Land Resources in Darfur Region, Sudan: Prisoners' Dilemma or Coase Outcome?

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The article tests institutional models of environmental pressure, for example, the Tragedy of the Commons, against evidence from Darfur region, Sudan. Three aspects are considered in detail: rangeland degradation, rangeland enclosure and the implicit rent gained from range destocking. A methodology to estimate the latter is presented and demonstrated using survey data. It is concluded that strong circumstantial evidence of a Tragedy of the Commons - famine, drought and insecurity - is misleading. Social institutions such as land tenure are both adapted to the existing resource endowment and flexible enough to accommodate changes in it.

INTRODUCTION

Darfur, the westernmost region of Sudan, has seen extraordinary environmental change in the latter half of the twentieth century. Big game, a pest up to the Second World War, is no longer seen, vast areas of savanna woodland have been cleared and during the last two decades rainfall has rarely come close to the long-term average. Tribal and ethnic tensions have increasingly flared up into open fighting. This culminated in outright famine in 1984/85 and near civil war in 1989/90.

Both crop land and range land are near enough open access resources with only a weak concept of community or tribal ownership, while livestock are private property and farmers work as individuals. The theory of the 'Tragedy of the Commons' argues that this combination of an open resource

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and individual management is a primary cause of enviromental degradation. Because access is open, individuals cannot prevent their neighbours from over-exploiting the resource and can only defend their share of it by overusing it themselves *[Hardin, 1968].*

In Darfur, all the classic requirements of Hardin's model are met and many have attributed the ample evidence of environmental and social decline to some process of this kind. 'The communal grazing system gives no incentive to the individual pastoralist to reduce his herd in the hope that he will be able to feed them better, for there is no assurance that his action will improve grazing as long as others continue to increase their herds' *[HTS, 1974].* The parallel argument is that on crop land farmers cannot maintain fertility by fallowing because others take over and crop the fallow. Population has grown rapidly, especially in South Darfur, and many consider that this can only increase the pressure on the land resource and accelerate the whole process.

The Western Savannah Development Corporation (WSDC) was established in 1978 by the Government of Sudan, the World Bank and the UK Overseas Development Administration specifically to tackle these issues and it has commissioned research on many facets of the problem, including intensive ground surveys of ecological change, socio-economic surveys, sociological studies and, in particular, detailed analyses of aerial photography and satellite imagery. Much of this evidence has been presented elsewhere, in a more general context *[Morton, 1994:Ch 4].* This article adopts a more rigorous analytical approach in order to test what may be termed an institutional model of environmental pressure in the context of rangeland production in Darfur.[1]

In the Tragedy of the Commons, inadequate social institutions, especially those to do with land tenure, are the key factor, and it is implicit that those institutions are rigid or too slow to change in the face of rapid population growth, economic development or both. The aim of this article is to answer two questions: (1) Have resource endowments changed enough to justify institutional change in Darfur? (2) If they have, is institutional inflexibility a barrier to the adjustments needed to prevent rangeland overstocking? It has been almost universally assumed that the answer to both questions is firmly positive.

BAGGARA AND FUR: CATTLE OWNERS IN DARFUR

Darfur is the greatest cattle producing region of Sudan and one of the greatest in Africa, supporting some three to four million head of cattle and over five million sheep and goats as well as a large camel herd on a land area as big as France. More than this, it is home to some of the most famous

Arab pastoralist tribes of Sudan: the Baggara or cattle people who fought with the Mahdi and the Khalifa against the British and subsequently became something of pets to the colonial administration. To this day tribes with famous names such as Rizeigat, Bani Halba, Ta'aisha and Fellata, roam the southern half of the region with their herds and sometimes far beyond, even to Cameroon in West Africa, carrying their reed mat houses folded up with the pots and pans on the largest pack bulls in the herd.

As its name indicates, Darfur was also the region of the Fur Sultanate, the dominant power of the western Sudan until the arrival of the Anglo-Egyptian Condominium. The Fur are one of several non-Arab but Muslim groups, many of which still retain their own language. These groups are predominantly farmers.

The romantic associations of the Baggara, and of pastoralism more generally, make it easy to take Arab Baggara as synonymous with pastoralist and Non-Arab with cultivator. From there it is a short step to believing that the frequent tribal fighting reflects conflicts of economic interest and that this struggle is intensified by growing pressure on a limited land resource. In reality, the situation is vastly more diverse. Few Baggara do not grow crops, many non-Arabs have cattle and both sides shift the balance between their crop and livestock operations according to market and other circumstances. There is even evidence of groups shifting tribal allegiances as part of that process *[Morton, 1994: 227-8]*.

Darfur has a single short rainy season and a long drought of seven or more months. All cattle management is dominated by the need to balance the unequal water and pasture resources available in these two seasons. Some degree of transhumance is critical, be it merely between the cropped valleys and nearby uplands or from one end of the region to the other and beyond. Some have drawn a sharp distinction between the livestock strategies of the pastoralist and those of the settled farmer who owns cattle, reinforcing the apparent ethnic divide. Here too, however, the distinction is more apparent than real. There is no clear dividing line between nomad and settled management of livestock but rather a continuous spectrum between the wholly sedentary herder whose cattle do not move at all during the seasons and the wholly nomadic one who never stops moving. Individuals shift position along that spectrum according to their own circumstances, more or less regardless of tribe.

DILEMMAS VERSUS OUTCOMES

Lipton has developed a neat structure for the analysis of open access resource problems by setting the Coase theorem[2] in opposition to the games theory model of the Prisoners' Dilemma.[3] Taking rangeland overstocking as

the central metaphor, he argues that there is a drift in the third world towards non-co-operative Prisoners' Dilemmas. He cites a number of reasons:

- Population growth increases the number of transactors and raises the transactions cost of negotiating a Coase deal. (The exact opposite of Hayami and Kikuchi's view that higher populations bring 'tighter' social structures and reduce social transactions costs *[Hayami and Kikuchi, 1981: Ch 2].)*
- Rapid development reduces the number of times that similar decisions have to be made and this makes it less likely that repeated plays of a PD game will reveal the costs of not cooperating.
- Risk aversion leads actors to prefer the least bad, safe result over a better one that depends on the honesty of others.
- Centralised governments and new legal codes undermine traditional social restraints but individuals remain unimpressed by the new authorities and free riding becomes easier.
- The Coase theorem explicitly excludes equity which means that Coasean rules on compensation may not work *[Lipton, 1985: 49ff.].*

It is implicit in Lipton's model that the Coase outcome can only be reached through cooperation. He rejects the alternative route, unilateral enclosure, on the grounds that its equity implications are unacceptable. This may be true when considering policy prescriptions but not when the aim is to analyse why a given community cannot escape from the Prisoners' Dilemma; since enclosure is, if anything, more likely to occur than cooperation. It was what happened in most of the developed world and the same extra-economic power that Lipton argues stands in the way of a cooperative agreement to destock the rangeland would be just what is needed to enable the powerful to enclose and so capture all the benefits of destocking for themselves.

The balance between the gains to be made from co-operative destocking and the transactions costs of organising it determines whether or not the externality involved is relevant. Lipton describes this balance as the `temptation of goodness': the incentive for each Prisonner in the Dilemma to make the socially optimum choice. It could, just as easily, be a `temptation of badness': the incentive for one herder to unilaterally enclose an area of range, in breach of customary law, and so capture the benefits of destocking for himself.

There are four phases to the Tragedy of the Commons:

(1) there is so much range land that the expansion of individual herds does not affect others at all;

(2) benefits to the individual who expands his herd outweigh the communal losses imposed on others;

(3) communal losses are greater than the individual gains but the difference is not enough to cover the transactions costs of a solution and so render the externality relevant; and

(4) 'Losses exceed gains enough that the light-grazing solution, if enforced on all, produces so much more total herd output than the heavy grazing solution that the difference suffices to pay the cost of social institutions to ensure the light-grazing solution' *[Lipton, 1985: 69].* Or the difference becomes large enough to pay the 'fencing cost' of the bad, enclosure route.

The situation in Darfur appears to support Lipton's analysis in every respect. Nevertheless, a different conclusion will be presented here, for two reasons. First, the very existence of significant overgrazing or overcultivation is questionable. Some 20 years of intensive research have still not produced a consensus on whether or not African ranges are `overgrazed', although recent papers suggest that the balance is shifting towards the sceptics *[Behnke and Scoones, 1991: 15ff].* The evidence on the condition of the Darfur range is unclear at best, while the pressure on cultivated land has actually decreased *[Morton, 1994: 181ff].* Second, there is good evidence that farmers and herders are able to convert common land into more or less private tenure, *where it is worthwhile.*

The correct conclusion is that it is not worthwhile. The problem is not one of population pressure, developmental change or transition of trust. Instead, it is the lack of any strong incentive or 'temptation' either way; partly because of the technical factors controlling returns to farmers and to livestock owners but more importantly because of the stifling and economic compression of the Darfur economy that has resulted, in the main, from a wider political failure of the Sudanese state *[Morton, 1994: Ch.3].* The externality of overstocking is simply not relevant.

MANAGEMENT, POPULATION AND CARRYING CAPACITY

There is now a large and increasing literature showing that it can no longer be accepted that African pastoralists are not rational economic agents *[Behnke and Scoones, 1991: 23ff].* The evidence for Darfur is reviewed in detail elsewhere with the clear conclusion that Darfuri cattlemen are entirely rational. They keep the number of animals they do for the good reason that it is profitable. If they do treat them as a store of wealth it is because there is no alternative investment which provides any better combination of security and return. If the Darfur range is overstocked, it is not because of any

'cattle complex' or special strategies of subsistence or risk-avoidance *[Morton, 1994b: 163ff]*.

To measure range overstocking directly it is necessary to compare livestock populations with the safe, sustainable carrying capacity of the resource but there is increasing scepticism about the whole concept of carrying capacity in Africa *[Bartels et al., 1990]*. The results from Darfur can only add to that scepticism. It has proved impossible, despite considerable efforts, to achieve a convincing estimate of livestock numbers and, given these difficulties of measurement, it is unlikely that a definitive answer will ever be possible. Indirectly, however, overstocking is looking increasingly implausible, simply because all attempts to tackle the problem meet with indifference from those who are supposed to be suffering from it and because the cry of overstocking has been raised so often and for so long, while stock numbers just keep on growing *[Morton, 1994b: 169ff]*.

AIR, WATER AND PASTURE

Nevertheless, the Tragedy of the Commons predicts that overstocking will occur even when economic agents behave entirely rationally in the search of maximum profit. Nor do doubts about the extent of environmental degradation disprove the contention that open access to the rangeland leads to significant economic losses.

There is an important distinction to be made between what may be termed congestion and degradation on open access resources. In Pigou's classic example of two roads, too many people will use the good one so that they get in each other's way. That is congestion, which might may be called an Annoyance of the Commons but is hardly a tragedy. Degradation, the Tragedy, would occur if the weight of traffic on the good road actually damages it. In poor pastoralist areas congestion itself might well reach tragic proportions, if it were to drive livelihoods down to poverty levels, but there is no doubt that most people consider that degradation is the true tragedy: the destruction of the long term potential of the resource.

The distinction is important for a number of reasons. First, because degradation can occur even on resources that are not free access. If mechanised farming in eastern Sudan mines the land resource, as is often said, it is not because of free access. Second, because the two are offsetting. By driving down current profits on on a free access resource, congestion may actually prevent the exploitation reaching a mining level at which degradation starts to occur. Lastly, economic losses from congestion might be significant long before degradation starts to occur.

To put this another way, overexploitation of a free access resource creates two separate externalities: congestion which affects all the herders

using the resource at the same time, and degradation which affects future generations of herders. The analysis which follows is restricted to the simpler, congestion case, although there seems no a priori reason to think that the result would be significantly different if this simplification were abandoned.

If it seems increasingly unlikely that it will ever be possible to measure carrying capacities and overstocking directly, there remain two other, possibly more powerful, ways to test the institutional model of environmental pressure and to determine where Darfur lies on Lipton's four-point scale. The first is to assess whether or not the institutional framework is as undeveloped and rigid as the model requires. Are the walls of the prison so very strong and inpenetrable? Are the transactions costs of a solution so very high? The second is to estimate directly the incentive to manage the land resource more carefully. This section addresses the first of these and the next section the second.

If overstocking is a real problem, it implies that neither of the two possible routes to escape from the Prisoners' Dilemma of non-co-operative misery can be taken: through negotiation or through unilateral enclosure; which could be by consent or by force, or through 'aggressive overstocking' by one herder to drive others off the range. In Darfur it is often suggested that the traditional consensus in favour of open access to rangeland remains too strong to allow enclosure while political and economic changes have destroyed earlier arrangements under which the larger tribal groupings controlled movements between their respective areas of rangeland by agreement. The relatively intensive efforts made by the Condominium authorities to manage tribal relations and support those arrangements, counted against them after independence. 'Any policy which tolerated nomadism was dismissed as colonial' *[Adams, 1982: 275].* This is a reversal of an argument put forward to explain similar problems in East Africa, especially Kenya, where it is argued that it was colonial penetration that first destroyed the 'adaptive' tribal institutions that prevented abuse of the rangeland *[Bennett, 1984].* Either way, these arguments match Lipton's view of 'old chiefly authorities and clan-like decisions' being undermined.

In reality, however, rangeland control at the end of the colonial era was very loose despite the years of support from the Condominium government. The only restrictions on the movement of livestock were those required to avoid damage to crops, except where there were special reasons for tribal tension.

> It is customary for any member of a tribe to have the right to graze his animals at will over the tribal land of his tribe providing that they cause no damage to cultivation or to gum gardens. The responsibility of

> keeping animals out of cultivation and gardens is on the herdsman. Grazing boundaries exist between tribes where ill-feeling has made them necessary. Similar boundaries may exist between sub-sections of a tribe or adjoining villages but they are an exception to the common practice. Strangers are required to gain permission to graze their herds *[Tothill, 1948].*

The situation has not changed. Livestock herders are still required to avoid cropped areas during the season and farmers should not crop on acknowledged livestock routes. The principal routes *(ar Murhal)* are defined by custom and latterly enshrined in local government orders. They are supposed to be 40 ropes, or 120 metres, wide. Each main route has many subsidiaries branching off it and running parallel and the herds travel rapidly between the cultivated areas in order to reach more open range where they can spread out to graze. Farmer/herder clashes are mostly the result of a herder losing control of his stock in transit, not because of direct competition over grazing land. (This is not to say that the 'loss of control' is always innocent.) From their side, herders resent cultivation because it blocks access to grazing or, especially, to water, not because of the loss of pasture. In normal times, there are acknowledged procedures for negotiating compensation for damage done to crops by livestock. A few hours' inadvertence by a herder can result in his having to sell two or three head of cattle to pay compensation.

In short, the customary procedures mediating between herder and farmer are designed to facilitate movement, not to control stocking. It is not irrelevant that one of Coase's examples of how the market can handle externalities is precisely that of cattle trampling crops and Darfuri customary arrangements that are still in place prove his point; that given clear rules, compensation arrangements can and do work *[Coase, 1960:1].*

The cattle owners of Darfur do not themselves appear to regard the range as being overstocked, at least not so much as to wish to tackle the problem. Under the WSDC programme single villages were encouraged to enclose relatively large grazing reserves and given considerable support in so doing, including measures to support their legal right to enclose. This did not lead to any obvious degree of destocking. On the contrary, the community allowed outsiders to bring their cattle inside the enclosure, more or less destroying the point of the exercise. This parallels experience elsewhere. `The Samburu voted out all grazing schemes when given the opportunity to do so in the late 1960s' *[Bennett, 1984].*

The customary position on rangeland is summed up in the saying that three things are free: *'Al Hawa wa Al Ma'wa Al Kala'* – air, water and pasture. Although acknowledged by almost all, this well defined position is being breached quite widely. Communities and individuals are establishing enclo-

sures which clearly do more than just protect the crops. These are known as *Zara'ib al hawa,* or 'enclosures of air', apparently in sarcastic reference to the traditional three things that are free. In the mid-1970s at the village of Diri, west of Nyala, 'about 30 people worked for 10 days constructing a communal enclosure for the village herd' . There were also individual attempts to 'enclose pasture by Zeribas' *[Haaland, 1980].*

Behnke, working in the same area in 1984, developed this to show that the degree to which range land was being enclosed and crop land acquiring more individual tenure depended on the distance from the major urban centre of Nyala, an important market for fodder *[Behnke, 1985].* In the JMRDP area, a relatively recent trend is the gradual extension of a plot cleared from virgin bush, year by year, until it includes an area of fallow. The cropped area is then rotated within the fenced area and the fallow produces a crop of natural grass which may be cut and stored *[JMRDP/HTS, 1985].* In yet another part of the WSDC area, the alluvium of southern district, transhumant herders reported that they had bought the right to graze over enclosed land, in most cases pure grassland not just crop land left to fallow *[WSDC, 1984].* All of the above instances indicate a move towards the enclosure of rangeland by groups or individuals to conserve fodder, in many cases for sale rather than for the household's own livestock.

To sum up, if there is a Tragedy of the Commons in Darfur, neither traditional structures nor Lipton's four factors of population growth, development change, risk aversion and 'transition of trust', adequately explain why the region's herders have failed to escape it. Where it is worthwhile, Darfuris are perfectly capable of finding both escape routes from the Prisoners' Dilemma: negotiation and enclosure. Where rules to organise negotiations over externalities are needed, to control transit damage by livestock, they exist and usually work. (I have argued elsewhere that the persistent violence in Darfur does not reflect increasing competition over resources but rather a failure of dispute-resolution mechanisms at the political level *[Morton, 1994: 226ff).* Similarly, where enclosure is likely to be worthwhile, Darfuris are happy to do it, regardless of the overt consensus against it, and there is no evidence of attempts to resist these enclosures. That in itself is is a strong indicator of the weakness of that consensus. Frequent tribal fighting has shown that Darfuris are not slow to defend those interests that do concern them.

Enclosure is not difficult but neither is it common and it is clearly related to special situations, in particular urban demand for fodder. The vast majority of the range remains open to all. There is only one conclusion left: that the benefit to be gained from controlling stocking is too small to justify the effort of enclosure or of negotiation. An indirect but forceful indicator of the low value placed on rangeland is the failure of attempts to extend it by providing

extra water supplies from *hafirs* (tanks) or from boreholes. Herders are not interested in maintaining these, in sharp contrast with farmers who make strenuous efforts to keep their water supplies going *[Adams, 1982: 273]*. Herders also make every effort to avoid paying for water for their herds, even where to do so might give access to better grazing.

THE 'TEMPTATION'

A games theory model allows an indicative analysis of the incentive to manage the range resource more carefully, to test by different means the conclusion of the previous section: that controlling stocking is not worthwhile. Table 1 shows a model herd of 1,000 head divided between a community and a free rider. For simplicity, offtake is used to denote returns net of costs. (An important part of the benefits from destocking might be expected to come in the form of costs saved when the herd is smaller, above all the cost of the capital tied up in the herd itself.)

TABLE I
MODEL OF A DARFUR CATTLE HERD (UNITS = HEAD OF CATTLE)

			THE COMMUNITY	
			No Change	Destock
THE FREE RIDER	No Change	Herd	990:100	810:190
		Offtake	72:8	64.8:15.2
		Total Offtake	80	80
	Destock	Herd		810:90
		Offtake		81:9
		Total Offtake		90

The columns show the choice taken by the Community, to keep stocks high or destock. The rows show the Free Rider's choice. (As the Free Rider will not destock if the Community does not, the bottom left box is empty.) In each box, the situation that results from the combined choice of both parties is shown, the Community's herd size and output on the left and the Free Rider's on the right. The current offtake rate, if neither party destocks is eight per cent, equivalent to that recorded in surveys from South Darfur. If the total herd could be cut by a tenth it is assumed that it would rise to 10 per cent. If the Free Rider decides not to co-operate, he will increase his herd to take up the slack created by the Community's destocking and total output will not change but his share of the total, overstocked, output increases.

What would happen if the Community offered the Free Rider a trade. To do this they would have to offer him as good a deal as he would get from increasing his herd to 190 and capturing all the gains of their destocking. Can they do it and would it be worth it? The answer is yes:

Community's co-operative gain:	81	-	72	= 9
Free Rider's non-cooperative gain:	15.2	-	8	= 7.2
Free Rider's cooperative gain:	9	-	8	= 1
Community bribe to Free Rider:	7.2	-	1	= 6.2
Community gain minus bribe:	9	-	6.2	= 2.8

How implausible is this? In some ways very. The Community's net gain is small, only four per cent of their original offtake and in a more real world the transactions costs between a community of thousands and potentially hundreds of free riders would be very high. However the real point of the model is to emphasise the very narrow range within which the Tragedy of the Commons can be operative; the narrow range in which the externality is relevant. A relatively small change in the assumed improvement in the offtake rate can shift the numbers either downward, to where it is not worth anybody's while destocking, or upward to a position where even the Free Rider unambiguously gains from co-operation.

In the model a ten per cent reduction in the size of the herd generates a 25 per cent improvement in performance: from eight per cent to ten per cent offtake. If offtake only increases to 8.9 per cent, an 11 per cent improvement, this is not enough to compensate for the reduction in numbers

TABLE 2
THE RANGE DILEMMA RELATED TO HERD PERFORMANCE

Offtake rate	Community Gain	Free Rider's Gain		
%	Cooperating	Cooperating	Not Cooperating	'Bribe'
8.9	0.0	0.0	7.2	-
10.0	9.0	1.0	7.2	6.2
11.0	17.1	1.9	7.2	5.3
15.0	49.5	5.5	7.2	1.7
20.0	90.0	10.0	7.2	0.0

and total offtake does not increase at all. On the other hand, if the performance is doubled by destocking then the Free Rider gains just as much from cooperating as he does from stealing the Community's reduction in numbers (Table 2). Well before the position is reached at which the Free Rider is unambiguously better off, the amount needed to bribe him to cooperate becomes diminishingly small compared to the Community's gains.

The conclusion is that the Tragedy of the Commons position is essentially

unstable; changes in costs, returns and technical productivity are all likely to push it down, to a position where there are no relevant gains to be made from the establishment of institutions to control over-exploitation of the free access resource; or up, to a position where the gains are so great that the incentive for all parties is towards resolving the problem.

Technically, a free access resource is overexploited when an excess of a variable factor of production (typically labour) is used to exploit it; excess in the sense that the marginal social return to that factor at that level of production is less than the marginal social cost. Where more than one variable factor is involved, one may create a greater externality than the other and the combination of factors will also be distorted. As a result, production will be unnecessarily expensive. It is even possible that the result will be under- rather than over-production off the free access resource *[Gould, 1972: 400]*. On the Darfur range, the two variable factors are labour and the capital value of the herd. Clearly, it is the herd size that creates the twin externalities of congestion and degradation, meaning that the problem lies in excessive application of capital.

Using data from Darfur and Gould's model, it is possible to estimate of the current level of the incentive to control overstocking, the Temptation to Goodness or Badness. The model is as follows:

K = Capital and R = the return on Capital
L = Labour and W = the wage rate
M = the free access resource (here Rangeland)
X = output

The production function is such that:

$$X = X(K,L,M)$$

and it has constant returns when all factors are variable, diminishing returns when M is fixed. By Euler's theorem, the total output X is divided amongst the three factors according to their marginal products as follows:

$$K.mpK + L.mpL + M.mpM = X \quad (1)$$

On standard assumptions, the marginal product of capital (mpK) equals the market return on capital (R) and the marginal product of labour (mpL) equals the wage rate (W). Since rangeland is a free resource the marginal product of rangeland (mpM) equals the market price, zero, so that:

$$K.R + L.W = X \quad (2)$$

The following data from a WSDC survey of the larger transhumant herds in Eastern District of South Darfur, the most important cattle producing area of

all, can be entered into the equation:

Cattle herd	100 head
Sheep	50
Goats	20
Total capital value	£s 13,640
Family Labour	1,095 mandays (3 x 365)
Herding:Daily Wage	£s 1 per day
Total Revenue	£s 2,035 (stock sales plus small amount of ghee)
Running costs	£s 396 (veterinary, water etc)

Source: WSDC *[1984].*

The return on capital (R) can be estimated from the following equation:

$$13640.R + 1095.1 = 2035 - 396$$
$$R = 3.99 \text{ per cent} \qquad (3)$$

The subsistence value of livestock products can be left out of the equation because they form part of the wage and would, therefore appear on both sides and cancel out. The wage rate shown is low compared to contemporary surveys of the farm sector, which show a return on family labour of around £s2 *[WSDC, 1982].* This partly reflects the missing subsistence value of livestock products but also the fact that farming does not offer the same 365 day employment as herding. Wages paid to labourers raising water for the cattle in the survey were paid between £s 30 and £s 50 per month plus food, supporting a 'family wage' of around £s 1. One major cost has been excluded, mortality. Losses recorded during the survey were high because of poor rainfall and rinderpest but it is assumed for analysis of the longer-term situation that losses on average balance out. Drought and disease may also have driven down prices at the time of the survey. However, this should have been balanced out to some extent by the fact' hat both the revenue and the capital value of the herd were calculated using the same market prices.

The purpose of this calculation is to get back to the question of the incentive to deal with the problem of overstocking. This may be done by looking again at the original equation:

$$K.mpK + L.mpL + M.mpM = X \qquad (1)$$

Given all the normal economic assumptions, the optimal level of production off the rangeland should be reached when the marginal product of that rangeland (mpM) is equal to the rent that is paid. It is because free access

means that the rent is zero that the rangeland is overused, or overstocked. Lipton's 'temptation to good' (or the alternative 'temptation to bad') can thus be measured by the rent that would be generated if the overstocking were cut back. If the potential rent is high then it will more than cover the transactions cost of negotiating a socially optimum Coase trade of the externalities or the fencing cost of individual enclosure.

It is a striking feature of the work on African rangeland that there are few direct estimates of what the potential production gains from destocking might be. All that can be done, therefore, is to calculate the level of rents that might be generated at various levels of destocking and of production improvement. Transforming the equation above gives:

$$mpM = \frac{X - K.mpK - L.mpL}{M}$$

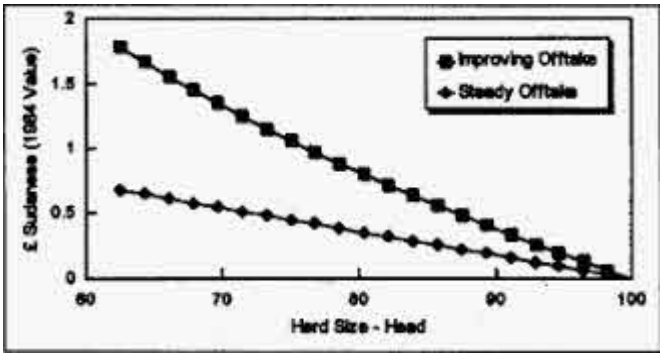
Taking the estimate of a safe sustainable stocking level of 10 hectares per 300 kg Livestock Unit, the example herd from the calculations above, which is about 87 LSU, would need approximately 900 hectares, which becomes the value for M. Two opposite assumptions may be made about the effect of destocking, giving the outer boundaries on the value of mpM, that is, the rent in Sudanese pounds per hectare.

On one assumption destocking raises the herd's performance substantially, such that total offtake increases as the herd gets smaller (labelled Improving Offtake in Figure 1, this is calculated on the basis that offtake increases by ten per cent for every ten per cent reduction in the herd). The opposite assumption is that the herd's performance only improves by just enough to hold the total offtake steady (Steady Offtake). In other words, the benefits of destocking come solely from the cost savings that result from a smaller herd. (The earlier simplification that Offtake denoted Returns Net of Costs does not apply here.) It is assumed that capital and labour requirements are in fixed proportion to the size of the herd. Those bounds are graphed in Figure 1.[4]

As the figure shows, even on the more optimistic assumption, the 'rent' only reaches £s 2 per hectare when the herd has been reduced by a very improbable 40 per cent: from a capital value of £s 14,000 to £s 8,750. This would imply that the owner would have around £s 1,800 a year (at 1984 prices equivalent to some US$ 600) with which to finance and maintain fences around the 900 hectares he would need, or to negotiate a deal with with his competitors. It is quite unlikely that this would be enough to fence around such a large area. It is easy to build a temporary thorn zariba at first, merely by felling the thorn trees along the line of the fence required but a zariba needs renewal every two or three years, thanks to the termites, and fresh trees have

to be dragged ever greater distances to do this; besides which even a good fence has to be patrolled. The alternative approach, herding the animals more closely and controlling numbers and access to different sections of the range, is likely to be at least as costly and, whichever method is used, nothing can prevent a loss of the mobility and flexibility that is a key advantage of the existing system.

FIGURE 1
IMPLICIT 'RENT' FOR DARFUR RANGE
£ SUDANESE PER HECTARE



One of the classic solutions to the problems of free access resources is taxation. Theoretically, it is difficult to calculate the correct level of tax and the tax has to be applied to the correct factor of production. Taxes on output do not have the right effect. Despite these difficulties 'quite crude approximations may be rewarded by significant efficiency gains' *[Gould, 1972:401]*. It is worth noting, therefore, that the colonial system, which is now in decay, was to tax livestock numbers, that is, the capital factor: the best theoretical option. Nowadays, government focuses its livestock taxation on sales, that is to say on output, because it is easier to collect.

CONCLUSION

The conclusion is that the institutional model of environmental pressure is not valid for Darfur. The ample circumstantial evidence of increasing pressure on both the crop land and the range land is misleading and it has diverted attention from the need to establish three facts: (1) that the traditional support for communal access to rangeland prevents enclosure for de-stocking or other reasons; (2) that the rangeland actually is overstocked; and (3) that more careful range management would result in higher

production. As far as the first is concerned, farmers can and do enclose rangeland, if it is worth it. For the second, enormous efforts to count cattle numbers and estimate carrying capacities have failed to show that the range is overstocked, in any practical sense that production is lower than it would be if numbers were reduced. Nor has it been shown that the range is in terminal decline. For the third, livestock research has barely got off the ground *[Morton, 1994: Ch 3]*.

To answer the two questions posed at the beginning, the resource endowment has not in general changed enough to justify changes in land tenure, and, where there has been such a change locally or in a limited sector, a process of institutional adjustment can be clearly discerned; indicating a greater degree of social flexibility than is generally realised.

Livestock herds in Darfur may not have even gone significantly beyond the first of Lipton's four phases in the Tragedy of the Commons, in which expansion by any one individual does not affect the rest of the community at all, It seems highly unlikely that the third phase, in which communal losses are greater than individual gains but not by enough to cover the transactions costs of social management, will be reached in the near future. This conclusion should not be taken to indicate, in any way, that the existing situation in Darfur is not extremely unhappy. To say that drought, famine and persistent tribal fighting do not prove the hypothesis of a Tragedy of the Commons is not to deny their existence but rather to show that the causes of these calamities must be sought elsewhere; above all in the inability of the Sudanese state to provide the minimal public functions needed to support a civil society *[Morton, 1994: 235ff]*.

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Notes

[1] The parallel situation in the cropping sector is analysed elsewhere with similar conclusions: that secure tenure in land can be gained without great difficulty but in most cases it is just not worthwhile and that expansion of borehole water supplies has actually reduced the intensity of land use *[Morton, 1994: 181ff)*.

[2] The thrust of the Coase Theorem is that if the rights to use a resource are well defined, then competing users will negotiate an efficient level of use that minimises the negative effects (externalities) that they impose on each other, provided that the transactions costs of that negotiation are not excessive. A classic example is that of fishermen who pay a factory to reduce the pollution it pumps into the river they fish, thus putting a market value on the externality.

[3] The Prisoners' Dilemma is whether to confess or not. If only one does so he may gain his freedom at the expense of the others, unless they also confess; in which case all are convicted. For the gang as a whole, the best option is to maintain silence so that all receive light sentences but the most likely outcome is the worst possible, that all confess because

they cannot talk to one another and agree a joint strategy. In other words they cannot negotiate a Coasean agreement because the transactions costs imposed by the walls between their cells are infinite.

[4] At the origin in the figure the herd parameters are based on the survey figures, simplified and expressed solely in terms of cattle for ease of calculation:

Survey Data: Herd Size = 100 Cattle, Capital Value (K) = £S 14,000, Labour Days (L) = 1095, Wage (W) = £S 1, Offtake = 11 Cattle Equivalent, Sale Price Net of Running Costs = £S 150

Calculated Parameters: Labour Cost (L.W) = *£s 1,095,* Income (X, Offtake*SPrice) = *£s1650,* Return on Capital (R, Eqn 3) = 4%, Cost of Capital (K.R) = *£s560,* Rangeland Required (M, See Text) = *900 hectares*

The implicit rangeland rent at the origin is then calculated substituting the underlined parameters into Equation 4 as follows:

([X]1,650 – ([L.W]1,095 + [K.R] 560))/[M]900 = £S 0.00 per hectare

If the herd is reduced by 10% the changed parameters are: Herd Size = 90, K = 12,600, L = 985, Offtake = 12.22(Improving) and 11 (Steady). Giving the equations:

Implicit Rent
Improving Offtake ([X]1833 - ([L.W]985 + [K.R]504))/[M]900 = £S 0.38 per hectare
Steady Offtake ([X]1650 - ([L.W]985 + [K.R]504))/[M]900 = £S 0.18 per hectare

Other points on the graph are calculated in the same way.

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