Beyond Mobility:
The Role of Fuzzy Access Rights and Common Property Considerations in Semi-Arid African Pastoralist Systems

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Abstract:
Increasing populations and agricultural encroachments upon rangelands are stressing traditional land management institutions in sub-Saharan Africa. We consider three characteristics of these systems: pasoralist mobility, common usage of communal pastures and the fuzzy, or imprecise, nature of traditional grazing rights. We find that in the presence of these factors the traditional system may be socially preferable to either privatization or the enforcement of complete common access for all users.

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Increasing populations and agricultural encroachments upon rangelands are stressing traditional land management institutions in sub-Saharan Africa. Many researchers have noted that mobility is a valued strategy of pastoralists in arid and sub-arid regions of sub-Saharan Africa (SSA), and is threatened by these forces. (cf. Ellis and Swift, 1988; Scoones, 1994; Swallow, 1994; van den Brink et al. 1995) These observations and the failure of earlier privatization strategies has led to a widening of the policy debate regarding the future of these systems. The adoption of policies believed to promote the effective management of common property resources has been added as a third policy alternative to be evaluated, along with privatization and maintenance of the traditional land access regime. In order to contribute to the policy discussion we focus on two features of SSA pastoral systems that greatly influence the benefits of mobility and affect the relative desirability of the above policy options.

First, pastures are generally grazed in common, so that more than one group may utilize an area in a given season. Second, these sub-Saharan pastoral systems are characterized by the fuzzy nature of grazing boundaries and fuzzily-defined access to pastures by different groups. In contrast to the predictions of the conventional common property literature, observers note that these ill-defined sets enhance the effectiveness of the pastoral system. These features lead to the following questions: 1.) Do common property considerations affect the benefits of mobility and hence the relative desirability of the three policy options identified above? 2.) Does the conventional common property analysis, which assumes that grazing areas and group membership are well-defined, adequately capture the logic of the system under examination? and 3.) If not, then does a model that captures the inherent fuzziness of resource access produce different results with respect to the relative desirability of these three policy alternatives and to the system's response to changes in the exogenous parameters?

Including Common Property Considerations in the Analysis of Mobility

We begin our analysis of SSA pastoralist land systems by considering a standard common property game following McCarthy (1996). We compare this game to the Van den Brink et al model of non-exclusive property rights, which enable mobility, for a single pastoralist. In our non-cooperative game, player A maximizes the following expression when he chooses his stocking rate for the common parcel:

$$a(1+\theta)(\alpha - \beta(a+b)/H)$$

where a is his own stocking rate, b is B's stocking rate on the common property parcel, θ is the shock to total gain due to weather and other parcel-specific factors, α is the per-head per hectare gain, H is hectares in the parcel and $\beta(a+b)/H$ is the reduction in gain per animal due to the externalities imposed by the total stocking rate. Under this standard common property regime, each player has full access to the available forage, and believes that his opponent has full access to the available forage as well. Under this specification, total use is of the common pasture $a+b=\frac{2\alpha H}{3\beta}$. For purposes of comparison, observe that each herder chooses a stocking rate of $\frac{\alpha H}{2\beta}$ for his privately-held core grazing area. The results mirror those obtained in countless non-cooperative games (c.f. Dasgupta & Heal, 1979); grazing pressure is higher on the common property resource, and rents are dissipated compared to the gains realized on the core areas.

Using these results, we can evaluate the effects of including common property considerations in a model otherwise similar to that developed by Van den Brink et.al. (1995). There, they choose whether or not to move animals to a new area in period two, after the realization of rainfall is known across all parcels. There is a transaction cost associated with moving to a new parcel; given this cost and known rainfall realizations for all parcels, they choose the optimal parcel for grazing. Similarly, in our model pastoralists graze their core areas during the first period, then, after rainfall realizations are known for each parcel, decide whether to move to the common area in period two. Following Van den Brink, our grazers move to the location with the highest return given that movement is costly. Our movement cost for each pastoralist is a function of the distance to the common pasture from his core and his stock. This cost term captures the per animal energy expenditure on movement, plus the added labor time dedicated to herding and guarding the animals. Rainfall is distributed identically and independently across pastures. Two rainfall realizations, high and low (θ_H and θ_L), occur with equal probability. Pastures have identical productivity parameters. Possible outcomes are described in Table 1.

Profits to each are significantly lower when they both use the common area than in any other case, for two reasons. First, the presence of the other clan reduces the forage available relative to when only one clan utilizes the common area during the second period, even if the common pasture is managed cooperatively. Following observed patterns of common grazing land use, however, where total stocking rates are often above those predicted by the cooperative framework, the non-cooperative behavior of the clans when both use the common grazing area creates negative stocking rate externalities, a second source of reduced profits for both players. These externalities reduce returns below the private stocking level returns on a per hectare basis, as shown in the table.

This comparison illustrates the importance of common property considerations in pastoral sub-Saharan Africa. Two important features of these systems are related to common use: 1) the number of users of common grazing land is dependent upon the weather shocks to their core grazing areas, and 2) the negative externalities associated with overgrazing when the commons are not perfectly managed.

Consider the identified effect on expected profits and variability, compared to when each herder is restricted to his core area. Expected profits are greater and profit variability is reduced for each player when he has access to two parcels and can move his herd ex post. Profit variance will be lower if there is cooperation over the common property plot rather than non-cooperation. (While here we have assumed that the relative value of the two rainfall shocks is such that a herder facing a low rainfall realization on his core area will move to the high-rainfall common area, even if he encounters the other herder, this assumption is not necessary for these results.) These observations may be summarized as follows:

Proposition: Access to a common grazing area increases expected profits and reduces profit variability relative to the case where herders are restricted to their core grazing area. Variability is reduced more when there is cooperation over pasture use.

Fuzzy Access Rights

As stated in the introduction, access to pastures is generally more complicated than a conventional common property model, such as the one above. In particular, grazing area boundaries and, more importantly, clans' membership in the grazing access group for given pastures, appear to be rather imprecise. Some clans may use a pasture consistently from year to year, other clans may use it two years out of five, and yet others may use it only occasionally. Further, clans' use of the pasture may depend on conditions in other parts of their grazing range.

Fuzzy set theory aids us in modeling these features of the grazing access system. Fuzzy property rights reflect the notion that access is to certain areas is considered either partial or incomplete by pastoralists**.** In the following analysis, we incorporate the notion of "fuzzy" access rights for the common pasture.

Fuzzy set theory examines imprecise phenomena that lack clearly defined class criteria.[1] The pastoralist land access system in sub-Saharan Africa appears to be this sort of system. Access rights are not clearly defined. Conflict between groups may arise due to the failure of a group desiring access to an area primarily grazed by another group to ask permission before moving, *and* may also arise due to the failure of the primary user to grant this permission when requested. The fact that both these situations may lead to conflict indicates that access is defined imprecisely, or fuzzily. If the primary user group had clearly defined rights which allowed it to exclude other groups arbitrarily, as in a private property regime, the refusal of permission to graze would not lead to conflict, within the context of the institutional system. The behavioral norm of other groups requesting access from the primary group indicates that, even though they expect to be

[1] Kaufmann and Gupta (1991), Driankov, Hellendoorn and Reinfrank (1993), Jamshidi, Vadiee and Ross (1993) develop basic fuzzy set theory. Dompere (1995), Mansur (1995), Greenhut, Greenhut and Mansur (1995) and Goodhue (forthcoming) use fuzzy logic to model features of economic systems.

allowed to graze, they do not feel that their right to do so is complete, as would be the case in a true common property regime.[2]

The previous section demonstrated that the benefits of mobility will not be eliminated by standard non-cooperative considerations when both herders utilize the common pasture. In part, this is because under our specification there are cases where both herders do not choose to graze the common pasture. We now shift our attention from the interaction between mobility and multiple users to the nature of access rights, and how these rights affect stocking decisions when the pasture is jointly utilized.

Under the fuzzy access formulation, herders do not regard their access to the common pasture as necessarily complete. They recognize that other clans may access the same land, so that the available forage is less than the total forage produced, and regulate their stocking decisions accordingly. Further, they consider their access not only incomplete, but also imperfect; their access rights do not allow them to exclude others from some portion of the available forage. Due to the nature of their access rights, they regard the externality due to overstocking to be more severe. The nature of their access rights and its effects on their stocking decisions is reflected in the following maximization problem, where P represents the degree of fuzzy access and ranges from 0 (no access, core area of other herder) to 1 (full access, own core area or crisp common property), and I indexes a and b:

[2] An alternative method of modeling the observed system of partial access would be to allow herders to have beliefs over the percentage access that they have to forage in a given area. This alternative, however, will be internally consistent only in cases where the pasture is perfectly managed. If the idea of percentage access is defined more broadly, then it becomes functionally similar to fuzzy access, but lacks an equivalent theoretical basis.

$$\max_i \; i(1+\theta)\left(\alpha \; - \; \beta\frac{(i+j)}{(P_I H)}\right)$$

Under this formulation, each agent stocks $i = (2P_I - P_J)\alpha H / 3\beta P_I$, j≠i. If $P_A + P_B = 1.5$, then fuzzy access rights lead to a total stocking rate equal to the stocking rate each herder chooses for his core grazing area. If the total level of fuzzy access is lower than 1.5, then the total stocking rate on the common parcel will be lower than the private stocking rate. If $1.5 < P_A + P_B < 2$, then the stocking rate will be higher than the private stocking rate, and lower than the crisp common property stocking rate. When $P_A + P_B = 2$, then the stocking rate is equal to the crisp common property stocking rate, since both clans believe they have full access to the available forage.

Returns for A from the common parcel are $W = (1+\theta)\dfrac{\alpha^2 H(2P_A - P_B)^2}{9\beta P_A}$. Note that for profits to be positive, A's access rights must be no less than ½ B's, and vice versa. With sufficiently different access rights, stock levels of those holding higher rights will drive total stocking rates so high that the negative externalities incurred by the low-access person will yield him negative profits. As may be seen in this expression, profits to Clan A are increasing in their own access and decreasing in Clan B's access.

The graph plots total returns to A and B. Each line is associated with a given level of fuzzy access for A. Higher lines denote higher levels of initial access. Note that total profits are highest when rights are asymmetric. At the extremes, when only one clan has full access,.the regime is equivalent to private property. For symmetric access rights, profits to each clan are everywhere below profits accruing when both have full access.

This can be seen in the following equation for the total social returns from the use of the common pasture: $\pi_a + \pi_b = \frac{\alpha^2 h}{9\beta}\left(\frac{(2P_a - P_b)^2}{P_a} + \frac{(2P_b - P_a)^2}{P_b}\right)$. Social returns will be higher under fuzzy common property than under crisp common property whenever $P_a^3 + P_b^3 > 2P_a P_b$.

Proposition: Relative to the crisp common property regime, fuzzy access rights may result in higher or lower total expected returns when access rights are costless and exogenously determined.

Proof:

Under the crisp common property regime, individual and total expected returns are

$\pi_a = \frac{\alpha_1^2 h_1}{4\beta_1} + \frac{\alpha^2 h}{9\beta}, \pi_b = \frac{\alpha_3^2 h_3}{4\beta_3} + \frac{\alpha^2 h}{9\beta}$, and $\pi_{total} = \frac{\alpha_1^2 h_1}{4\beta_1} + \frac{\alpha_3^2 h_3}{4\beta_3} + \frac{2\alpha^2 h}{9\beta}$.

Under the fuzzy access regime, individual and total expected returns are

$\pi_a = \frac{\alpha_1^2 h_1}{4\beta_1} + \frac{\alpha^2 h\left(2\overline{P_a} - \overline{P_b}\right)^2}{9\beta\overline{P_a}}, \pi_b = \frac{\alpha_3^2 h_3}{4\beta_3} + \frac{\alpha^2 h\left(2\overline{P_b} - \overline{P_a}\right)^2}{9\beta\overline{P_b}}$, and

$\pi_{total} = \frac{\alpha_1^2 h_1}{4\beta_1} + \frac{\alpha_3^2 h_3}{4\beta_3} + \frac{\alpha^2 h}{9\beta}\left(\frac{\left(2\overline{P_a} - \overline{P_b}\right)^2}{\overline{P_a}} + \frac{\left(2\overline{P_b} - \overline{P_a}\right)^2}{\overline{P_b}}\right)$. Note that the expected returns to each individual's private parcel are unaffected by the property rights regime governing the common parcel. Comparing the two expressions for total returns, we see that the fuzzy access regime will result in larger expected returns if $\overline{P_a}^3 + \overline{P_b}^3 > 2\overline{P_a}\,\overline{P_b}$.

This proposition is illustrated in the graph. Total returns in the crisp common property case correspond to the heavy horizontal line.

Privatization

This proposition provides a guideline for cases in which governmentally-guaranteed access for specified clans to well-defined pastures would increase social welfare. If the condition fails, then converting the traditional fuzzy access rights system to a standard common property regime would be welfare-improving. Although this analysis abstracts from access maintenance costs and access right determination, it provides some indication of when the traditional fuzzy access system is likely to be socially preferable.

The government may be able to enforce compensation across groups when it privatizes, or more simply it may only be concerned with social welfare. If the government is interested only in social welfare, or the sum of returns to the two groups, then exclusive access privatization will increase expected social welfare whenever $P_a^3 + P_b^3 < \frac{9}{4} P_a P_b$. If property rights are sufficiently asymmetric, and sufficiently high for the two clans the condition fails and the traditional fuzzy access system dominates privatization in expected terms. (An example of such a pair is (1, 0.65).)

To evaluate the relative desirability of the government enforcing crisp common property rights, we refer to our earlier analysis. Recall that ensuring full common access dominates the traditional fuzzy access system whenever $P_a^3 + P_b^3 < 2P_a P_b$. Whenever this condition holds, though, privatization dominates both options. Consequently, the expected value criterion indicates that government enforcement of full common access will always be dominated by one of the other two options. These results imply that in many cases it is more desirable for the government to seek to strengthen the traditional regime than to impose a new land rights system.

Conclusion and Implications

We find that common property concerns reduce the gains from mobility, possibly significantly. We model the fuzzy nature of grazing access, which is not considered in a standard common property analysis. We derive the condition under which the traditional fuzzy access system will dominate the conventional common property system in expected value terms. Empirically, this will occur when one clan primarily utilizes a pasture, but another clan also maintains access. In expected value terms, privatization dominates the traditional regime whenever a conventional common property regime dominates the traditional regime. These findings indicate that it may be undesirable to create a conventional common property regime.

By introducing institutions designed to promote effective common property management, advocates hope to improve the performance of the conventional common property regime so that it approaches the performance of the private property regime in expected value. Our analysis indicates that under some conditions, even a *perfectly* managed conventional common property regime may not perform as well as the traditional fuzzy access regime. Therefore, it may be more desirable for the government to adopt policies that promote the maintenance of traditional land management institutions than to either privatize grazing lands or redefine access rights.

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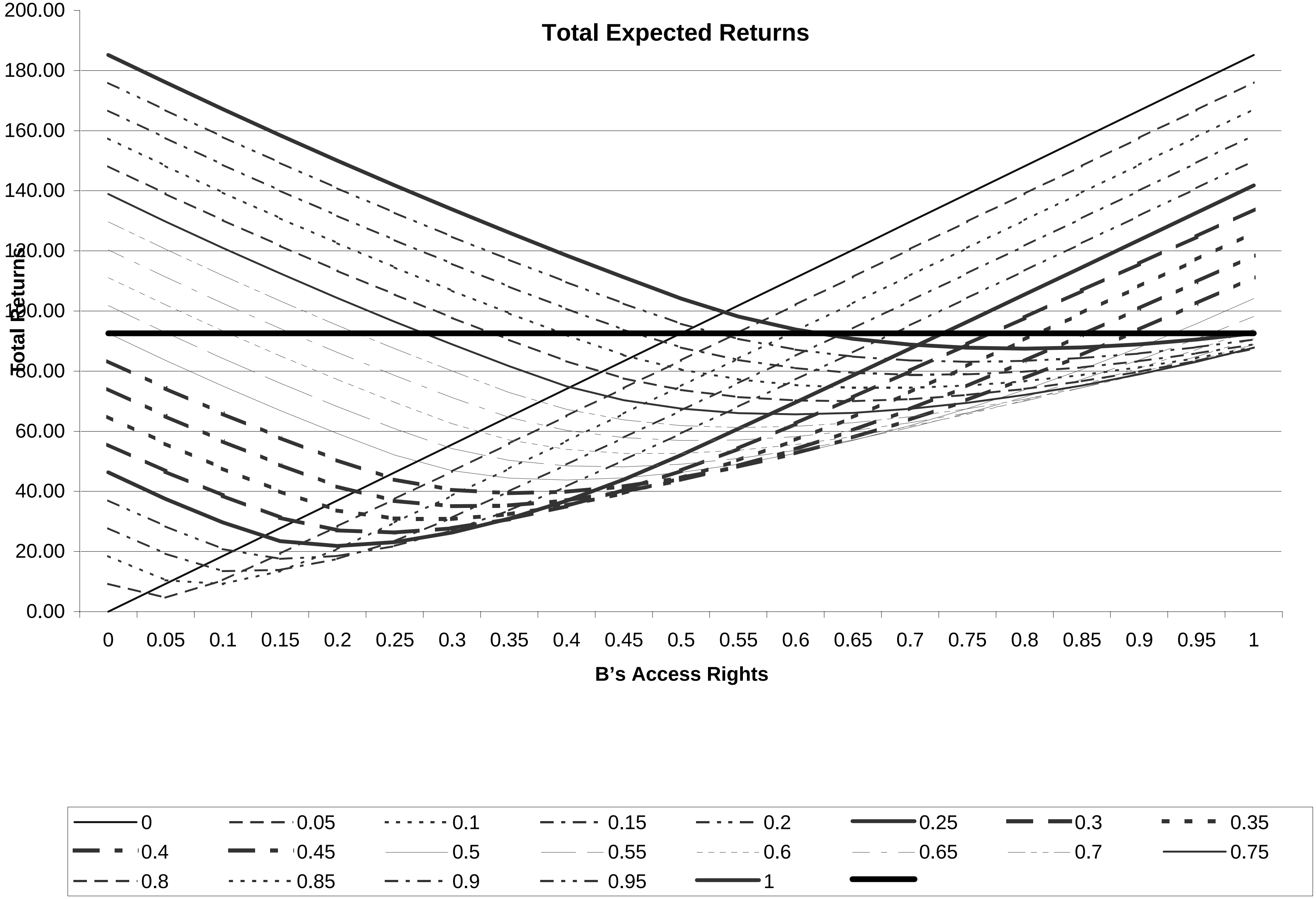

Total Expected Returns
Total Returns
B’s Access Rights
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
0.8
0.85
0.9
0.95
1

Rainfall Shocks			Profits	
A's Core	**Common**	**B's Core**	**A's Profits**	**B's Profits**
High	High	High	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$
High	High	Low	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$	$\frac{(\alpha-t)^2 H}{4\beta}(1+\theta_H)$
High	Low	High	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$
High	Low	Low	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$	$\frac{\alpha^2 H}{4\beta}(1+\theta_L)$
Low	High	High	$\frac{(\alpha-t)^2 H}{4\beta}(1+\theta_H)$	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$
Low	High	Low	* $\frac{(\alpha-t)^2 H}{9\beta}(1+\theta_H)$	* $\frac{(\alpha-t)^2 H}{9\beta}(1+\theta_H)$
Low	Low	High	$\frac{\alpha^2 H}{4\beta}(1+\theta_L)$	$\frac{\alpha^2 H}{4\beta}(1+\theta_H)$
Low	Low	Low	$\frac{\alpha^2 H}{4\beta}(1+\theta_L)$	$\frac{\alpha^2 H}{4\beta}(1+\theta_L)$

* In reality, the herder will choose: $\max\left\{\frac{(\alpha-t)^2 H}{9\beta}(1+\theta_H), \frac{\alpha^2 H}{4\beta}(1+\theta_H)\right\}$