterns in a long-term perspective.

2.1. Ecological Potential of the Rendille Home Range

Mean annual precipitation and the number of month per year without effective rainfall are the two most significant parameters determining the ecological potential. Others, such as potential evapo-transpiration, mean temperatures, the sum of sunshine hours per year, the annual and seasonal variation of rainfall and the risk of drought are closely correlated to the two key figures. With increasing aridity, i.e., with decreasing mean annual precipitation, seasonality becomes more pronounced as the periods without effective rainfall grow longer; the growing period for the vegetation becomes increasingly limited and the seasonal and annual variation of rainfall increases sharply. The reliability of rainfall events declines with a simultaneous increase of the risk of drought. If a drought is defined as the complete failure of one rainy season, it occurs two to three times in ten years. If it is defined as the complete failure of two consecutive rainy seasons it occurs two to three times in thirty years. Complete failure of three consecutive rainy seasons might occur once in thirty years, i.e., once during the economically active life span of a pastoralist.

Rainfall, all other factors being equal, determines plant growth. Table 1 gives some estimates of forage production of different vegetation components together with a value for the permissible off-take of the biomass produced. Permissible off-take has been defined as the proportion of the total biomass produced, which is useable as animal feed, if range deterioration or degradation is to be avoided (Schwartz, 1991).

Biomass production in the herblayer, which is the major source of forage for cattle, sheep and donkeys, ranges from close to 500 kg/ha to just over 3000 kg/ha at mean annual rainfall values of 100 to 500 mm. The shrub layer, which is the preferred forage source of

Table 1. Rainfall and Estimated Forage Production in Marsabit District [kg DM*/ha/year].

Rainfall [mm/year]	DM Production		Permissible off-take [%]	Growing period [days/year]
	Herblayer	Herblayer + shrubs		
100	450	600	25	35–65
200	1080	1600	30	55–85
300	1710	2600	40	70–120
400	2340	3600	50	125–175
500	3160	4600	50	150–220

* = Dry Matter.
Source: Schwartz, 1993, in Baumann, Janzen und Schwartz, 1993.

(a)

(b)

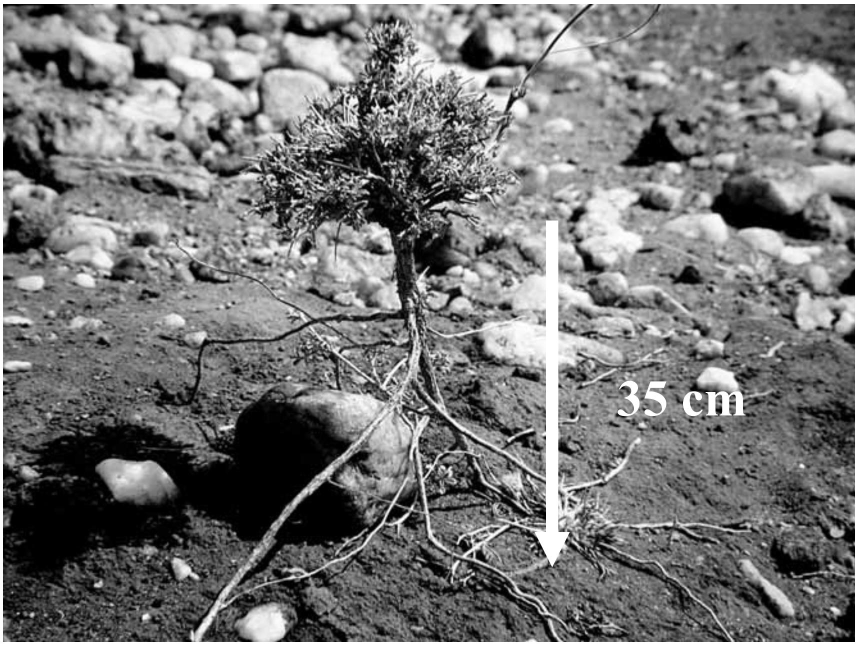

Figure 1. Dwarf Shrub *Indigofera spinosa*, Normal Growth and with Heavy Grazing. (a) Normal growth form of a small (60 cm) multi-stemmed dwarf shrub *Indigofera spinosa*, a common leguminous plant in the dry lowlands of Marsabit District. Because of the high protein content of leaves, fruits and young shoots it is a preferred browse species for goats and camels. (b) Growth form of the same species *Indigofera spinosa* after very frequent defoliation by livestock near a permanent watering place. The multi-stemmed shrub has transformed into a tight crown of short secondary and tertiary shoots which protect the remaining foliage from herbivores. Erosion, facilitated by reduced ground cover, has lowered soil surfaces by 35 cm since the shrub has germinated approximately 12 years prior to the date of the photograph.

goats and camels contributes another 30% of the amounts produced in the herblayer. Permissible off-take increases with increasing rainfall from 25 to 50% of the annually produced biomass. Actual off-take through overstocking, however, often exceeds these values by far, leading to impaired vitality of the range vegetation, to shifts in the number and composition of desirable and undesirable species, to long-term reduction of biomass production and ultimately to soil degradation and erosion (see Figures 1a and 1b).

2.2. Materials and Methods

Different types of data sources were used for the study. Historical information dating back as far as the turn of the century, the results of a two-year series of aerial surveys, the results of a large scale ecological survey and mapping exercise which produced a number of biophysical and ecological maps of the District and some satellite images of the area, notably LANDSAT and NOAA images.

2.2.1. Historical Information

A historical study of Rendille migration patterns was conducted by N. W. Sobania in 1980. Some of the raw data of this study, consisting of oral histories of the migration of seven clan oriented settlements (gobs) and using the Rendille traditional calendar and vernacular place names as references, were analysed to produce maps of annual and seasonal occupation densities during the time period between 1941 and 1978. The estimates were based on a map grid of 10 by 10 km.

2.2.2. Aerial Surveys

In an effort to determine short term land use and migration patterns in the Rendille home range 12 aerial surveys were carried out at approximately two-monthly intervals over two years in 1979 to1980. Site and size of settlements as well as numbers of households and numbers of domestic livestock present in the settlements were recorded. This involved total photographic cover of all settlements in the survey area from a low flying aircraft during the hour immediately after sunrise, when all stock was expected to be retained in the night enclosures. All counts were originally accumulated within a map grid of 5 by 5 km squares. For the purpose of this presentation a 10 by 10 km grid was used matching the one used in the historical survey.

2.2.3. Ecological Survey and Mapping Exercise

From 1988 to 1997 the Government of Kenya with the support of the German Agency for Technical Cooperation (GTZ) was conducting a large scale ecological survey and mapping exercise in ten arid and semi-arid districts in Northern Kenya. Each district was covered by 20 to 24 thematic maps on climate, soils, vegetation, hydrology, geomorphology, erosion status, range condition etc. Marsabit was the first district to be finished and all relevant information was available in 1991 (Schwartz, Shaabani, Walther, 1991). These maps were used to interpret spatial preferences recorded in the historical and the aerial survey in relation to permanent and seasonal physical and ecological features found in the district.

2.3. Results

2.3.1. Historical Land Use Patterns

Table 2 summarizes a few results of the analysis of the historical study. Although some of the oral histories could be followed back as far as 1904, it was only in 1941 when all seven settlement records could be matched. 1950 saw the construction of the first two deep boreholes in the area, 1963 independence from colonial rule brought a certain breakdown of internal security (tribal fighting) and 1971 saw the establishment of the first mission station in Rendille country.

The reduction of the home range utilization from 8100 km^2 to 3500 km^2 during this period is obvious, just as the reduction in the number of moves over significant distances, i.e. entrance into a grid square from outside. Clustering of settlement moves increased with time around mechanized boreholes and, during the last period, around two mission stations, which again were placed close to the boreholes.

2.3.2. Present Land Use Patterns (Established by Aerial Survey)

The grid net in Figures 2 and 3 delineates roughly the Southwest quarter of Marsabit District as shown in the map of the present home range of the Rendille (Figure 4). Figure 2 shows the cumulative occupation density by households calculated as household days per grid square for 24 months. It is evident that extreme clustering occurs in two locations, Kargi (grid reference 3/9) in the North and Korr (grid references 8/7 and 8/8) in the centre of the home range. In both locations are permanent settlements with trading centres, dispensaries, primary schools, and mission stations. Cumulative household and also total livestock densities are highest in the vicinity of the two centres. The inverse picture is shown in Figure 3, which represents livestock numbers per household. These are highest at the greatest distance from permanent water sources and human population centres. This indicative of the fact that wealthier pastoral households are more mobile and tend to graze their stock at some distance from highly frequented locations.

Table 3 summarizes some evidence that spatial preferences for settlement site selection change with the season. In survey 3 at the end of a rainy season, extreme dispersal of settlements can be noted, 35 grid squares are occupied. Site preference is given by range condition class [4] whereas in survey 7 at the end of a dry season extreme contraction of settlements has occurred, only 14 grid squares are occupied, and site preference is given to the availability of permanent water.

Table 2. Number of Grid Squares [10 ∗ 10 km] Occupied by Seven Clan Settlements and Number of Entrances by Settlements into Grid Squares in Four Distinct Periods Since 1941.

Time period	No grid squares occupied*	Total no of entrances	No of entrances within the present home range	
			Total/period	Mean annual total
1941–49	81 (+30)	589	499	55.4
1950–62	70 (+24)	564	506	38.9
1963–70	61 (+8)	324	318	39.7
1971–78	35 (+1)	248	237	29.6

* Figures in brackets indicate number of movements outside the present home range.

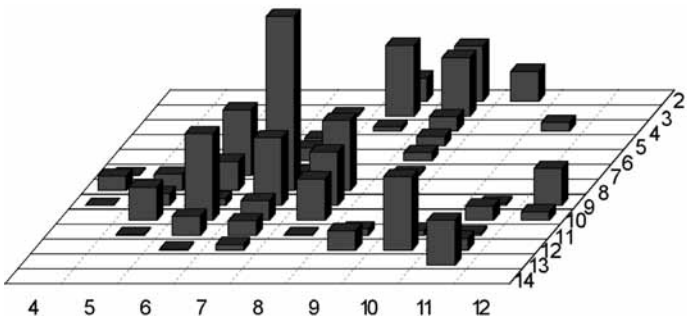

Figure 2. Cumulative occupation density of Rendille home range.

Cumulative occupation density [household days/grid square/24 months] observed in 12 aerial surveys of the Rendille home range. Counted household numbers were multiplied with calculated length a stay in days within one grid square (10 × 10 km).

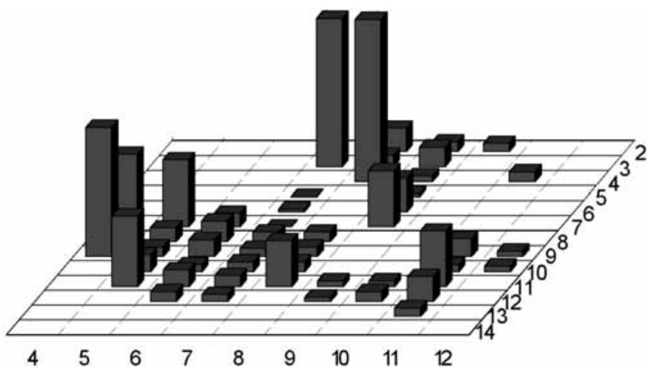

Figure 3. Mean number of livestock [TLU] per household within grid square observed in 12 aerial surveys of the Rendille home range (10 × 10 km). (TLU = Tropical Livestock Unit = 250 kg live weight; 1 camel = 0.7 TLU, 10 sheep or goats = 1 TLU).

Table 3. Occupied Area [Number of Grids], Range Condition Score and Water Availability Score for Nomadic Settlements at Two Different Seasons.

	Survey 3			Survey 7		
	End of rains			End of dry season		
Grid occupancy score	Grid squares occupied	Range condition score	Water availability score	Grid squares occupied	Range condition score	Water availability score
1	10	.76	0	1	.8	1
2	3	.77	.45	—	—	—
3	10	.76	.45	5	.78	.8
4	1	.66	.57	1	1	.75
5	5	.66	.75	2	.55	.87
6	1	.58	1	1	.33	1
7	5	.58	1	4	.28	1
8	1	.36	1	1	.28	1
	total 36	mean .67	mean .44	total 15	mean .58	mean .83

A principal components analysis was carried out using 11 key variables related to site preference such as survey results and data from the mapping exercise. Only about 40 percent of the variance in site preference could be accorded to the variables median rainfall, range condition, vegetation cover index and availability of permanent water. There is strong evidence that non-ecological factors play a major role. In survey 11 a moderate contraction of settlements accompanied by highest livestock numbers per household were recorded in the middle of a dry season. The reason for this and the resulting site selection was a major ritual occasion, the male circumcision, which takes place only once in 14 years. An aseasonal contraction of settlements and livestock was noticeable in survey 8, following an outbreak of banditry in the Western half of the Rendille home range, presumably instigated by Somali tribesmen (*shifta*).

2.3.3. Ecological Significance of the Recorded Land Use Patterns

Figure 4a shows the location of permanent water sources in the south-western quarter of Marsabit District (Bake, 1991). The 10×10 km grid covers the present home range of the Rendille, approximately 15,000 km^2. In Figure 4b, an overlay with the standardized cumulative occupation density by pastoral households illustrates that one of the most important factors for settlement site selection for the majority of pastoral households is availability of permanent water in a short distance (Schwartz et al., 1995).

Total livestock occupation (TLU days) follows the same distribution pattern. In contrast to this livestock numbers per pastoral household show an inverse distribution pattern. Highest numbers of livestock per household are found at larger distances from water (Maps 2 & 3).

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Figure 5a shows the livestock to household ratio against the background of a NOAA satellite image, whereas in Figure 5b the background is a map of range condition (Herlocker, 1991). It is obvious that preferred settlement sites for wealthy households are characterized by availability of green vegetation at the beginning of the dry season and by fair to good range condition.

The opposite is the case with animal-poor households. One of the major factors is the availability or the lack of pack animals for household water transport (Schwartz, 1986). Range condition and green biomass availability are clearly a function of distance to permanent water and/or to high human occupation densities. In grid 8/8 (Korr) the highest cumulative occupation density was observed with 224,600 household days in 24 months within one grid square of 100 km^2. Considering the firewood consumption at 2.5 kg/household/day this alone amounts to an annual off-take of woody biomass of approximately 280 metric tons, not accounting for the off-take for building materials and fences and the amount eaten by browsing livestock. Degradation of vegetation and eventually soils is inevitable at such land use intensity. In consequence one also has to realize that poor households, due to their lower mobility will, usually graze their stock on poorer and further deteriorating pastures (Figures 6a and b). On the other hand rather large areas of the available range at greater distance from permanent will remain under-utilized and in good condition.

2.4. Conclusions from the Case Study

There is a long term trend to increased sedentarization, characterized by reduced number of significant movements of settlements, a contraction of the home range as a whole and particularly during the dry season. The long term trend is masked by seasonal expansion, or rather a strong seasonal fluctuation of home range size. Seasonal trends, however, are again masked by other factors, such as ritual events, security breakdowns or others.

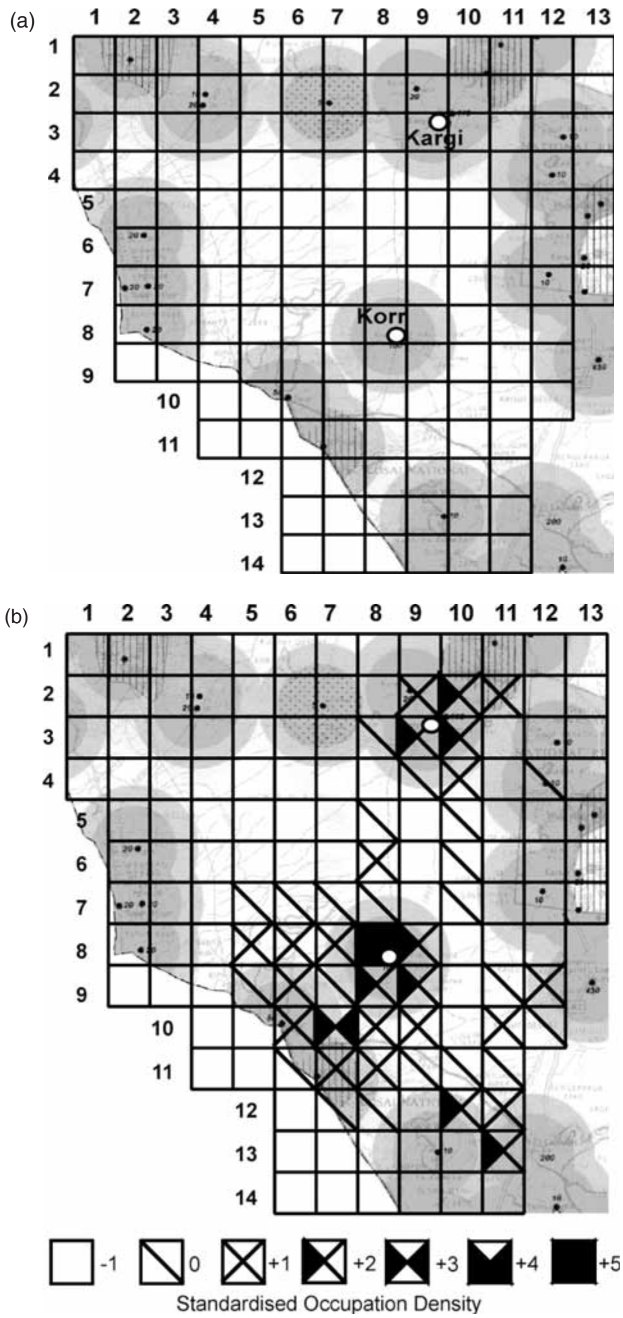

Figure 4. (a) Location of permanent water sources in the Rendille home range. The circles indicate 10 and 15 km distance to the permanent water, the small figures give the estimated water yields in m^3/day. In the vicinity of the two settlements Korr (8/8) and Kargi (9/3) are deep mechanised boreholes which yield 100 and 110 m^2/day respectively. All other water sources within the grid are traditional shallow wells with yields between 10 and 20 m^2/day. (b) Overlay of the standardised occupation density on permanent water distribution. (Standardised occupation density is calculated as mean number of recorded household days per grid square plus or minus standard deviation units. 0 reflects the mean density, −1 densities below the mean, +5 signify the highest observed densities.) Highest occupation density is restricted to the 10 km radius around the high yielding boreholes at Korr and Kargi. The highest density was recorded at Korr (grid reference 8/8) with 224,600 household days within the 24 months of the aerial survey.

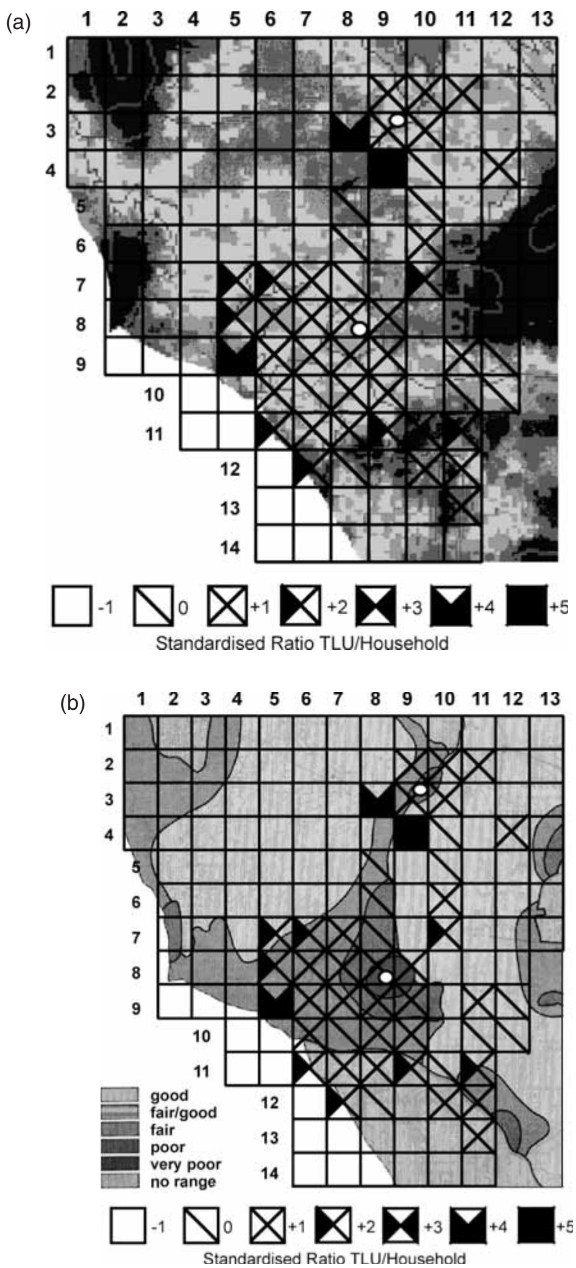

Figure 5. (a) Distribution of livestock in relation to availability of standing green biomass at the beginning of the dry season. Green biomass is shown in shades of green in a modified NOAA satellite image. The standardised ratio TLU/ household has been calculated as mean number of TLU/house-hold within grid square plus or minus standard deviation units. 0 reflects the mean ratio, −1 densities below the mean, +5 signifies the highest observed ratio. Highest numbers of livestock (TLU) per household have been found in areas where green biomass was available at the beginning of the dry season. (b) Distribution of livestock in relation to recorded range condition. (The standardised ratio TLU/household has been calculated as mean number of TLU/house-hold within grid square plus or minus standard deviation units. 0 reflects the mean ratio, −1 densities below the mean, +5 signifies the highest observed ratio.) Highest numbers of livestock (TLU) per household have been found in areas with fair to good range condition. Condition was poor to very poor in the vicinity of boreholes and settlement centres.

(a)

(b)

Figure 6. Rendille settlements, with livestock and impoverished. (a) Aerial photograph of a wealthy Rendille Gob (village) settling at grid reference 7/5 approximately 28 km from the nearest permanent water source. There are 32 huts built in a circle around the animal enclosures. The small white dots are sheep and goats; the larger dark ones are camels. The 32 households have available to them at the time an average of 17 TLU/household. (b) Aerial view of an impoverished Rendille Gob (village) settling at grid reference 10/2 at approximately 1.5 km from a deep borehole and approximately 2 km from Kargi trading centre. The 28 households have available to them at the time 35 camels, which translates into 1.8 TLU/household.

Reduced mobility of households is probably compensated for, at least partially, by retaining or increasing the mobility of the herds. The strong fluctuation of livestock numbers per household between surveys can be taken as evidence supporting this statement.

Contraction of nomadic settlements around permanent water sources which have developed into centres of social attraction such as Korr and Kargi are indicative for the fact that subsistence production is giving way to market oriented production supported by wage labour (money returns from migrant workers). Fratkin (1989) found strong evidence for this in Korr.

The long term effect which can be expected is an accelerating depopulation of marginal areas and population concentration around a few commercial centres. This will certainly cause severe environmental degradation, however, only on a very limited scale within the region as documented in the recent range condition map.

3. CONSTRAINTS TO LIVESTOCK PRODUCTIVITY AND TRADITIONAL ADAPTIVE STRATEGIES

Constraints to livestock productivity in the traditional pastoral production systems can be divided into three different categories: normal constraints, disasters, and long term, irreversible changes such as increasing population pressure and constant loss of pastoral lands. The first two have always been part of the systems and adaptive strategies have developed to compensate for their effects. The third group is of more recent origin and largely beyond the control of the pastoralists.

Normal constraints are seasonal, annual, and spatial variation of rainfall and, accordingly, seasonal, annual, and spatial variability of quantity and quality of the available forage. Other normal constraints are endemic diseases, helminth burdens, external parasites and losses through predators and stock theft. Normal constraints can reach disastrous proportions from time to time. Rainfall variability can turn into drought, endemic diseases into epidemics and stock theft into tribal or civil war, which in turn can result in catastrophic stock losses for individual stockowners or even whole groups of pastoralists.

As an insurance against such events pastoralists strive to increase stock numbers, in order to provide security in case of losses, to leave a remainder of feasible size, to rebuild their herds. Thus, the expansion of herd sizes in "normal" times, not stricken by drought, disease or unrest, is a rational strategy and not a projection of prestige, social status, and wealth. Although it is true, that parallel to increased numbers of animals, an increased social standing for the owner will develop, this has to be seen as a favourable by-product of an effort to safeguard future survival.

Traditionally, risk-reducing adaptive strategies are herd diversification and herd dispersion. Herd diversification is practiced as an insurance against major disease outbreaks since the different domestic species are generally not susceptible to the same pathogens. Beside this, the different dietary preferences of the various domestic species also allow for a better utilization of pastures that may not be suited for one or the other domestic herbivore species. Herd dispersion is a second risk-reducing strategy, which is frequently practiced in traditional systems. Stockowners separate their herds and have them herded in areas sometimes up to several hundred kilometres apart; this is primarily a measure against forage shortages and raiding. If the family is large enough, the different herding units are managed by its members, and family reunions and rearrangements of the different stock sections take place either during the rainy season or during certain ritual occasions.

A related form of dispersion, although of a different significance is the formation of stock alliances and stock patronages that is independent of family size and social status. Individual animals or small groups of animals are given out to other stock owners who are either needy or in some way entitled to compensatory claims. Often the animals are never recovered by the original owner, but in times of hardship the son or even grandson might reclaim some or even all of the loaned stock from the recipient's heirs. This risk reducing strategy is common among all pastoralists whose social organization is based on clan and age-set structures and should be regarded as a system of mutual social security rather than an actual management tool.

The most conspicuous adaptive strategy of migratory pastoral production systems was, and still is, the mobility of households and herds. The migrations which are dictated by the availability of forage and water can follow various patterns but are always characterized by the combination of individual stock ownership and communal land use. This combination does not usually promote sustained-yield resource exploitation whenever land becomes scarce, and in particular when dry-season grazing reserves are no longer accessible. If confined to rainy season pastures throughout the year, the mobility of pastoral households and herds will be reduced to only minor moves, for hygienic or ritual reasons, since energy expenditure for a major move is not compensated for by a significant improvement of pastures.

4. RECENT IRREVERSIBLE CHANGES IN PASTORAL LIVESTOCK PRODUCTION AND MODERN ADAPTIVE STRATEGIES

Traditional pastoral production systems have remained stable for a long time, particularly through flexible responses to short-term variations of the climatic conditions. Today, however, numerous demographic and economic changes of long-term nature occur which trigger adaptive changes likely to transform this system significantly. The most salient feature is an emerging precedence of market oriented production over the traditional subsistence production. The major changes in the system are as follows:

- *Increased population pressure*: Pastoral populations are increasing steadily in the whole region. These increases at slower rates than in agricultural and urban groups, but may reach as much as 2% per year, which is no longer compatible with the human support capacity of the land.
- *Losses of pastoral lands*: A constant loss of pastoral land has to be noted. Competing land use systems such as commercial ranches, rainfed and irrigated agriculture and National Parks and Reserves occupy increasingly the small pockets of high potential land within the pastoral areas.
- *Reduced mobility*: Increases of the pastoral population and simultaneous losses of communal pastures are leading to a reduced mobility. Deterioration of the internal and external security aggravates this.
- *Environmental degradation*: The major effect of these developments is a general, but locally often severe environmental degradation, particularly around permanent settlements, mechanized water sources, mission stations etc. Although it can be generally stated that semi-arid to arid pastures show a remarkable recuperative potential in times of good rainfall, it cannot be denied that irreversible destruction of range vegetation has occurred and is spreading.

The change from a long ranging and highly mobile herding system to a short-range and semi-sedentary one bears the potential for both negative and positive effects. Amongst the most obvious negative effects are:

- the increase of environmental degradation,
- increased production risks for the individual herd owner as well as for the industry as a whole due to the disappearance of traditional adaptive management strategies,
- and the accelerated breakdown of social structures which previously served as a form of social security system within herding communities.

The emerging trends toward short-range herding systems have definitely deleterious effects on range vegetation and soils. Severest impacts are found around permanent wells and boreholes and in the immediate vicinity of permanent settlements. They are, however, limited spatially to a small section of the total range. Range enclosures and privatization on the other hand may lead to more widely spread damage. Grazing pressure on the residual open range is becoming exhaustive, migrations have to be rerouted, some migration routes may be closed permanently, thus increasing pressure on others, and, since areas with higher potential are usually enclosed first, the residual open range areas possess lower support capacities and are prone to faster degradation.

Enclosed range areas, although generally of slightly higher potential than the open range, are not immune against diminishing range condition, since stocking densities are rarely matched to the support capacity of the range but rather to the needs and demands of the stock owners, which often results in overstocking. Additionally, erratic spatial rainfall distribution during certain seasons or years may reduce forage growth in some enclosed areas and lead to temporary but severe overstocking and irreversible degradation. This may be aggravated if the breakdown of traditional resource-sharing attitudes in the pastoral system prevents emigration of herds from private lands.

Dry land farming, which is expanding within the agro-pastoral context, has adverse effects on range condition and soils. Land clearance and the sparse and temporary ground cover provided by annual crops favour increased erosion and often lead to irreversible degradation of range areas (desertification).

The consequence of all these effects, beside the inevitable range degradation, is a slow decline of herd productivity, reduced size of individual livestock holdings and productive land, and an increasing drought susceptibility of the whole system.

4.1. Economic Consequences of Sedentarization

The sedentarization of pastoral households is intrinsically related to the incorporation of pastoral economies into regional and national markets. Whether the observed emergence of market oriented production over traditional subsistence production is an additional cause or merely a consequence of sedentarization remains ambiguous; both processes are generally so intertwined that it is difficult to distinguish cause and effect (Sikina et al., 1993). Nevertheless, both processes entail a gradual change in pastoral herd management and species composition, and, ultimately, a redefinition of production goals. Many studies in pastoral systems have documented changes in species composition in pastoral livestock herds arising from population increase, reduced mobility, and commercialization of production. Wealthy Bedouins in Saudi Arabia have turned from camel-rearing to sheep-raising (Abdalla et al., 2001). Likewise wealthy Rendille pastoralists have exchanged camels for cattle because of their higher retail value on local markets (Hary, 2000), and wealthy Boran herders in Southern Ethiopia have switched from cattle to camels to produce milk for sale in urban markets like Moyale or Guba (Younan, 2002).

Poor pastoral households, in contrast, concentrate on sheep and goats. The rapid rate of reproduction of small stock makes them a major means of post-drought recovery. Moreover, accumulation of small stock is a sensible strategy for poor households since they are easily converted to cash for household needs, and can be utilized as a means of acquiring large stock. Data presented by McCabe (1987) for the Ngisonyoka Turkana suggest a shift from a pastoral subsistence based on cattle to one based on small stock in a situation where livestock holdings per capita are decreasing. In contrast to sheep and goats, cattle have the disadvantage of being large indivisible units, such that substantial amount of the herder's wealth is stored in only a few animals. Poor households are therefore less vulnerable to livestock losses when concentrating on small stock, since here, the capital accumulated in each animal is minimal.

Patterns of small stock and cattle or camel utilization vary according to the scale of the operation unit. Poor pastoral producers achieve a greater efficiency of utilization of their small stock in terms of milk, meat and especially live animal sales than wealthy producers. Due to their low livestock to human ratio and pressing consumption needs, poor households have to engage in market exchange in order to convert their livestock products to foodstuffs with higher energetic value (Grandin, 1988; Sikina et al., 1993). With respect to cattle, poor herd owners tend to rely on an intensive extraction of milk from their herds, whereas richer herders deliberately forego some of the potential milk output in favour of calves and derive higher levels of income from live animal trade. In general, poor producers attempt to offset diseconomies of scale by intensive methods of extracting value from animals (Behnke, 1984).

The case of the Maasai group ranches suggests that the growth in small stock holdings may also be linked to a change in rangeland vegetation induced by an increase in land use pressure (Njoka, 1979). Goats in particular have a wider dietary range and lower water requirements than cattle, and are better adapted to cope with drought and poor grazing conditions such as often occurs in the vicinity of permanent settlements. Thus, the increase of small stock holdings especially among stock-poor households could also be interpreted as an adaptation to a degrading habitat. In general, it can be expected that those households that diversify their herds by keeping a significant proportion of sheep and goats may likely adapt more readily and securely to a sedentary lifestyle (Hary, 2000).

5. CONSEQUENCES FOR THE FUTURE OF PASTORAL ECONOMIES

From the foregoing, a number of consequences for the future of pastoral economies in Kenya can be anticipated. First, the rapid integration of pastoral economies in regional and national markets will continue to impact on management strategies and production goals of pastoral producers. The process of commercialization is, however, not neutral to scale, and will therefore affect large and small subsistence operations differently. Large herd owners can more readily accommodate the shift from in-kind milk and meat production to market oriented meat production, since the reduction in overall biological productivity implied by this shift is potentially more than offset by the higher economic profitability achieved through live animal sales (Behnke, 1984). Small operation units, in contrast, can not afford to abandon traditional subsistence forms of animal use. The potential off-take rate of live animals for sale from their herds is too low to meet the household expenses required to substitute the majority of subsistence products for non-pastoral foodstuffs. Small herd owners will therefore have to retain a predominant subsistence oriented mode of production in order to increase herd sizes for an eventual shift towards commercial production. On the other hand, the process of commercialization has been observed to entail a reduction in the number of surplus livestock from wealthier households available for redistribution through animal loans, gifts and other transfers, thus depriving small herd owners of an important source of livestock to build up their herds. In addition, those producers who successfully make the shift to commercial production will attempt to reinforce their economic superiority by acquiring private use rights to land, a widely spread phenomenon in North and East Africa (Bounejmate et al., 2001). Together, these developments will further undermine the viability of small production units and increase income disparities in pastoral societies (Bennett, 1988).

A second concern relates to the tendency of livestock herds to grow in commercialising pastoral economies, a trend which will aggravate the pressure on natural resources already exerted by the growing and sedentarizing pastoral population. This is because the decline in biological productivity per animal unit in commercial operations may force herd owners to increase their herd sizes in order to maintain overall household income levels. On the other hand, herd owners can also benefit from economies of scale by increasing their herds, since larger herds tend to have lower per unit operating costs. Whereas under the traditional, labour intensive subsistence mode of production, herd growth is restricted by labour availability, this limitation is relaxed in a commercialising operation, thus encouraging producers to increase their operations.

Lastly, the economic polarization of pastoral societies will promote the exclusion of poor, subsistence oriented households from the pastoral sector. Households falling below the minimum livestock per capita ratio required to insure self-sufficiency have a limited set of alternative strategies to choose from in order to complement household incomes. They may either realize additional income from herding for other, wealthier households, seek for wage labour in non-pastoral activities, or abandon the pastoral economy altogether and migrate to small towns or large cities in search for employment (Fratkin & Roth, 1990). Yet, the capacity of pastoralism to absorb surplus labour from households which lack sufficient stock to support themselves independently is very limited. In most African countries, employment opportunities outside the pastoral sector are few and pastoralists are at a comparative disadvantage in competing against the often better educated agriculturalists. Under these conditions, the likelihood of an increase in the number of displaced and destitute pastoralists is high.

In light of the complexity of the problems with which pastoral economies are confronted today, it would seem difficult to isolate a single development strategy that is capable of simultaneously alleviating the above mentioned social, economic, and environmental concerns. The present demographic and macroeconomic conditions in the African drylands prevent the relocation of large parts of the pastoral population to other sectors of the national economy. However, the exclusion of marginal operation units from the pastoral economy is largely unavoidable in the ongoing process of commercialization.

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