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OVERGRAZING AND RANGE DEGRADATION IN AFRICA: IS THERE NEED AND SCOPE FOR GOVERNMENT CONTROL OF LIVESTOCK NUMBERS?

by

Lovell S. Jarvis

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Introduction

Livestock production has been an integral part of farming systems for hundreds of years in many regions of Africa, but there is little evidence on the herd size or range conditions in the pre-colonial period. The great rinderpest epidemic, 1889 to 1896, severely reduced the cattle population and the human population dependent on it. Some estimate that herds fell to 10% or less of their previous level (Sinclair, 1979). This caused the emergence of forest and brush and the invasion of tsetse in some regions, which further harmed the remaining pastoralists.

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Since that epidemic the livestock and human populations in most of Africa have grown substantially. By the 1920's, some European observers suggested that systematic overgrazing and range degradation might be occurring as a result of common range, and argued that an alternate land tenure system or external stocking controls were essential to avoid a serious reduction in production. These assertions - whether motivated by concern for herder welfare or eagerness to take over pastoralist land -- have been made repeatedly in subsequent years.

Considerable grazing land has been removed from the traditional range system during this century, to provide European colonists with land, to establish parastatal commercial ranches, to create individual or group ranches controlled by Africans, or to permit expanded agricultural production. Most of such land is located in the most productive regions.

Considerable areas remain under traditional grazing, nonetheless, and concern for their use has been heightened during the last decade as a result of the severe droughts which struck much of this area from 1968 to 1974 and again in 1978. Animal losses, range degradation, and famine occurred in each case. Another drought is now in progress. Some fear that range degradation will lead ultimately to desertification. Pressure has been renewed for measures to reduce grazing pressures before it is too late. However, herders strongly resist stocking controls in most areas and, when controls have been applied in pastoralist areas, they appear to have been largely unsuccessful and/or have reduced rather than increased pastoralist welfare

(Sandford, 1983).

Group ranches offer promise, but have encountered problems in many areas and it remains unclear whether they will resolve both efficiency and equity concerns (Halderman, 1972, Oxby, 1982). Parastatal ranches -- involving direct government control of rangelands -- have been largely failures (Sandford, 1981). Private commercial ranches have a mixed record, e.g., Devitt (1982), but these offer offer no solution for pastoralists as a group.

Moreover, overstocking may not be the principal cause of range degradation -- when the latter occurs, and range quality in most areas may not have deteriorated significantly over the longer run (Penning de Vries, 1983; Greenwood, 1980). Finally, traditional systems exploit the available resources in ways which, at least in many dimensions, are remarkably efficient (Halderman, 1972; Sandford, 1983; McDowell, 1983; Behnke, 1983a; de Ridder and Wagenaar, 1984a and 1984b). Each of these factors suggests that government intervention may not be essential or, at least, should be undertaken only cautiously.

Nonetheless, population and the labor force is growing rapidly in nearly all African countries. The demand for agricultural and livestock products is rising. Land is scarce. Employment growth in the manufacturing and the service sectors is slow in most countries. Whatever the current situation, therefore, the pastoral sector is likely to come under increasing pressure in the future. Change will occur, to the benefit of some and the detriment of others. It is important to understand the functioning of traditional systems, the alternatives to them, and the external variables which will affect livestock development so that policy can promote change of the most desirable sort.

The data available on overgrazing, range degradation, and the effect of herd controls are limited. The relationships involved are complex. And opinion remains diverse. I initially sought to establish some conceptual framework which would help in sorting out the primary issues and in interpreting the evidence available. That task ended up absorbing nearly all my effort.

The primary issues are the following. Is livestock pressure on African ranges too great? If so, what is the nature and the magnitude of the costs associated with overstocking? Are there any acceptable means -- either economic or political-- by which these costs can be reduced? Should the number of animals be reduced or growth at least limited in the future, or are there other preferred means for reducing grazing pressure -- such as expanding the number of watering points or improving range vegetation? If grazing is to be controlled, how can this best be done? And how will specific economic policies affect overgrazing.

I began with an agnostic view regarding one of the most controversial issues -- whether governments ought to intervene to control livestock numbers. It seemed that common ranges could easily lead to overgrazing even though they usually contain some controls on access, but that well-intentioned government intervention might worsen the overall situation. That is still my view, although I am also convinced that more individualized tenure is needed in many of the traditional range systems.

Communal Ranges, Overgrazing, and Range Degradation.

It will be useful to clarify several concepts. The first concerns land tenure and property rights in grazing. I follow the distinction drawn by Ciriacy Wantrup and Bishop (1975) between "open access" pastures, where there are no property rights so that anyone has right of use; "common property" pastures, where a set of specified owners hold joint -- but not necessarily coequal -- rights of use; and "private property" pastures, where only one individual has rights of use. Sandford (1984) has pointed out that in African traditional range systems the distinction has usually been one of degree along the continuum from open access to various forms of common property.

In general, so long as resources are abundant, open access prevails and is efficient. As demand increases, competition results in the evolution of differentiated property rights, both restricting the type of use to some persons and guaranteeing types of use by others (Demsetz,1967). Ultimately, property rights may be conferred on an individual. A movement toward greater specificity of property rights will be referred to in this paper as more "individualized" tenure (McCown, Haaland, and de Haan (1982) use the term "individuated" in a similar sense.)

Open access range, by definition, indicates a lack of control over pasture use. There is much theoretical and empirical evidence to show than an absence of control over a scarce resource will result in its overutilization, implying economic loss. This is precisely why pressure for individualized tenure emerges as resource demand increases. Although the social institutions regulating land use can be expected to gradually adapt to such pressures, the institutions existing at any moment may be inadequate to avoid some overutilization. Institutional development will usually lag behind the growth in demand for resource use, largely because the institutional development required to avoid overutilization generally involves social conflict. Some potential users almost inevitably lose while others gain in the movement toward individualized tenure.

African traditional range systems evolved within a framework of common access to land. This framework appears to have been well suited to the ecological and sociological conditions faced, particularly in the very arid to semi arid regions where rainfall is low, seasonal, and highly unstable. Small ranches -- such as might result if land were subdivided into individual parcels for all herders -- are ecologically unviable in these areas. Many such parcels will not have forage or water throughout the year, or from year to year, sufficient to sustain a herder's family and cattle -- even though other relatively accessible areas will have ample supplies of the same. Thus, migration in search of forage and water, whether seasonal or continual, is a means by which man can extract greater output from the available resources. Small herds managed by individuals also require little capital other than animals, permit extraction of milk as well as meat, and provided gainful employment for all, often within a relatively egalitarian society.

Within a common range system, access to land and, especially, water, was maintained by military or political strength and reserved on most occasions for members of the same ethnic or kinship group; exceptions were sometimes made during severe drought in expectation of reciprocal future assistance. As individual tribal groups expanded in number, they sought new territory and frequently clashed with other pastoralists or agriculturalists.

In regions having relatively greater and more reliable rainfall, the existence of common range probably depended more on low population density than on ecological conditions (Behnke, 1983b). In these areas, population density has been rising rapidly and agricultural activity is now more intense. The pressures for more individualized land tenure are greater because the economic gains from controlling land access are much larger. Some land is now usually reserved for cropping while other land is still used as common range.

The second concept to be defined is overgrazing. This term is frequently used in studies of pastoralism, but is rarely defined precisely. Agreement on its meaning is important to permit a useful discussion of issues. The definition used here is economic. Overgrazing implies that the stocking rate on a given pasture is too high, i.e., economic resources are used inoptimally and the value of society's output is less than it could be. In theory, everyone could be made better off if overgrazing were eliminated because total output would rise and those who lost in the process could be compensated by those who gained.

A third concept is range degradation. Range degradation, or range enhancement, may occur whether or not overgrazing is occurring. This is a source of continual confusion. Range degradation, as defined, simply means a decline in primary productive capacity, caused by any factor. Grazing pressure is only one factor causing changes in range conditions; other factors include climate, fire and other sorts of human activity. However, the potential for damage to range conditions from overgrazing is higher when vegetation is stressed and the stocking rate is not significantly reduced. This is a primary reason for linking overgrazing and range degradation.

Including range degradation in the definition of overgrazing means that overgrazing occurs whenever the present value of all future livestock production (choice of the proper discount rate is not considered here) is below its potential as a result of an excessively high current stocking rate. Overgrazing can result in decreased primary (forage) production or in decreased secondary production -- given the available primary production (undergrazing occurs if the stocking rate is too low).

An Economist's Theoretical Approach to Overgrazing.

The following analysis is similar to and borrows heavily from that of Shapiro and Ariza-Nino (World Bank, 1983). Jarvis (1980), Hopcraft (1981), and Stryker (1984) provide similar, but less detailed analyses.

A simple framework will establish additional concepts. The effects of elaborating on this framework can then be shown. Assume that a fixed area of land produces the same amount of forage each year. How many animals should be grazed on this land? The problem and its solution are illustrated in figures 1, 2 and 3.

The relationship between animal productivity and the stocking rate is shown in figure 1. To further simplify the problem, it is assumed that all animals are identical and produce only beef. This is unrealistic; animals of different age and sex have different forage requirements and it is well known that the primary output of pastoralism is milk. However, this assumption focuses attention on forage utilization and it can be altered without changing the nature of the results, e.g., milk production responds to improved nutrition in a qualitatively similar fashion as does beef.

The forage available to each animal and the associated weight gain are dependent on the number of animals grazed. At first, each animal will have as much feed as it can eat and will grow at the maximum rate. As more animals are added, they will begin to compete for feed and their consumption will decline, reducing their weight gain. At the limit -- n' -- each animal will have only enough feed to satisfy its maintenance needs and will gain no weight. The herd is maximized in terms of size, but as a whole also gains no weight (Mott, 1960; Hart, 1980 and Malachek, 1981, cited in Shapiro and Ariza-Nino; Connolly, 1976). (Conceptually, this situation is analogous to a herd of wild game whose biomass is essentially constant over time.

Total beef produced per unit of land equals the beef produced by each animal multiplied by the number of animals grazed. This relationship is shown in figure 2, where the weight gain per land unit as a function of the stocking rate is imposed on the curve already shown in figure 1.

The relationships indicated are insufficient to determine the economic optimum stocking rate, because this require consideration of costs and benefits. In figure 3 the value of output and the cost of producing it are each shown as a function of the number of cattle grazed on the land available. To obtain the value of output, physical output is multiplied by the price of beef. (Multiplying by price will not change the shape of the output curve. If the price is arbitrarily set equal to 1 -- for example, $1 per lb. -- economic value and total weight will be represented by the same curve.)

Production costs are measured by what the non-land inputs would be paid if utilized elsewhere in the economy. Land cannot be moved and receives only a rent, defined as the value of all benefits resulting from use of this land to produce livestock after a competitive return to capital, labor, and other inputs has been deducted. Animals are capital; they can be sold and the money received can be invested elsewhere at a rate of return (say r, the interest rate). If pastoralists do not receive a return at least equal to r on their livestock capital, they will tend to sell animals and shift funds to other investments. Animals must also be herded and watered, requiring labor. Labor must earn a return at least equal to that offered in other economic activities or some pastoralists will shift into other activities.

This analysis assumes that pastoralists are aware of and sensitive to opportunities existing in other sectors of the economy, and/or that agriculturists and others will invest in livestock if the returns are higher than available elsewhere. This approach may seem overly simplified and economic to many. Obviously, pastoralists do not strictly maximize profits. However, numerous anthropological studies have shown that pastoralists utilize their resources economically to achieve a relatively high output within a harsh and unstable environment -- and such resource use is broadly consistent with this analysis. Further, empirical evidence indicates that many pastoralists are increasingly commercial while many non-pastoralists are investing in livestock on traditionally pastoralist-controlled range, e.g., e.g., Swift (1979b) and Behnke (1983b). Pastoralists and farmer-herders are also increasingly attracted by employment outside the sector, e.g., Kerven (1984).

The total private cost associated with each additional animal must be less than the value of production achieved if it is to be profitable. When the value of output and the private cost of producing it are equal, as occurs at n+, no additional animals will be grazed. This point, known as the open access equilibrium, indicates the number of animals which a group of competitive pastoralists will find economically attractive to herd (Shapiro and Ariza-Nino, 1983; see also the fisheries literature, e.g., Allen, et al., 1984). This number is less than the maximum which is biologically sustainable because individual herders want to benefit from their herds, have to bear costs in maintaining herds, and experience a decline in benefits and a rise in costs as additional animals are added.

A simple and often used assumption in this type of analysis is that the aggregate private costs of herding rise proportionately with the size of the aggregate herd. This assumption is usually justified on the basis that the optimum sized herd for the individual pastoralist is determined by rising costs, and that all herders have approximately the same costs (Shapiro and Ariza-Nino, 1983). Evidence exists that the individual herder's average cost per animal does first decline and then rises as more animals are herded, so that that eventually it becomes unprofitable to increase herd size (Swift, 1979b). The distance which a herd must travel each day while grazing rises geometrically as the size of the herd increases (Bayer and Otchere, 1982, cited in McDowell, 1984). Disease risk also rises and the labor demands of watering become impossible for an individual to fulfill. The aggregate cost curve shown and the analytical results yielded will thus be generally correct.

Some authors have argued that rising costs will place a limit on the number of animals which any individual herder wishes to hold, thus making overgrazing unlikely so long as the pastoralist population is small relative to the available grazing area (Shapiro and Ariza-Nino, 1983; Stryker, 1984). This argument is plausible, at least historically, but increasingly it has less force. Evidence shows that pastoralist herds are not all of equal size, nor are they held purely for subsistence purposes. The ownership of herds in most countries is highly skewed, with a relatively small proportion of owners holding a large proportion of total cattle (Sutter, 1983; Little, 1983; Hopcraft, 1981; Agency for International Development, 1980.) Large herds are usually broken up into smaller units, with some herded by employed pastoralists or given out in exchange for future services. Meat is increasingly produced for commercial sale and larger numbers of agriculturalists and urban residents have been investing in cattle, sometimes employing pastoralists to herd them (Swift, 1979b). Thus, the aggregate herd is no longer strictly limited by the size of the pastoral population.

Given these qualifications, figure 3 can be interpreted.

1) The vertical distance between the output and the cost curves indicates the total profit achieved. The maximum profit occurs at n*, which is the economically optimal number of animals to graze. This profit is equal to q* - c*, where q refers to output and c to costs. The profits shown also equal the maximum annual rent which a private owner would be willing to pay to use the land in this way.

2) n* is less than n^; the herd which produces maximum profit is lower than that which produces maximum output.

3) n* is also less than n+, the open access equilibrium. The model predicts that ranges having open access will be stocked more heavily than those with closed access. A potential indicator of overgrazing is therefore a comparison of the relative stocking rates on controlled versus open ranges -- assuming, of course, that accurate adjustment can be made for differences in land quality and the use of other inputs, including management. These qualifications are sufficiently strong to make accurate comparisons difficult.

4) Any stocking rate different from n* results in below optimal profits and therefore a lower output value for the economy as a whole -- including the pastoral and other sectors.

5) Profits at the open access equilibrium, n+, are zero. The potential value of the land resource is totally dissipated. Herders receive income from a return on the assets they own -- capital, labor, purchased inputs -- but receive none of the profit (rent) which would be associated with the land under a closed range system. Herders' incomes increase only as, and in direct proportion to, the inputs they own.

6) Undergrazing -- having fewer animals than n* -- can reduce profits as much as can overgrazing. This is a simple characterization of the argument in favor of an opportunistic strategy vs. a conservative strategy (Sandford, 1982).

7) The precise locations of n*, n^, n+, and n' -- as well as the total amount of profit (rent) attributable to the range resource, depend on many factors. The curves which have been drawn could have other shapes. The relative position of the herd sizes will always be the same, e.g., n* is the lowest and n' the largest, but n+ can be relatively close to n* or far away depending on the shape of the output curve and the slope of the total private cost curve.

8) The higher are total private costs, *cet. par.*, the lower is the profit (rent) accruing to land and therefore the lower the potential economic losses due to overgrazing. As expected, marginal lands far distant from markets will offer few profits and there will be less pressure to convert these to private control.

The previous analysis indicates that overgrazing is potentially important *even if no range degradation occurs*, i.e., if the productive capacity of the range is maintained from year to year.

Common vs. Open Access Range.

Overgrazing will always result on open access ranges in the long run, i.e., after all potential investors in livestock have been able to adjust to the opportunities offered, unless:

1) Production is insensitive to the stocking rate, or if

2) Access controls exist and are effective.

The first condition is impossible if taken to the extreme, although livestock density could be below the critical point for some time, converting the overgrazing issue into a long run problem. The scientific evidence regarding overgrazing in Africa is extremely spotty.

The second condition requires that open access have been converted to either private range or common range where the access rules governing common use specifically ensure that the stocking rate is optimal.

There are cases where access rules on common range have been reasonably effective in this respect. For example, Ciriacy-Wantrup and Bishop (1975) cite a historical case of English peasants sharing grazing rights on common lands. Grazing was permitted only during daylight hours and only during the annual grazing season, which was determined by the group on the basis of forage availability. Each user could graze only as many animals on the commons as could be maintained with his private feed base during the rest of the season. Where these rules were insufficient to avoid overgrazing, a collective process (stinting) assigned a uniform quota of animals -- a number of horses, cattle, sheep, ducks, etc. -- to each user.

Note that common access controls require rules governing use over longer periods as well, e.g., if the human population grew, the number of individuals holding quota rights had to be limited, with other peasants necessarily excluded, or individual quotas had to be continually diminished. Ciriacy-Wantrup and Bishop do not indicate whether this occurred. However, a number of social institutions currently regulate access to pastures in several developed countries, including Switzerland, Austria, Finland, England and Wales (Gilles and Jamtgaard (1982). These institutions have evolved over centuries and apparently function well. Thus, it seems that common range institutions, if properly organized, may control range use adequately. However, such institutions are likely to function best when undertaken by a small, homogeneous group so that benefits can be easily perceived by all users, responsibilty assigned, and adjustments made rapidly to changing range and livestock conditions (Runge, 1981).

The major question of concern here, of course, is whether traditional livestock institutions in Africa are adequate to control overgrazing. Some observers, like Little (1983), indicate that such institutions may have originally played such a role, but suggest that they have badly weakened as a result of government intervention, population growth, changing local political structures, and the rise in commercial transactions. Others, like Sandford (1984), indicate that African traditional systems influenced many aspects of pastoralists life, but seem rarely to have restricted animal numbers per se.

Determining the Actual Impact of Overgrazing.

Numerous authors have asserted that overgrazing is important on traditional ranges in specific areas of Africa, but generally the evidence advanced is only a cursory description of vegetation changes in response to heavy grazing. Rigorous analysis of stocking rates, animal productivity, and total output on common as opposed to private range -- adjusted for different input levels -- is rarely found. Moreover, the interaction among these variables is crucial as is shown below.

Sandford (1982) contains a thoughtful discussion of overgrazing in Zimbabwe; he indicates that stocking rates on communal lands are well in excess of estimated carrying capacities, but also notes that secondary production per hectare is higher on communal than on commercial lands, even though primary production is about 15% lower (Kelly, 1973, cited in Sandford). Utilization of the communal pastures is more intense.

Sandford's findings, supported by Behnke (1983a) and de Ridder and Wagenaar (1984a and forthcoming), suggest that pastoralists produce more from a given range than do commercial ranchers. This is important evidence for a revision of views regarding traditional systems as the latter have been thought by many observers to be less productive than commercial ranching. However, it is possible for traditional systems to produce more per hectare than commercial ranches without contradicting the overgrazing argument. Pastoralists utilize different production technologies than commercial ranchers, involving substantially more labor for carefully leading their cattle to the best available grasses and for milking, and less non-cattle capital. They also produce a different output mix, including milk, blood, and draft power as well as beef. Direct comparisons of the output achieved per hectare are therefore insufficient to indicate whether overgrazing exists, or even which technology is most economical, though they are illuminating in other respects.

A possible situation is shown in figure 4. Pastoralists are assumed to produce more than commercial ranchers at each stocking rate. Output per animal for any given stocking rate can be measured by the slope of the line connecting the origin (O) and the corresponding level of total output, i.e., OA and OB for stocking rates n^*_c and n^+_p respectively. For simplicity, costs are assumed equal in the two cases, e.g., line OB. As shown, although output per animal is higher on commercial ranches for the two stocking rates considered, output per hectare is higher on traditional range. That is, total output is higher on the traditional range for all relevant stocking rates, even when commercial ranches have optimum stocking rates and the traditional land is in open access equilibrium.

The situation shown in figure 4 is consistent with information in de Ridder and Wagenaar (1984a and forthcoming). The latter find that in eastern Botswana stocking rates on traditional range are <u>twice</u> those on commercial ranches in similar ecological areas, while output per Livestock Stocking Unit (in liveweight equivalents) is approximately 40% <u>lower</u> and output per hectare approximately 25% <u>higher</u>, respectively. These are preliminary results; no evidence on costs are available.

Note also that if grazing controls effectively restrict stocking rates on traditional lands below $n+_p$, both animal productivity and total output would be higher than shown. Clearly, it is possible for some overgrazing to occur on pastoralist lands and yet for total profits under the traditional system to be higher than those under the private commercial system. In brief, overgrazing on commercial lands does not necessarily make the shift from a traditional to a commercial system economical.

One piece of evidence does seem to support the hypothesis that overgrazing may occur in most traditional systems; animal productivity increases on most common ranges after a drought to levels substantially above those prevailing under "normal" conditions before the drought (Meadows and White, 1977; Dahl and Hjort, 1977). Increased productivity is attributed to the reduction -- through sales and deaths during the drought -- in the livestock population, leading to improved nutrition per animal when the range recovers. As shown in figures 2 and 3, reducing the stocking rate (with forage constant) is likely to cause significant increases in productivity per animal almost only when the stocking rate was previously above n*.

What are the magnitudes of the losses being discussed? Are they large or small in absolute amount and/or relative to national per capita GNP? What impact would stopping overgrazing have on economic welfare? Only the roughest answers can be given, but even a crude estimate may suggest approaches which might provide more trustworthy figures.

Overgrazing, if carried to the extreme, results in total dissipation of profits (land rents). The amount lost on an annual basis can therefore be approximated by determining the total hectares of pasture land available in a given country, multiplying this amount by the per hectare value the land would have under capable, private management, assuming that such management has the incentive and would avoid overgrazing. The value of all pasture land can then be multiplied by the return expected on capital each year to obtain the annual income (rent) which the land should yield -- and which is lost to overgrazing. The annual income lost can be divided by the total population to obtain the resulting decrease in per capita income, which can then be considered relative to total per capita income in each country.

Overgrazing should cause the greatest damage in countries which depend most heavily on pastoralism. Data from FAO were used to calculate the losses shown in table 1. The assumptions utilized are: 1) all pasture rents are dissipated, 2) unimproved pasture land has a value of US$10 per hectare -- probably a reasonable figure for much of the arid to semi-arid areas under pastoralism, but other values can be easily substituted to get different results, and 3) the rate of return is 15% -- to convert land value losses into annual rental losses.

These crude results -- which ought not to be taken too seriously -- suggest that the losses from overgrazing are not trivial and indicate that efforts to limit overgrazing have economic interest. Nonetheless, the losses do not appear huge -- it is easy to imagine that efforts to reduce overgrazing could cause great conflict and suffering, and thus counterbalance amounts of this magnitude. The pastoralists are those who potentially have the most to gain and also the most to lose (from government interventions to reduce overgrazing).

The economic losses from overgrazing appear large only for Chad and Mauritania, two of the poorest countries which are most highly dependent economically on pastoralism. Note that if land is valued at US$50 per hectare in Ethopia and Kenya, to take account of quality differences in the highlands, their losses are still relatively small.

As previously noted, the assumption that all of the potential rent is lost exaggerates the estimates of overgrazing losses. Some pastures in each country are privately owned and others, even if communal, may have institutional restrictions on stock numbers. To the extent such controls are effective, the stocking rate is less than n+. Of course, a breakdown in such controls would signify a movement toward n+.

An increase in the profitability of livestock production, such as could result from rising demand for pastoral products and improvements in livestock technology, could induce greater overgrazing. However, by increasing the potential gains from controlling range access, they also increase the pressures for control. Behnke (1984) makes this point eloquently through numerous historical examples, i.e., enclosures in England and fencing rangelands in the American West. The argument suggests that overgrazing losses in Africa have not been too high in the past else pressures would have emerged to introduce more rigid controls. This situation, which could change rapidly in the future, is discussed again below.

The Potential for Continued Herd Expansion.

Pastoralist herds apparently have been expanding in most of Africa throughout this century, e.g., (West, 1972). How is such behavior consistent with the argument presented here? It is possible only if 1) stocking rates were initially well short of the open access equilibrium and have been expanding toward it, 2) range capacity has been increasing as a result of capacity increasing investments, e.g., water points and veterinary interventions, or 3) herd costs have been declining. The scanty evidence suggests that 3) has not occurred and that 1) and 2) are each probable. However, cattle herd growth is significant, averaging nearly 2% per year between 1965 and 1980 for Africa as a whole (McClintock, 1983). This will increase stocking rates by about 50% in 20 years. Further, the costs of expanding capacity on open access range are very high.

It is often argued that investments in water points or vaccination campaigns will have little impact on output within common range systems. This depends on whether access is controlled or not. However, even for open access range, investments have positive impact in the short run -- which may explain why such interventions have nearly universal appeal for pastoralists; see figure 5. Assume that a government undertakes major water investments on behalf of pastoralists. If these water points expand carrying capacity, output (and pastoralists' incomes) will initially shift from q_a to q_b because the number of animals remains temporarily at n+. However, the higher profits to pastoralist activities will then induce a long run herd expansion to n+, causing output to decline to q_c. Continued government investment will thus allow some continued increase in output, but a much smaller amount than if the range were closed. In fact, output will increase only in the same amount that herders' direct costs increase. There is no long run economic return to such government investments in an open access system.

This raises a crucial issue. Some mechanism for assigning the benefits of capacity expanding investments is essential or such investments will not be made. Thus, an open access system will lead to uneconomic use of existing resources and fail to encourage otherwise profitable investments so that output will increase more slowly over time than with a closed access system.

Climatic Variation, Herd Adjustment and Overgrazing.

To this point the analysis has assumed that the amount of forage available is constant over time. However, the amount of forage may vary from year to year, primarily because of climatic variation and/or overgrazing, and this fact must be incorporated into the analysis. The effect of climatic variation is considered first. For simplicity, it is assumed that rainfall oscillates randomly about its average level, and that the annual amount of forage produced is a linear function of the annual level of rainfall. Figure 6 shows the stocking rate-livestock output relationship for the forage available in a year of normal rainfall (the center line), and the relationships which might occur in years of "high" and "low" rainfall.

The optimum stocking rate for each forage level is indicated by the respective n_i*, assuming that herd adjustment is costless. These optima indicate that herd adjustment in response to variations in forage availability is profitable. However, producers will usually not adjust as much as shown by the n_i* because adjustment is not costless. For example, producers will be hesitant to sharply reduce the size of the herd during years of low rainfall because they will be unable to rapidly increase the herd when rainfall rises again. The herd growth rate is biologically limited to a maximum of 7-10% per year (Dahl and Hjort, 1976), and relatively few animals usually are available for import from other regions. Severe destocking in one period thus implies that pastures will be understocked during several future periods (assuming a return to normal weather), with a correspondingly lower economic output than had it been possible to maintain herds. Pastoralists will seek to husband a larger number of animals through drought than would maximize short run profits, thus achieving higher long run profits.[1]

[1] Sandford (1982) has shown that the more instable is climate, the higher is the optimal stocking rate relative to the forage usually available <u>during drought</u>. It can also be shown that the more instable is climate, the lower is the optimal stocking rate (and output) relative to the <u>average</u> amount of forage produced over time on the affected range.

Livestock prices also usually decline significantly at the beginning of a drought and rise to higher than normal levels when the drought is over and herds are being rebuilt. This further reduces the economic profitability of adjusting the herd in response to climatic variation. When drought occurs the producer (whether rancher or pastoralist) faces reduced production and possible death of his animals. His alternatives are to maintain his herd, accept some weight loss and mortality, but hope that most of his animals survive, or to sell animals as quickly as possible, converting them into capital which can be preserved and reconverted into animals after the drought is over. His choice will depend mainly on the prices his animals will bring now, the expected price of purchasing new animals in the future, and the probability that individual animals will survive the drought. Other considerations include the value of the production his animals should achieve during the drought versus the cost of alternative food to sustain his family if he sells his animals, and the costs of herding versus the income he could earn in another activity. Under African conditions, relatively few sales are profitable.

In Ethiopia, for example, a fat steer is worth approximately 6 quintals of grain during normal periods, but this falls to 1 quintal during drought and rises to more than 7 quintals during the period of herd recovery. These price swings, which are extremely difficult to predict since few are certain when a drought will begin or end, make selling and repurchasing animals to avoid a drought very costly. A producers who sells to preserve capital will find that for every 7 animals sold he will be able to repurchase only 1. While it is better to have 1 than none, these exchange relationships are so unfavorable as to cause many producers to wait out the drought even if heavy mortality is the alternative.

Note also that the inability of African markets to absorb an increased supply of beef during a drought contributes to producers' lack of herd adjustment and, indirectly, to higher animal mortality. The inelasticity of beef demand is a principal reason for sharp price swings. This results in the retention of additional animals, in the availability of less forage per animal, and in higher animal mortality. Improving the terms of trade to livestock producers during droughts would alleviate this problem, though this will not be easy to achieve.

Climatic instability will also alter the manner in which overgrazing occurs and is perceived. As analyzed in previous sections, increased overstocking leads to progressively declining output per animal and (after a point) declining total livestock output. Such changes ought to be clearly perceptible through time. However, when climate is unstable overgrazing is likely to lead to more frequent drought and lower output may be reflected primarily in greater periodic mortality. Stocking rates -- and output -- can also be undesirably low for some years after a drought, but output per animal can be quite high during non-drought years, even when pastoralists are operating at an open access equilibrium.[2] Such effects may be much harder to perceive because they appear to reflect natural rather than economic phenomenon.

[2] Drought is defined as the shortage of some economic good (forage) brought about by inadequate or badly timed rainfall (Sandford, 1978). This definition ensures that for any given weather pattern, the liklihood of drought -- and of mortality for each animal -- rises as herd size increases. (de Ridder and Wagenaar, forthcoming, suggest that in Botswana traditional ranges, with higher stocking rates, suffer more frequent droughts than do commercial ranges, with lower stocking rates.)

The argument can be outlined as follows. Assume there are no controls on range use, that "normal" rainfall occurred for several years, and that the herd has grown beyond n* toward n+ (consider the top curve in figure 6). A year (or two) of low rainfall then occurs, shifting the stocking rate-livestock output relationship to the lower curve. The initial herd cannot be sustained under these conditions. The extension of the lower curve below the horizontal axis indicates that animals will lose weight and/or die in increasing proportion the higher is the stocking rate. Output and, possibly, the herd will decline with the degree depending on the drought's severity and duration. When the drought is over, animal productivity will rise (as reflected by a shift to the top curve) and the herd will begin to grow.[3] This growth continues until another drought occurs again or the open access equilibrium is reached.[4]

[3] Total maximum herd size is restricted by the recurrence of drought even though growth between droughts is high. During the 1960-61 drought, for example, 65-80% of the total Maasi herd in Kajaido District in Kenya is estimated to have died (Hedlund, 1971; Schlueter, 1975; and Jacobs 1973). Another serious drought occurred in 1973-74. Thus, even at a 7% annual growth rate, the herd would only double over 12 years; if more than 50% of the herd died during an average drought, and/or if droughts occurred more frequently than every 12 years, the total herd would be shrinking rather than rising.

[4] Output will fluctuate significantly from period to period. Open access equilibrium occurs when the expected internal rate of return on herder investments, net of expenses, equals the discount rate. The issues in this section require a mathematical model for full development.

It is sometimes argued that pastoralists maximize herd size to increase the probability that a herd of economically viable size will emerge from a drought (Dahl and Hjort, 1976). Taken literally, this seems improbable insofar as there is a substantial cost to maintaining more animals than are needed in the short run, given the implied extra work and/or reduction in consumption or cash earnings. However, if pastoralists' herds are continually being reduced by the effect of drought, over which individual pastoralists have little control, the effort to "maximize" herds may simply reflect the effort to achieve a target herd size which is rarely, for most producers, ever attained (Halderman, 1978).

Note also that the individual pastoralist may have little control over the range available to him, depending on the efficacy of the mechanisms used to control access within traditional range systems. If no mechanisms exist, destocking will allow an individual pastoralist to increase per animal forage availability for his remaining animals only to the extent that, even during drought, continual migration and careful scouting result in location of some forage. He will not be able to hoard forage as can a producer controlling access to his range.

Range Degradation.

The economic analysis of overgrazing, as presented thus far, has been concerned with getting too little secondary production from a given amount of primary production. However, range degradation may be caused by overgrazing and if so the analysis ought also to consider this.

Almost all livestock pressure results in some changes in vegetative cover, composition, and/or productivity. The impact can be either positive or negative in terms of output achieved. Greater grazing can increase the production, palatability, and nutritive content of forage, at least in the short (McDowell, 1984) and perhaps in the longer run. Man, by clearing trees, burning, and use of grazing animals, has been largely responsible for the development and the maintenance of grassy savannahs (West, 1972; Cummings, 1982). Much of this area would otherwise revert to bush or forest. However, the degree of grazing required for positive effect is not clear, and excessive pressure during periods when vegetation is stressed or seeding appears to be damaging under at least some conditions (Barnes, 1982). Animal preference for certain species cause these to be grazed intensively, which may cause them to weaken or die, allowing other less desirable and valuable species to dominate. Soils may erode, reducing fertility and water absorbtion.

Even if range degradation occurs, this need not be irreversible. Savannah systems appear resilient (Walker and Noy-Meir, 1982; de Ridder, et al, 1982; Penning de Vries, 1983; Greenwood, 1980) and often spontaneously, if gradually, recover their capacity once grazing pressures are relieved. In other cases, improvements in soil structure and fertility can be engineered and desired species reseeded. Thus, irreversibility refers only to those situations in which the species mix has departed from that previously existing, where spontaneous recovery will not occur, and where it is uneconomic to engineer such recovery (Sandford, 1982).

The discussion of irreversibility suggests that an economic as opposed to a physical definition of range degradation is also appropriate. Pastoralists and ranchers are interested in plants which will increase the value of livestock production. They may also be interested in plants which enrich the soil, enhance moisture absorbtion, and prevent soil erosion, but to be valuable these must eventually result in greater output, via utilized forage, and this impact can be perceived directly.

The complexity of the issues nonetheless makes it extremely difficult to measure range degradation in practice. Range degradation or enhancement can be measured directly through changes in primary production (range vegetation and soil conditions) or indirectly through changes in secondary production (animals) (Sandford, 1982).

Measurement of primary production is difficult, costly, and time consuming (Penning de Vries, 1983). More importantly, the ultimate interest is animal production, not vegetable production, so that a measure of primary production may not provide a meaningful indicator of range degradation (Sandford, 1982).

Unfortunately, it is also difficult to capture the impact of range degradation, in the sense of vegetation and soils, through measurement of secondary production; this requires a complete and consistent definition of output over time, and adjustment for changes in all non-land inputs, including rainfall. Due to climatic instability, most pastoralist production indicators will show substantial short and intermediate run variation so that valid measures must capture a long run trend.[5]

[5] Fowler (1981) presents evidence that herd technical efficiency may have declined over the last 15 years in Swaziland and attributes this to overgrazing. His argument is reasonable, but the data base is inadequate to support a strong conclusion (Jarvis, 1982). I have tried to develop similar measures for traditional range in Zimbabwe, but found the data on both output and inputs insufficient.

All outputs must be considered, e.g., milk, beef, blood, draft, and dung, not just beef (Sandford, 1982; Behnke, 1983a). The prices of different outputs may change over time, making interpretation of their aggregative movement more difficult. Theoretically, a mix of animal species is more efficient on most African pastures (McDowell, 1984), suggesting that a proper measure of range degradation could require experimentation with various animal mixes.

Factors affecting range capacity other than vegetation also must be considered, e.g., watering points, labor, vaccination campaigns and increased crop residues.

The difficulty of measuring overgrazing suggests that this is not likely to be the deciding factor in whether or not to establish grazing controls or to move toward different tenure systems. However, an improved understanding of the relationship between grazing and range conditions will be of use to all livestock producers, whatever their access to land.

The above discussion is illustrated stylistically in figure 7. Assume that the forage initially available is given by the top curve. Assume also that optimal grazing, at n*, implies that no long term range degradation is occurring so that the expected amount of forage -- and livestock production -- remains constant each year. The results from these assumptions contrast with those which occur if it is assumed that that range degradation occurs when the stocking rate is at n+, leading to a decline in productive capacity. The dotted lines indicate the expected capacity in successive periods; continued overgrazing leads to continued capacity decline. The situation illustrated is set to conform with common expectation, e.g., open access leads to reduced output in the short run and also to yet lower output over time. If true, there is additional reason for controlling range access.

It is clearly important to the choice of the optimal grazing point to determine whether increased stocking leads systematically to decreased range capacity. Unfortunately, there is as yet little clear empirical evidence in most regions. It seems likely, however, that even optimal grazing will involve some periodic range degradation (Greenwood, 1980), especially in regions of instable climate. As shown previously, even producers on private range will graze intensively during drought, accepting some short to intermediate run decline in primary production in order to maintain larger herds and thereby achieve higher secondary production when rains reappear. However, the producer on private range will not wish degradation to be too severe as this would decrease rather than increase future production. As he receives all range benefits, he should be willing to destock during drought, maintain stocking rates below normal levels after rainfall has improved, and/or invest in range improvements in order to maintain or increase long run productive capacity.

The pastoralist operating on open range, and even on most common ranges, finds himself in a fundamentally different position. He too will want to maintain animals during a drought and he has incentives to retain higher numbers than the producer on private range because he cannot capture much of the future benefits from lighter stocking in the present. The pastoralist will be aware that heavy grazing during a drought reduces long run range capacity, but he also knows that the pressure of his herd has little impact on the availablity of forage to him, either now or over time. Other herders will act independently of his actions, maintaining their herds in the short run and the long run if his sales, by freeing up fodder, make this profitable.

Meat Prices

Price policy is crucial to livestock development, affecting the profitability of production and therefore the amount which occurs. The affect of meat price changes on production will be different on open access ranges from that on closed access ranges, as illustrated in figure 8. Assume that the price of beef is initially 1 so that production capacity is shown by the lower line. Then assume that the price of beef rises to 1.5 so that production capacity, in terms of value, expands proportionately over its whole range. Physical output capacity is unchanged. Thus, the lower curve shows the quantity of meat produced for each stocking rate, whatever the price.

If access is controlled, a price increase will induce producers to increase herd size from n^*_1 to $n^*_{1.5}$. Profits rise dramatically and physical output also expands (as shown by movement up the lower curve). The higher is the beef price, the greater are the social (and the private) returns to controlling range access.

A higher price has a different effect if herds always expand to the open access equilibrium in response, e.g., from $n+_1$ to

$n+_{1.5}$. In each case no profits (land rents) are earned. The value of output expands slightly as a result of the higher price, i.e., a to b, but only by the amount total costs increase. The stocking rate moves toward the biological maximum and physical output actually declines -- shown by movement along the lower curve, a to c. Thus, an increase in price could have precisely the opposite impact desired. Many African countries are experiencing an increase in urban meat demand and are hopeful that higher prices will call forth higher, not lower beef supplies. The output decline shown in figure 8 indicates vividly the type of problems which uncontrolled access to a natural resource can cause.

Even with open range access wherein a higher price leads to lower total output, a higher beef price can result in a higher marketed supply of beef. If pastoralists, who currently produce mainly milk for self subsistence (Dahl and Hjort, 1976; Halderman, 1978; McDowell, 1983), produce more meat and exchange it for other goods, the shift in output mix can outweight the effect of the allocational inefficiency in terms of beef supply, making the allocational inefficiency less apparent to government.

Shapiro and Ariza-Nino (1983) found that the optimal slaughter age of mature animals (steers, cows) is unresponsive to changes in beef prices under the technological conditions generally faced by West African pastoralists, primarily because herders cannot increase animal nutrition on common ranges. This result has been incorrectly interpreted to indicate that price policy will have little effect on offtake rates or herd size.

Even if the slaughter age of adult animals is unresponsive to beef price increases, there is great scope for reducing the current mortality/slaughter rate of male calves. Many male calves are slaughtered at an early age or die from neglect because it currently is unprofitable to fatten them (Dahl and Hjort, 1977; Meadows and White, 1979). However, the value of male calves -- as growing machines -- will increase rapidly if beef prices rise (Jarvis, 1974; 1980; Shapiro and Ariza-Nino, 1983). In response, the composition of the herd will alter, with pastoralists holding larger numbers of males for fattening and, necessarily, fewer cows.

Tax Policy

Overgrazing results from open access range because individual pastoralists find it profitable to add animals even after total profits begin to fall. Various means of external control have been suggested to avoid this, including a grazing tax -- an annual charge levied on each animal retained on the range (e.g., Stryker, 1984). The optimal tax is that which makes the individual herder's costs equal to total costs by charging for the pasture resources utilized. The generalized effect can be illustrated in figure 9. The optimal tax, t^*, when multiplied by the the optimal stocking rate, n^*, yields total tax receipts equal to the maximum potential profits (land rents), i.e., $t^*n^* = q^* - c^*$. Total herding costs, including the tax, equal the value of output at n^*. The figure shows that output falls more rapidly than tax receipts as the stocking rate is varied so that any stocking rate different from n^* would lead to economic losses for herders. This is expected to cause them to remain at n*.

Although an optimal grazing tax is theoretically capable of improving resource allocation, it is unlikely to prove satisfactory in practice. To identify n* and t*, rather precise information regarding the stocking rate-livestock output relationship is required, yet this is rarely available. The tax will be difficult to implement, incurring high administrative costs, which could largely offset the increased resulting production. Most important, the tax is likely to substantially reduce pastoralists' incomes in both the short and the long run, causing severe welfare problems.

Consider first the long run. Two examples can illustrate the types of possible effects. Assume pastoralists operate initially at the open access equilibrium, n+, and that imposition of the tax causes them to shift to n*. Total livestock "profits" will rise, but pastoralists receive none of this because the tax channels an equal amount to the government. The tax effectively shifts land ownership to the government and pastoralists pay rent for its use. In equilibrium, pastoralists receive only the (opportunity cost) return on their labor, animal capital, and other inputs used in herding. Moreover, as they use fewer assets at n* than at n+, pastoralists' net income declines, i.e., to q* - t* = c*, from q+, all of which they previously received. Numerous pastoralists will thus be forced off of the range even though production is rising.

The situation is worse if pastoralists initially operated to the left of n+, i.e., if institutional controls on common range constrained stocking rates to n_c. The tax then causes pastoralist incomes to fall from q^c to $q^* - t^* = c^*$.

Adjustment costs cause the taxes short run effects to be more severe than the long run effects whether pastoralists operate in open or in controlled access. For example, assume again that the stocking rate is initially n+ and total output is q+, well below q*. Clearly, if the optimal tax t* is imposed, pastoralist income would temporarily become negative. Herders could pay the grazing tax only by selling part of their herd, but higher slaughter will depress beef prices, worsening the pastoralist's situation. Insofar as most pastoralists have herds which provide only the minimum subsistence food supplies, large numbers of pastoralists would be suddenly forced out of pastoralism -- with no clear alternatives. Most likely, herders would not pay and directly oppose such measures, creating a political crisis. If the tax is first imposed at a lower level and gradually increased, individual herders will face decreased incomes until the tax has reached t* and the herd has adjusted to n*.

A grazing tax would also have to be varied to adjust to changes in n* as climate causes changes in forage availability. Otherwise taxes would remain far too high during drought and too low during range recovery. It seems unlikely, however, that a bureaucratic institution far removed physically from the range will be able to determine accurately the optimal stocking rate for different areas of a large range and thus be able adjust the grazing tax appropriately. If not, the attempt to use a grazing tax could actually reduce output as well as pastoralist welfare.

Although a grazing tax is unlikely to work as intended, this is not an argument for tax exemption of pastoralists. All states tax their subjects to pay for government expenses and services. Pastoralists ought to receive government benefits and they ought to pay their fair share of taxes. Some tax, on income or wealth -- including cattle, is appropriate. However, if the herd extraction rate is 20% (de Leeuw and Konandreas, 1982, cited in McDowell, 1984; Sandford, 1982; Behnke, 1983a), a tax equal to 2%-4% of the herd per year is likely to be the maximum collectable tax. This is not likely to have great effect on overgrazing. Moreover, such a tax is appropriate only if governments provide pastoralists with improved services: roads, communications, health posts, education, justice, protection, and the like. These benefits would encourage pastoralism, offsetting part of tax's effects on grazing.

Governments also may impose fees for specific livestock services such as veterinary interventions, but these fees cannot have higher cost than the value of the services to pastoralists, or they will not be used. Thus, imposing fees for services should have little noticeable effect on overgrazing.

Stocking Controls

Efforts to control overgrazing are likely to be better accepted by pastoralists if implemented in the form of stocking quotas or tenure changes which provide pastoralists with control over land because each of these effectively transfer potential pasture rents to pastoralists themselves.

Stocking quotas are inferior to control over land, at least in the long run, because they create no direct incentive for pasture related investments. Stocking quotas -- like grazing fees -- need also be altered in response to production capacity changes, a bureaucratically difficult task. Quotas are also difficult to enforce and they are a source of great and continuing friction among pastoralists who inevitably disagree regarding their appropriate distribution (Hopcraft, 1981). And quotas are subject to abuse and corruption because the monetary value from obtaining bureaucratic relief is great.

Changes in Land Tenure

Closed access to ranges can potentially end the overgrazing problem. Two basic systems of ownership are possible: private land, where an individual or group is responsible for limiting the stocking rate under the assumption that self-interest will lead it to optimize the output of the asset controlled, and public land -- as through a parastatal ranch -- under the assumption that public officials act essentially as private owners.

Public control and operation of rangelands in Africa has been unsuccessful in nearly all cases (Sandford, 1981, 1983). In addition, public control leads directly to loss of lands by pastoralists who are the traditional users of such land. Both equity and efficiency grounds therefore argue strongly against this solution to the overgrazing problem.

Private control has a better record and may offer the only long run solution in many areas. The primary issue in considering changes toward individuated tenure is equity, not efficiency: how should "land" be divided among pastoralists (groups of pastoralists), or between pastoralists and non-pastoralists. These are extremely knotty issues (Hopcraft, 1981; Sandford, 1983; Halderman; 1978; Oxby, 1982; Lawry et al, 1984 and Behnke, 1984). The principal need -- from the pastoralists's perspective -- is to ensure that lands traditionally considered his grazing territory are reserved. But this involves myriad claims and counter claims -- by different pastoralist and agriculturist groups -- which can be adjudicated only by those who know the specific situation.

There is a growing literature on experiments with group ranches in Africa (Oxby, 1982; Halderman, 1972 and 1978; Awogbade, 1983; Olang, 1982; Galaty, 1980). These studies indicate that such ranches have been less successful than expected in achieving output increases. However, continuing, if cautious, efforts to promote this sort of change appears to offer a potentially attractive solution. A major problem is often the failure for group ranches to achieve clear rules regarding pasture use, which has often resulted in a few aggressive pastoralists largely monopolizing group resources. There is clear risk that these ranches will be transformed into private holdings, with most of the pastoralists becoming waged herders working for those owning nearly all the cattle or leaving pastoralism altogether. While such a transformation may eventually be acceptable, if it occurs more rapidly than the bulk of pastoralists can willingly accept, great hardship will result. Thus, some means are needed to strengthen the communal structure and to emphasize egalitarian rights and controls.

Explaining The Focus of Traditional Pastoral Institutions

Previous sections have indicated the potential for economic losses from open access ranges. It thus seems somewhat surprising that the anthropological literature provides relatively few cases of pastoral systems having obvious mechanisms for controlling against overgrazing (Sandford, 1984). African pastoralist systems are very old. They contain institutional mechanisms, sometimes quite severe, for governing many aspects of tribal life for the common good. These mechanisms, and the systems themselves, appear to have evolved steadily over time in response to a wide range of changing circumstances. Why then would pastoralists not implement grazing controls if the lack thereof began to result in clear and substantial welfare losses? Or, if grazing controls existed, why would their operation not be so important as to be central to all discussions of tribal life?

Overgrazing pressures may simply not have been so great, given the population-reducing effect of the Rinderpest Pandemic, the opportunities for expansion into new areas, and the potential to expand capacity through veterinary interventions, increased water supply, and, at least until recently, conquest and raiding. Alternatively, drought may have periodically reduced herds (and pastoralist populations) and, although painful, either the relationship between overgrazing and drought losses was not perceived or possible mechanisms for reducing overgrazing appeared even more painful than the losses.

Herd controls would imply a sharp alternation of pastoralist traditions, one whose social cost could be great, and might also cause efficiency losses of other types equal to those they seek to avoid. Controls on herd numbers would necessarily imply greater centralized intervention into the decisions of individual pastoralists, and the limitation on herd accumulation could reduce incentives. If the better pastoralists were unable to accumulate animals, overall herd growth could be reduced along with the traditional mechanisms which ensured that pastoralists whose herds were reduced during drought or epidemic received loans of animals from others more fortunate. Control over specific grazing areas by small pastoralist groups, a mechanism which approximates private use, appears feasible only where forage availablity is relatively stable and this too eventually requires controls on numbers.

I have no good answers to whether or how frequently overgrazing now exists on traditional range in Africa, or why, if it does, social controls have not been forthcoming to correct it. Answers seem required, however, if we are seriously to attempt improvements to the existing pastoralist systems. It would be erroneous to impose controls which were not needed, either because resource constraints were not yet binding or because pastoralists had adequate mechanisms to handle the problem though these were not recognized or well understood by outsiders (The paper by David Jones, this volume, discusses a case where new institutional mechanisms for stocking controls on pastoralist lands seem to be emerging). Non-pastoralists have usually underestimated pastoralists, often contending that they were poor range managers and achieved low productivity, while the evidence increasingly indicates that they manage their anaimals very well. Pastoralist systems also provide employment for a relatively large population and interventions must be concerned to preserve this aspect for the intermediate future as employment elsewhere in most African economies is sharply limited.

Economic Development and Pastoral Development

Economic growth in other areas of the economy could greatly ease the problems of pastoralists on common ranges. Labor is one of the most important inputs to pastoralism and any increase in the opportunity cost of labor should make pastoralism less attractive. Herders could be drawn into other activities, allowing increased incomes to remaining pastoralists. The prices of livestock products should increase more rapidly.

There is little evidence on the trends in income levels among pastoralists, although Behnke (1984) discusses several examples where outside development has improved pastoralist welfare. It would be useful research to determine whether pastoralists' incomes have followed the general income growth trend of the countries they inhabit.[6]

[6] Income data for 14 African countries having important pastoralist sectors show a wide variation in performance (World Bank, 1983). The average growth rate in per capita income from 1969 to 1981 is 1.6%, but the coefficient of variation within the sample is nearly 2.0 and individual growth rates range from -2.2% to 7.9%.

Conclusions

Assertions of overgrazing have been abundant for many years. Pastoralist herds have expanded greatly during this period and, although the effects of drought have been suffered repeatedly, it is not clear that pastoralist welfare is worse today than before. A number of "revisionist" livestock specialists have recently questioned whether overgrazing is really the problem it has been made out to be. Concluding that it is not, on various grounds, they have sought to shift the focus of livestock policy off of herd numbers and onto other means of increasing livestock productivity and pastoral welfare. I am sympathetic with this effort -- even though the thrust of this paper may seem to in the opposite direction. We share a common fear that a focus on overgrazing will encourage harmful intervention: grazing fees, poorly implemented stocking quotas, or changes in land tenure resulting in enrichment of a few -- perhaps not even pastoralists -- and impoverishment of the rest.

Nonetheless, examination of the common range-overgrazing dilemma indicates the nature of the problem faced by pastoralists. Rising pastoralist populations and declining pastoralist area, combined with weakening traditional institutions, could lead to increased overgrazing. External controls like grazing taxes and stocking quotas seem unlikely to provide efficient or equitable solutions. Land tenure changes, such as strengthening traditional control mechanisms, establishing group ranches, or movement toward individualized tenure may offer a more attractive solution, but no easy answer seems apparent.

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Figure 1

Weight Gain Per Animal As Function Of Stocking Rate

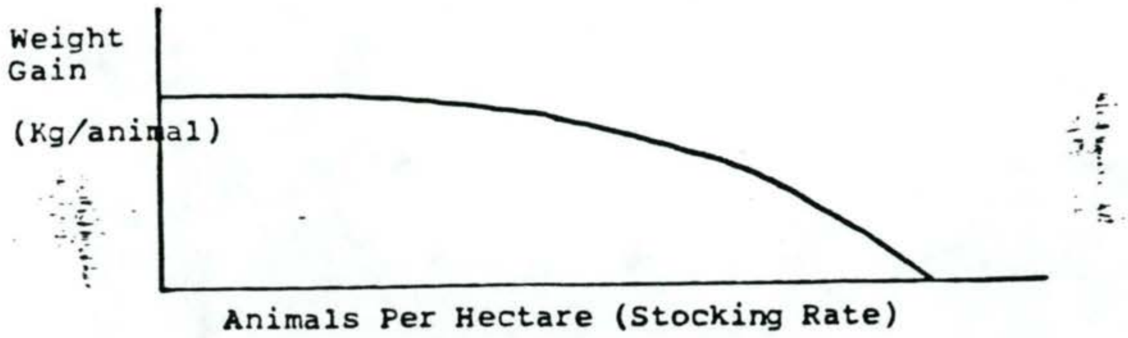

Figure 2

Weight Gain Per Hectare As A Function of Stocking Rate

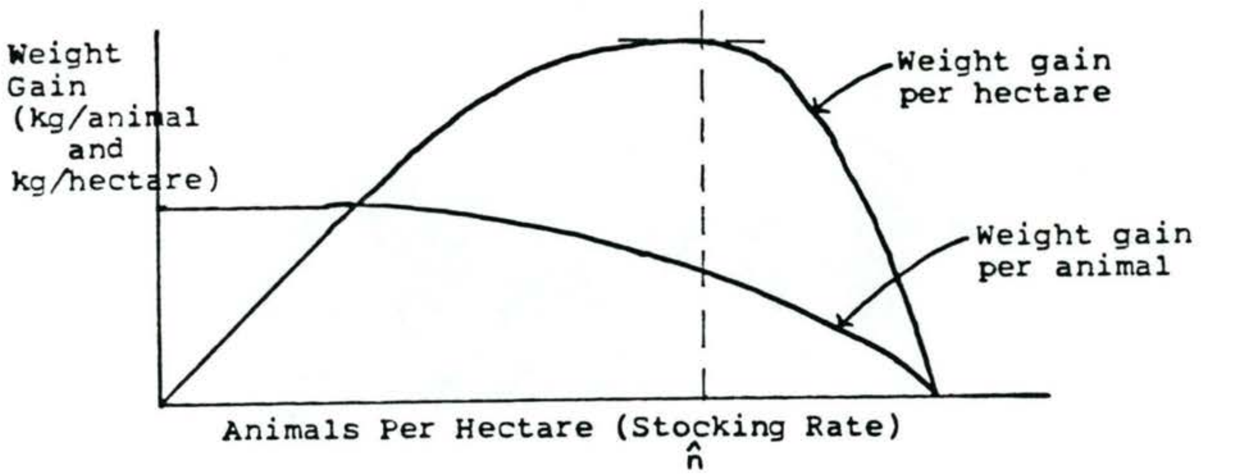

Figure 3

Value of Livestock Output and Costs of Herding
as Functions of Aggregate Herd Size

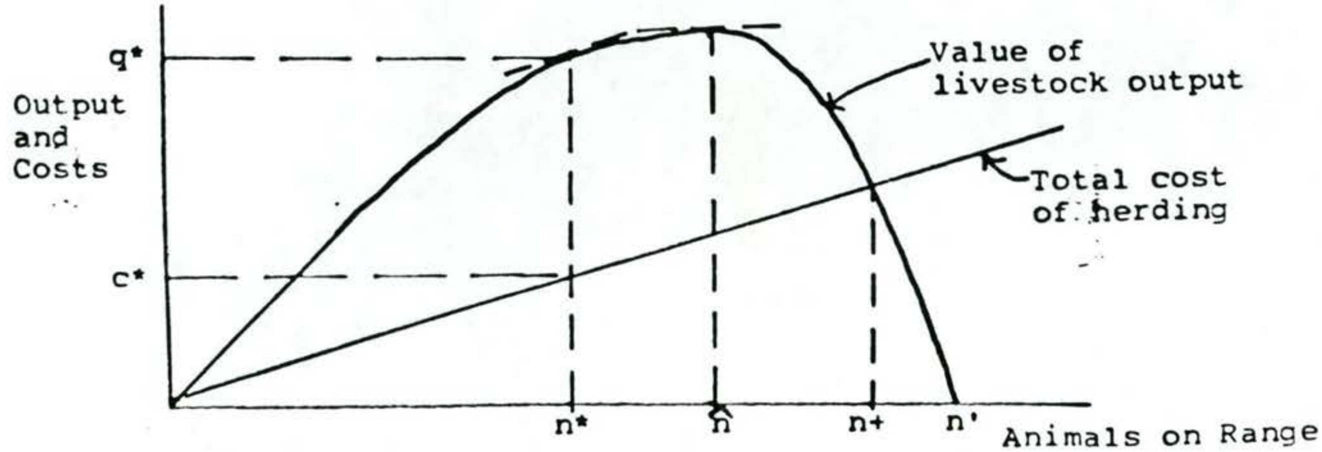

Figure 4

Possible Comparisons of Pastoralist and Commercial Livestock Productivity

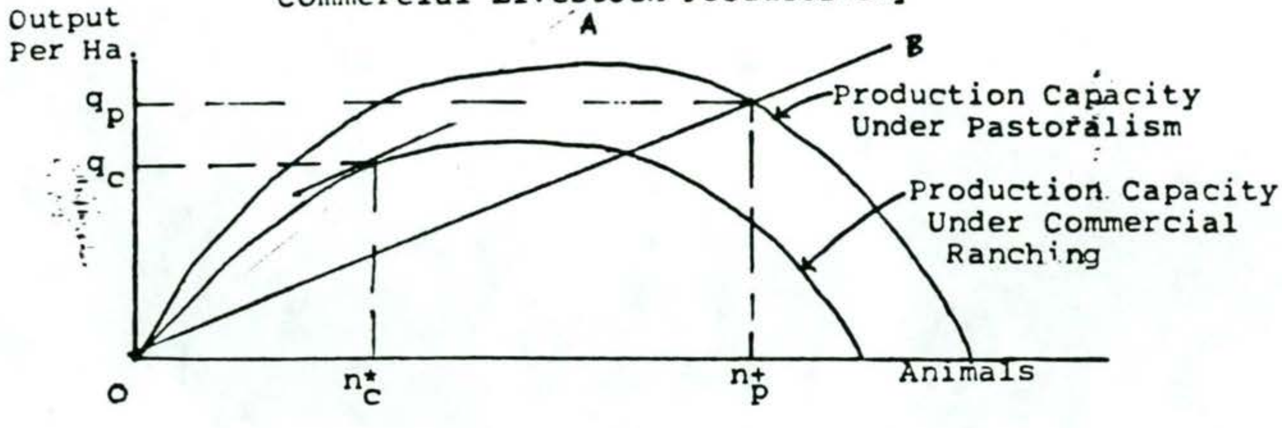

Figure 5

Short- and Long-run Output Response to Productivity Increasing Investments

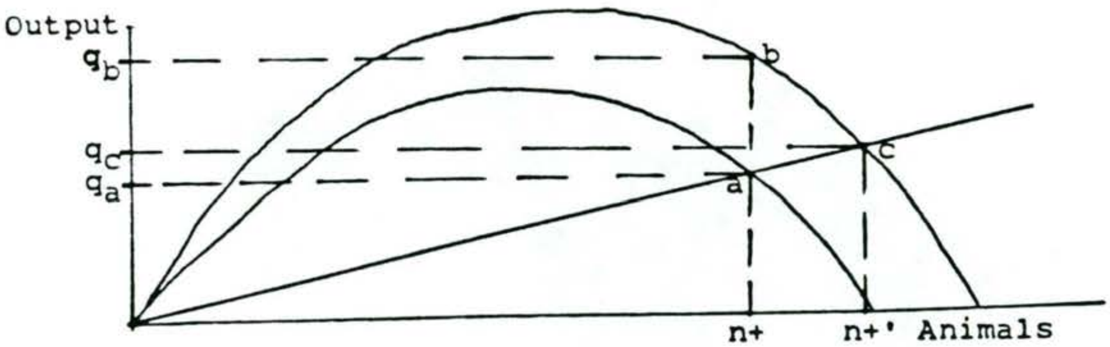

Figure 7

Overgrazing and Range Degradation

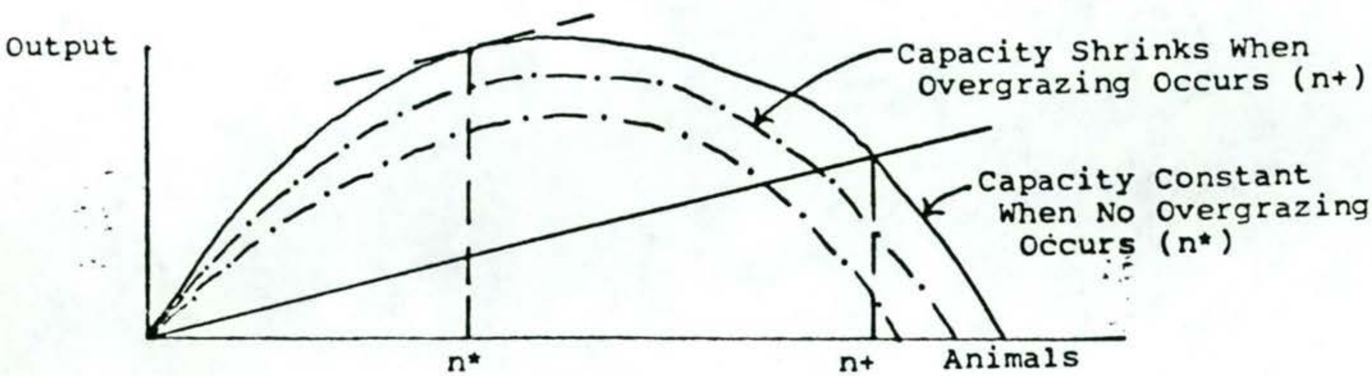

Figure 6
Forage Variation in Response to Climatic Change

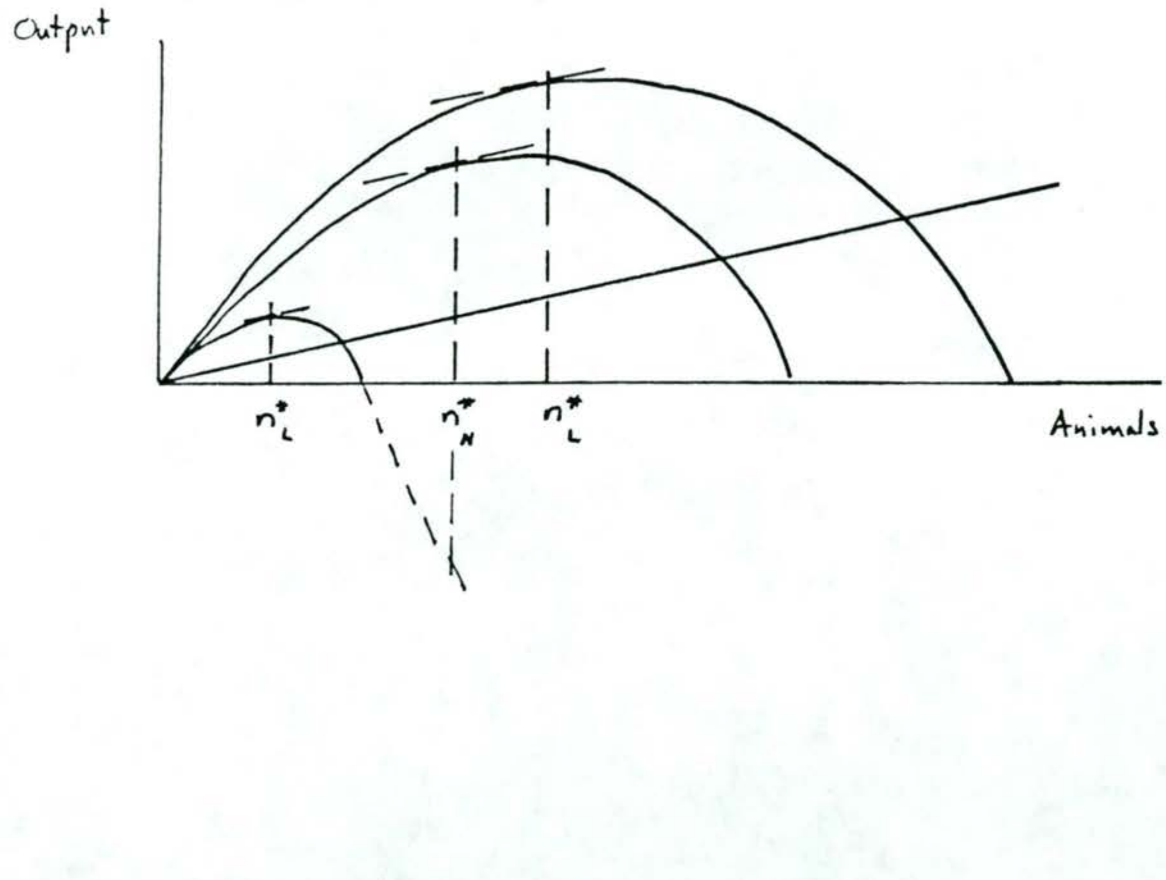

Figure 8

Impact of Beef Price Increase

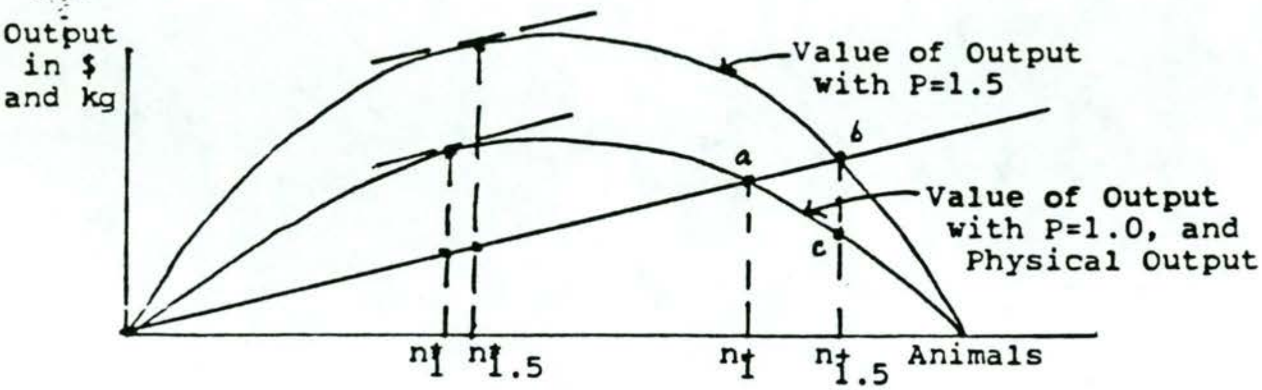

Figure 9

Effect of Grazing Tax on Pastoralist Production and Income

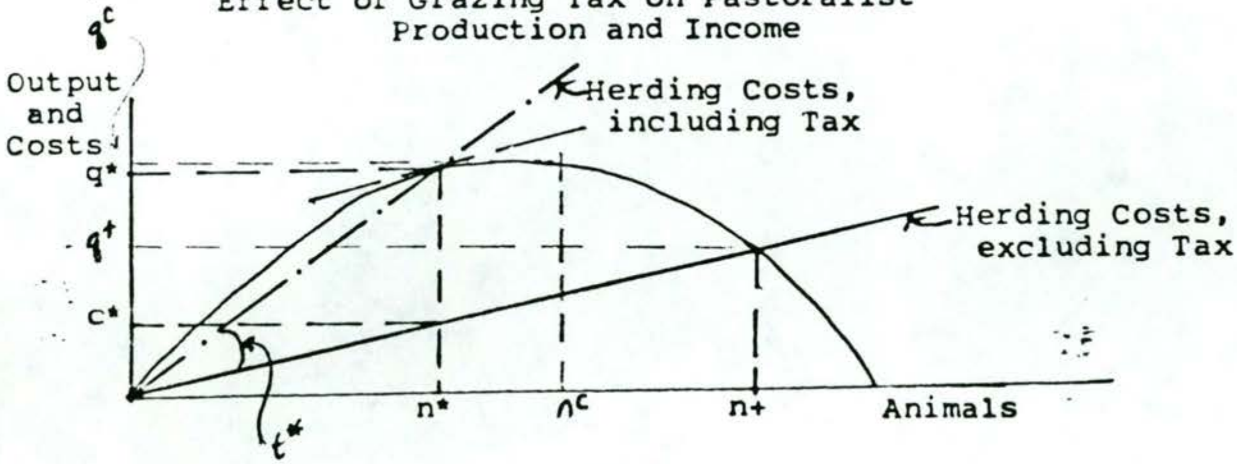

Table 1

Economic Losses Due to Overgrazing
(Illustrative Estimates)

Country	Pasture Value (US$ millions)	Annual Rent Loss (US$ millions)	Per Capita Loss	Percent Per Capita GNP
Chad	$450	$68	$15.0	15.0
Mauritania	$391	$59	$36.0	12.0
Somalia	$289	$43	$9.0	3.0
Sudan	$569	$85	$5.0	0.1
Ethopia	$451	$68	$2.0	1.5
Kenya	$40	$6	$0.4	0.4

Source: FAO data; author's calculations.