THE ECONOMICS OF CAIN AND ABEL:

AGRO-PASTORAL PROPERTY RIGHTS IN THE SAHEL

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The complementarity of the economic systems of nomads and farmers is often overshadowed by the conflicts inherent in the competition over the control of land. The conflict is one of property rights. A dynamic programming model of the West African Sahel is presented that simulates the emergence of a dual economy based on the comparative advantage of the farmer and the pastoralist. The model illustrates that exclusive private property rights have no claim to optimality. The analysis of risk in an intertemporal framework suggests the optimality of another type of property right--the right to flexible adjustment typically claimed by the pastoralist. Multiple property regimes provide optimal settings for farmers and pastoralists.

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1. INTRODUCTION

> Some say that the quarrel arose at Earth's division between the brothers, in which all land fell to Cain, but all birds, beasts and creeping things to Abel. They agreed that neither should have any claim on the other's possessions. As soon as this pact had been concluded Cain, who was tilling a field, told Abel to move his flocks way. When Abel replied that they would not harm the tillage, Cain caught up a weapon and ran in vengeful pursuit across mountain and valley, until he overtook and killed him [Graves and Patai, 1964: 91].

We draw on the story of Cain and Abel to focus attention on the differing property rights regimes inherent in sedentary agriculture and in pastoralism. This perspective is necessary in light of the recent rather widespread belief among development experts that private--individualized--and exclusive title to land in Africa is the sine qua non of improved economic performance [Feder and Noronha, 1987; Feder and Feeny, 1991]. This new perspective is also timely given the recent developments in property rights theory, particularly with respect to land uses at the extensive margin [Bromley, 1992, 1991, 1989; Bromley and Cernea, 1989; National Academy of Sciences, 1986; Larson and Bromley, 1990; McCay and Acheson, 1987]. Finally, this perspective strongly amplifies the recent developments in the field of rangeland management suggesting the need for more flexible strategies of natural resource use [Cousins, 1992; Behnke and Scoones, 1991].

The conflict between Cain--the farmer--and Abel--the herder--should be understood as one of property rights. In agriculture as well as livestock production, property rights emerge to secure income streams generated by production activities. The nature of the income stream, then, may affect the type of property right that is likely to be established. The crucial difference between sedentary farming and nomadic livestock production is that they differ in ability to react ex post to temporal uncertainty; in other words, they differ in flexibility.[i]

Unfortunately, property rights essential for livestock production in the Sahel have been eroded by a long history of conflicts. More recently, a number of state interventions that expropriated pastoralists of

property rights crucial to their economic systems have clearly favored farmers over pastoralists in the allocation of private property rights. These changes have created general uncertainty over property rights to natural resources, thereby inducing a de facto open access situation. The resulting tragedy of open access, induced by public policy, has substantially increased the costs of running the pastoralist economy (i.e. its transaction costs) and adversely affected the pastoralists' ability to overcome periods of drought. Ever since the publication of Sen's [1981] seminal essay on the relation between famines and Entitlements, the implications of the loss of property rights to the Sahelian nomads need no further elaboration.

In this paper we develop the case for property regimes as instrumental variables in development policy, and we show that highly diverse and variable agricultural ecosystems demand property regimes that allow quick human response to new exigencies. We establish the microeconomic relationship between environmental variability, choice of technique, and property rights in a dynamic, partial equilibrium context. We demonstrate the importance of flexibility as an optimal strategic response of individuals faced with input uncertainty and develop a model simulating a dual economy that arises as the result of rational choice by individuals faced with temporal uncertainty. Such rational choice includes the choice of optimal property rights regimes which allow capture of the income streams of techniques appropriate for a particular agroecosystem.

The model, while in the vein of Demsetz [1967], does not lead us to conclude that exclusive private (individualized) property rights in land are necessarily optimal. Given spatio-temporal risk, other types of property regimes may be more appropriate. Over-exploitation of natural resources in the Sahel has often been associated with the introduction of techniques that allowed for a more intensive use of a given range without the formulation of the type of property rights regimes that could regulate and coordinate such use. As development policies reassess the role livestock in Africa and elsewhere, it is essential that programs be formulated with clarity and coherence so as to avoid the mistakes of the past when "private" or "group" ranches were regarded as the solution to pastoralist "problems."

In the second section of the paper we develop a theoretical model of the dual economy of Cain--the farmer--and Abel--the nomad. The Biblical parallel is used to emphasize both urgency and universality of the problem. The model simulates a dual economy based on the comparative advantages of two different

production techniques faced with environmental uncertainty. An economic theory of optimal production techniques and property rights is developed in a context of dynamic risk. In the third section we use the model to describe the agro-pastoral production system of the West African Sahel. In the fourth section we touch upon policy issues, both in a historical as well as in a current framework.

2. A DYNAMIC MODEL OF AGRO-PASTORAL PRODUCTION

Economists have generated an extensive literature on the effects of risk and uncertainty on economic decision making. However, risk is commonly modeled as if it were "timeless." The formulation of the problem in terms of timeless risk precludes the theory to investigate important economic behavior such as learning and the use of adaptive strategies--dynamic decisions influenced by new information that becomes available over time. Once we introduce temporal risk, a wider variety of economic behavior under risk can be modeled.[ii]

If economic institutions are a response to risk of various types, it seems logical not to restrict analytical attention to only one type of risk. In other words, the recognition that risk is not timeless, but changes over time, is important for the analysis of economic behavior and institutions in general, and property rights in particular. If a farmer puts up a fence around his fields and establishes an exclusive property right to the land, he reduces the risk that others may claim the field, and he assures himself of the full benefits of any investments he would care to undertake in his fields. He establishes ex ante certainty to the exclusive use of the land. The higher and the more certain the income stream he can derive from the exploitation of his field, the more he will be willing to pay for the "fence," i.e., the exclusive property right.

However, where there is ex post uncertainty there is a positive economic value attached to the capacity to adjust ex post. Thus, the ex ante certainty that a nomadic pastoralist would acquire by fencing his range in a situation of extremely variable rainfall, and with a limited potential to improve the productivity of the range, does not represent high economic value. The nomad, then, might not be interested in an exclusive property right to a particular field. He might be more interested in establishing a property right that would enable him to ex post adjust to temporal uncertainty. In particular, he would value property rights that assured him spatial mobility.

Such property rights assure the right holder of a secure income stream. From a pastoralist perspective, establishing tenure security means establishing the security of such property rights as best suited to capture the income stream of a spatially mobile economic activity.

In the following, an economic model is presented that captures the dominant characteristics of the production systems of nomads and farmers in a stylized Sahelian environment. The model simulates a dual economy based on the comparative advantages of two different production techniques with respect to environmental uncertainty.[iii] Choice of technique and choice of property regime become a function of particular eco-zones [Bromley, 1989].

In the model, the climate in the world inhabited by the farmer, Cain, and the nomad, Abel, is not a constant, but a variable. The north is arid and rainfall is extremely variable. Moving south, average rainfall increases while the variability is reduced. Each isohyet runs perfectly west-east over the region. Thus, movements along a particular isohyet do not cause changes in mean or variability of rainfall. This is a stylized approximation of the climatic conditions found in the Sahel. The simulated rainfall regime incorporates this basic pattern.[iv] Every grid on the imaginary map of the world in which Cain and Abel live falls under some specific rainfall distribution. Laterally (i.e., grids from west to east on an isohyet), each grid exhibits realizations from probability density functions with the same moments. North-south movements perpendicular to the isohyets exhibit realizations drawn from density functions that incorporate simultaneous changes in E(**e**) and Var(**e**). This climatic variable defines different eco-zones and is central to the following model.

Cain and Abel live in a simple two-period world in which it can rain in both periods. To optimize fodder availability for his herd, Abel attempts to stay perpetually mobile (for two periods in the model). Given actual rainfall in period 1 (represented by the realization of the random variable **e**) he makes his location decision x_1. This may also be called his ex ante choice. After Abel has observed rainfall in period 2, he decides to move his herd to a new location x_2, exploiting the new grazing opportunities which present themselves. This is his ex post choice.

If we solve Abel's problem recursively, i.e., through backward induction from period t = 2 to t = 1, we would take the following steps. The optimal choice of period 2 location (x_2) is given by the maximand of a

function f representing "ex post utility." The function f is assumed to be strictly concave in its arguments. We postulate that this choice of period 2 location will in general depend on his period 1 location, the period 2 rainfall, and the property rights regime in place. Nomadic nonexclusive property rights are defined as property rights that secure the profit stream of the livestock production activity wherever such production takes place. Note that nonexclusivity does not necessarily mean open access. Nonexclusivity implies that, ex ante, exclusive rights to a particular production location do not exist, but that rights of access exists which are restricted to a well-defined number of property right holders. We leave the exact definition of these rules of access unspecified at this point. Suffice it to say that such rules generally solve a coordination problem, which--in the empirical case of Sahelian pastoralists--are typically solved in a common property regime. Under open access, no coordination would exist, and the number of potential users could be unrestricted.

Consequently, Abel's problem in period 2 is the following:

$$\underset{x_2}{\text{Max}}\ f(x_1, x_2, e, Z) \tag{1}$$

x_1 = location at time t = 1

x_2 = location at time t = 2

e = rainfall distribution in period 2: not known at t=1, but known at t=2.

Z = variable representing property rights. If Z=0, property rights are non-exclusive. Such rights allow Abel to change location in period 2. If Z=1, exclusive property rights exist which prevent locational mobility.

The above optimization problem yields the optimal period 2 location:

$$x_2^* = x_2^*(x_1, e, Z) \tag{2}$$

Working backwards to the period 1 problem, we can formulate the choice of location as based on Abel's subjective expectations with respect to rainfall distributions and the profits incurred through relocation to x_2 after a particular rainfall. Optimal locations x_1 and x_2 are governed by the following dynamic programming problem:

$$\text{Max}\ E_1\{\text{Max}\ f(x_1, x_2, e, d, Z)\} \tag{3}$$

$x_1 \quad x_2$

where E_1 is the expectations operator in period t = 1 over the random variable e, and d represents a transaction cost parameter associated with movements.[v] We allow for transaction costs since the establishment of property rights, whether exclusive or non-exclusive, will normally involve costs associated with information gathering, contracting, and enforcement.

Figure 1 compares the ex post utility obtained under three assumptions.[vi] The first alternative assumes perfect mobility. The second alternative has transaction costs imposed on mobility. The third alternative, labelled "immobility", assumes that Abel stays in the same location during both periods. Utility under perfect mobility is graphed as the solid line. In this case, i.e. if movements are costless, Abel does not have an a priori preference for a given location. If transactions costs on movement are imposed, the expected utility is reduced and a southern location becomes more desirable. The expected value of utility if Abel remains at his period 1 location (under an immobile production scheme) is indicated by the lowest dotted line in Figure 1. Abel would want to move south given the higher expected value of rainfall and lesser variance there. At some point Abel might even prefer to settle in the south and establish himself as a rancher with a fixed location.

Property rights that allow Abel to secure the benefits derived from a strategy based on flexible response to environmental variability have positive economic value. In general, the value of flexibility F (measured in utils) is given by:

$$F = \underset{x_1}{\text{Max}}\, E_1\{\underset{x_2}{\text{Max}}\, f(x_1, x_2, e, d, Z)\} - \underset{x_1 = x_2}{\text{Max}}\, E_1\{f(x_1, x_2, e, d, Z)\} \geq 0 \qquad (4)$$

The value of the nonexclusive property regime (Z = 0) is derived from the value of ex post flexibility F. Abel assesses the value of nonexclusive nomadic property rights by comparing the result of the maximization problem under full mobility with the result of a maximization problem under no mobility. The absence of such nomadic rights would constrain Abel's choice of x_1 to be equal to x_2. If $x_1 = x_2$, it can be shown that F = 0.

[FIGURE 1 HERE]

The expected value of flexibility with and without transactions costs is shown in Figure 2. The solid line represents the value of flexibility without transactions costs; the dotted line represents its value with transactions cost taken into account. As expected, the value of flexibility is highest in the North and lowest in the South, whereas the introduction of transactions costs lowers the value of flexibility for every point of the grid. Note that an increase in demographic pressure can be modelled as an increase in transaction costs.

[FIGURE 2 HERE]

What would be Abel's maximum willingness to pay for a nomadic property regime which, after all, is not costless to uphold? If we express the problem in monetary values, we can introduce initial wealth **w**. Abel's willingness to pay for nonexclusive property rights Z = 0 would be implicitly defined by the following equation:

$$\underset{x_1 \quad x_2}{\text{Max}}\, E_1\{\max f(w - WTP, x_1, x_2, e, d, Z = 0)\} = \underset{x_1 = x_2}{\text{Max}}\, E_1\{\max f(w, x_1, x_2, e, d, Z = 1)\} \tag{5}$$

w = initial wealth
WTP = Willingness to Pay

This equation gives an implicit definition of Abel's willingness to pay for property regime Z = 0. If his willingness to pay is positive, Abel will demand nonexclusive property rights, i.e., Z = 0. The willingness to pay for such a property regime will in general increase with the value of flexibility. As shown in Figure 2, the value of flexibility is highest in the north. Extreme rainfall variability increases the value of an adaptive strategy vis-à-vis a nonadaptive strategy, and, thus, the likelihood that a nonexclusive property rights regime would be established.

Whereas the optimal domain of such a regime in our model is in the north, its territory (a particular set of ex post locations) is not *a priori* defined. Only *ex post* movement following a particular realization of the random rainfall variable will define actual territorial occupation.

We have shown that Abel's production technique induces a demand for property rights that enable him to capture the benefits of flexibility. The base comparison of expected utility (with or without

transactions costs) was always with a situation in which his pastoralist activity was restrained by immobility. For Cain, the farmer, the problem is different. Being a farmer, Cain makes the *ex ante* choice of location for the two periods. By definition, he does not move his farm between the two periods. Cain's technology of sedentary farming is an inferior choice in the arid north. Furthermore, as one moves south the comparative advantage gradually shifts from pastoralism to farming.

Cain's maximization problem is defined as:

$$\underset{x_1=x_2}{\text{Max}}\ E_1\{g(x_1, x_2, e, d, Z)\}, \tag{6}$$

where g(.) is Cain's utility function.

Cain's choice of property regime is also derived from a comparison between two maximization problems. Cain compares expected utility of crop production under an exclusive property regime with the expected utility of sedentary livestock production. Thus, we assume that initially Cain is a sedentary pastoralist, who ponders whether he should switch production technology, given the ecosystem in which he finds himself. In making this choice, Cain realizes that he will have to secure the benefits of crop production by establishing exclusive rights to the location. For instance, Cain will need to protect his crops against possible incursions of Abel's herds. Such exclusive cultivation rights are indicated by the variable Z = 1. Introducing initial wealth w, Cain's willingness to pay for an exclusive property rights regime will implicitly be given by the following equation:

$$\underset{x_1=x_2}{\text{Max}}\ E_1\{g(w - WTP, x_1, x_2, e, d, Z = 1)\} = \underset{x_1=x_2}{\text{Max}}\ E_1\{g(w, x_1, x_2, e, d, Z = 0)\} \tag{7}$$

If, for a given location, Cain's willingness to pay is greater than zero, he will demand an exclusive cultivation property right Z = 1.

Given the above model, it is now possible to endogenize the choice of technique and property rights regime given the rainfall probability distribution of a particular location. Ruling out the settlement of conflicting claims by violence, we could evaluate for each location x the maximum willingness to pay of each individual. The property rights regime governing the location will then depend on whether the WTP of Abel

is greater than, equal to, or smaller than the WTP of Cain. We know from (4) that for Abel an adaptive strategy performs always at least as well as a non-adaptive strategy:

$$\underset{x_1}{\text{Max}}\ \underset{x_2}{E_1}\{\text{Max } f(x_1, x_2, e, d, Z=0)\} \geq \underset{x_1=x_2}{\text{Max}}\ E_1\{f(x_1, x_2, e, d, Z=0)\} \tag{8}$$

However, we do not know a priori for a given grid on the map whether Abel's WTP is larger or smaller than Cain's WTP. The relative magnitude of these WTP for a given location determines the optimal production technique and property rights regime (see Figure 3). By comparing these WTP, we can assess the optimal property regime and therefore endogenize the choice of particular economic institution. Figure 3 identifies an equilibrium point where the two WTP are equal.

[FIGURE 3 HERE]

The area to the north of the equilibrium point will be the optimal domain for livestock production and fall under Abel's nonexclusive nomadic property rights. The area to the south, *ceteris paribus*, will be the optimal domain for crop production governed by Cain's exclusive cultivation property rights. The domain of Abel's technology--with technology here defined as the combination of the optimal technique and the appropriate property right--does not imply exclusive territory. For Cain's technology, however, optimal domain does imply territorial exclusivity. The choice of technology in the model is made given period 1 location.

3. THE AGRO-PASTORAL PRODUCTION SYSTEM OF THE SAHEL

For the Sahel the stylized north-south sequence of agricultural resource exploitation largely conforms to the model presented in the previous section. Pure pastoral nomadism is practiced in the arid Saharan north characterized by extremely variable rainfall of less than 200 millimeters per year. Pure nomadism can conceptually be defined as a perfectly mobile system of extensive livestock production with virtually no permanent place of abode, and no crop production. As one moves south, rainfall patterns become more stable, with average rainfall increasing to more than 800 millimeters for the Guinean

savannah zone. The Sahel roughly occupies the transition zone between the Sahara and the Guinean savannah zone. In this transition from low and highly variable rainfall to high and more stable rainfall patterns, one finds the fully mobile livestock production systems gradually associated with some form of crop production.[vii] Such systems can be classified as seminomadism. Much of the southern Sahel is characterized by transhumance systems. Under the latter systems, trek routes are shorter, while part of the population is sedentary and engaged in crop cultivation.

Sahelian pastoralists typically employ several routes for the annual movement from dry-season pasture in the south to rainy season pasture in the north. The routes can range between 100 and 400 kilometers and are "anchored" on one or more relatively sure waterpoints, such as a lake or a flooded valley. The more southern Sahelian transhumance systems employ shorter routes. However, multiyear periods of extreme and prolonged drought are a recurrent phenomenon across the Sahel, and they trigger pastoral movements over long distances. It is not unusual for such migrations to cause the crossing of several national borders, while the return to the original country may only occur several years later. The existence of such "drought contingency routes" is a vital part of any pastoral strategy in the Sahel [Starr, 1987].

Two countervailing forces oppose southward movements of pastoralists. The first is the incidence of diseases detrimental to human and animal health, such as river blindness and trypanosomiasis. The second countervailing force is the increase of the farming population density. Population pressure reaches a relative maximum in the so-called "sorghum belt", where large Sahelian population centers such as N'Djamena, Kano, Sokoto, Niamey, Ouagadougou, and Bamako are found. The area further south, however, is generally less densely populated. This is caused by increasing health hazards associated with a more humid climate and by a particularly unfavorable interaction between the shorter length of the dry season and increased leaching of the relatively shallow soils.

A closer look at property regimes associated with pastoral production systems reveals that the capacity for flexibility in movement is at the basis of their definition. Instead of making all production decisions ex ante, which would preclude the use of new information, the pastoralist adopts a strategy that allows for an ex post reaction to new information about rainfall and pasture conditions or, in other words, the temporal resolution of risk. Consequently, property rights of pastoralists emphasize the possibility for

contingent, i.e., state-dependent, movements--exactly as modeled in the previous section. Such property regimes do *not* attempt to establish exclusive rights to a particular piece of land *per se.* Thus:

> The pastoral Fulani displayed little concern with territorial identity or the defence of particular grazing areas; they were more interested in rights of access to pastures, water, and salt for their cattle than they were in the ownership of land [Frantz, 1986: 18-19].

Typically, the tribal organization of a nomadic property regime enables each economic unit to be continuously mobile since no single permanent trek route would be optimal under environmental uncertainty. The property regime, then, does *not* define a fixed territory for its members [Baroin, 1985; Clanet, 1975]. On the contrary, the relational aspects of property rights are stressed as pastoral peoples need to continually move around [Neale, 1969]. Movements need to be coordinated with other lineages and tribes, as well as with farming populations. The different itineraries of annual transhumance may be coordinated in advance by an assembly of lineages in order to minimize the risk of interference. Under such property regimes, lineage heads function as stewards of the system, while cattle are private property [Lainé, 1982]. The lineages thus form a management group that establishes rights and duties with respect to the use of pastoral resources (access to trek routes, pasture, water, et cetera). Nomadic property regimes, then, achieve a mix between individual incentives and group incentives mediated by--indeed, defined by--institutional rules.

Even the more "sedentarized" pastoralists of the southern Sahel who practice restricted seasonal movements within zones of 30 to 50 kilometers, will typically not claim exclusive property rights to their potential grazing area. Lineages' management rights constitute property regimes that are not directly exclusive in terms of territory: they define priority access rights to water and pasture. The management right of lineage, however, needs to be asserted or "activated" by the digging of wells, the erection of camps, and actual grazing. To the extent that nonmembers do not interfere with members' management and access rights, nonmembers also have access to the resources. However, the grazing areas are not open access regimes. Rules specifying priority access to water effectively regulate the usage of the territory by nonmembers whenever needed. Territorial exclusion, then, is indirectly achieved when needed by

controlling the access to the crucially scarce factor but not by directly claiming exclusive territorial title to the land as such.

Pastoralist property regimes of the Sahel are best described as common property regimes [Wade, 1992]. Unfortunately, the "tragedy of the commons" as described by Hardin [1968] has tended to associate resource over-exploitation with common property regimes. However, empirical work on common property regimes has shown that over-exploitation is caused by the absence of common property rules, not by the presence of such arrangements. This suggests that the "tragedy of the commons" should be relabeled the "tragedy of open access" [Bromley and Cernea, 1989].

The claim for exclusive territorial title to the land is properly associated with sedentary farming systems. Whereas pastoralist mobility capitalizes on the ability to adjust ex post to the variable environment, farming systems of the semiarid tropics employ a number of cultivation techniques that stress ex ante, as well as ex post, adjustment to environmental risk. Here, risk reduction is obtained through portfolio diversification (an ex ante risk reducing technique) by choosing production activities and assets that exhibit low or negative covariances with respect to each other. Intercropping and plot scattering can be seen as good examples of such portfolio diversification. In this context, exclusive private property rights can emerge as the appropriate property regime.

For farmers, another set of production strategies, e.g. variable planting dates and replanting is designed to adjust ex post to temporal risk in a manner comparable to the "nomadic" adjustment to risk [Chavas, Kristjanson, and Matlon, 1991]. Moreover, from a similar perspective, general techniques of shifting cultivation and crop rotations are themselves ex post adjustments, permitting the farmer to adjust to the variable productivity of the resource base [Warren and Maizels, 1977]. In Niger, one observer described a farming system as "agricultural nomadism" in view of the continuous movement of farms in search for fertile soils [Cissé, 1982]. Even intensive and sustained manuring may not allow for permanent cultivation in some parts of the Sahel; the compound and the animal parkings are continuously moved in a rotational pattern so as to spread the benefits of manuring and to avoid over-exploitation of a particular plot [Thomson, 1982].

Typically, the individual farmer can obtain the use rights of a particular plot out of a common pool of plots managed by the lineage head. As long as the farmer uses the plot, he or she has exclusive property rights over the yield of the plot. However, given the limited scope for permanent cultivation of a particular plot, there emerges an option value for ex post adjustment, i.e. the value of having access to a different plot at some point in the future. The membership of the community bestows a right to *farm*, but not necessarily to a *particular* farm. In this respect, the common property regimes of farming communities are basically similar to the pastoralist regimes. The similarity is caused by the need to solve a similar problem of coordination, since in both cases individuals are likely to make ex post adjustments that need to be coordinated within the group, or else risk causing negative externalities to others.

Common property regimes typically evolve to solve such coordination problems by specifying access rules to resources and enforcing them over a well-defined membership. In other words, the common property regime provides the market across which internalization of the negative externalities can be negotiated. In cases where common property regimes are said to cause "tenure insecurity" for the individual, the community may in fact be preventing individuals from (re)creating a negative externality by disassociating themselves from the common property rules. The benefits of exclusive, individualized property, then, need to be weighed against the social cost of the externality.

In summary, the agro-pastoral production systems of the arid and semiarid tropics typically incorporate a mix of mechanisms that allow for adaptive strategies to changing environmental conditions. In the case of Sahelian nomadism, the economic value of such flexible strategies has found its expression in continuous movements of the production unit over time, i.e., "spatio-temporal flexibility". Empirically, one can observe a relation between the riskiness of the environment and the importance of flexibility-based adaptive strategies to the agricultural production system.

Property rights theory suggests that a pluralistic property rights regime under which both private and common property regimes could co-exist and co-evolve would be efficient in capturing the economic value of different adaptive strategies. Nomadic property regimes allow pastoralists to implement adaptive strategies to environmental uncertainty. An adaptive strategy and its associated property regime generally require ex post coordination between economic actors. By contrast, a nonadaptive strategy typically requires

only ex ante coordination. Thus, the informational requirements of adaptive strategies will induce the establishment of a common property regime if coordination between individuals is less costly under centralized management at the group level than under a system of private contracting between independent actors.

5. POLICY ISSUES

Policy makers and analysts often speak of a "nomadic dilemma" when referring to the predicament of nomads in the Sahel and elsewhere in Africa. The "nomadic dilemma" is seldom understood as a problem of property rights, but, rather, as one of nomads "lacking modern education, ignoring frontiers and spreading cattle diseases" [Adamu and Kirk-Greene, 1986: xiii]. Additionally, "Pastoral nomadism tends to be regarded as anachronistic, unconducive to good administration or education, and is expected to be superseded in time by `resettlement' programmes" [Mortimore, 1989: 223]. Thus, a commonly held assumption is that nomadism is ultimately doomed and that efforts should be geared towards making this outcome as painless as possible, e.g. [Lowe, 1986]. This attitude is best illustrated by a proposal for a principal motion at the Fifteenth International African Seminar on Pastoralists of the West African Savannah that bluntly states that it is not in the interests of the pastoralists to continue to lead a nomadic way of life. Instead, they should settle down, while the governments of the region should take care "to preserve whatever is worth preserving in their culture, including their languages" [Adamu and Kirk-Greene, 1986: xvii].

The empirical reality of the resilience and economic importance of pastoral production systems provides a stark contrast to the above presumptions. Perhaps 25 percent of the total population of West Africa can be classified as pastoral [Sihm, 1989]. In Sahelian West Africa (Senegal, Mali, Burkina Faso, Niger, and Chad) livestock production typically accounts for 30 to 40 percent of total agricultural value added. Shapiro [1979] estimated that cattle originating in Mauritania, Mali, Burkina Faso, Niger, and Chad constitutes more than 50 percent of all slaughter cattle in the wider West African region, whereas only one-tenth of West African cattle production can be attributed to sedentary livestock production systems. The so-called "low-productivity" Sahelian livestock production systems operate at levels of animal protein production per hectare that significantly exceed the levels for comparable regions in the United States and

Australia [Breman and de Wit, 1983]. Comparisons between transhumant and sedentary livestock production invariably show greater animal productivity under the former production modes [Penning de Vries, 1983].[viii]

The supposedly "subsistence oriented" and "backward" nomadic economy supplies all major urban centers in West Africa with a steady flow of meat [Swift, 1986]. This flow is assured by an elaborate international trading network that links the Sahelian pastoralists with the major consumption centers on both sides of the Sahara desert. Paradoxically, the nomads' alleged poverty and backwardness do not seem to inhibit the governments of the region in levying a plethora of direct taxes on cattle trade. Similar direct taxation of farmers is virtually non-existent.

Moreover, the balance of political and economic power between pastoralists and farmers in the West African savannah has steadily been shifting towards farmers. At worst, the process has led to the simple annulment of pastoral property rights. At best, transaction costs have increasingly been shifted onto the pastoralist production system. The undermining of pastoralist property rights is probably first and foremost related to a decline in political influence. Additionally, population pressure has increased the opportunity costs of arable land. The end result is that Abel's "domain" has shrunk dramatically.

From the 13th century onwards, incited by the demand for slaves emanating from the trans-Saharan trade, the horse-riding peoples of Saharan origin had engaged in predatory activities on their Southern neighbors of Niger-Congo origins. This predatory pattern reached its climax during the 18th and 19th centuries, when pastoralist tribes effectively colonized large portions of the West African savannah through an imperialist expansion strategy based on professional warfare. This system rested on the mobilization of large armies of slaves, on the mobility of cavalries--which explains why the invasions stopped short of the tse-tse fly infected forest zones--and on the effective control over tribute-paying farming populations [Bah, 1986; Franke and Chasin, 1980].

The French colonizers attempted to pacify the region through the sedentarization of the nomads and the abolition of slavery. Policies of *divide et impera* were employed to reduce the political power of the nomads, but at times the attacks on the nomadic hegemonies, such as the 1917 massacre of the nomadic

aristocracy at Tanut in Niger, were direct and brutal [Lainé, 1982]. When the upkeep of the slave economies became infeasible and feudal taxation revenues dwindled, the nomadic empires quickly collapsed.

The voluntary or involuntary incorporation of sedentary farming populations in the nomadic political economy was a key strategy pursued by the nomads of the West African savannah [Lovejoy and Baier, 1976; Konczacki, 1978].[ix] In some cases, transfers between the two systems were part of a formal political economy ruled by "urbanized" pastoralists who monopolized the trans-Saharan trade routes, while assuring themselves of a steady food supply through the operation of slave plantations. In other cases, the transfers occurred as part of a pattern of opportunistic raids of nomads into the southern farming zones. Finally, and probably in the majority of cases, a symbiotic relationship existed between the rural pastoralists and their farming neighbors, based on the complementarity of the two production systems [Baier, 1976; Mortimore, 1989; Forde, 1960].

In the last decades, however, there has been a marked increase of conflicts between nomads and farmers, generally at the expense of the nomads. In particular, what has been called the "colonization" of the Sahel by the farming population greatly reduced the spatial flexibility on which the pastoralist technology was based. Nomads had to circumvent larger cultivated areas, lengthening their routes and increasing the costs of operating the pastoralist system considerably.[x] Additionally, new irrigation schemes typically occupy large areas of valley bottom lands, which constitute crucial pastoral resources during the dry season.

Unfortunately, both Sahelian and coastal governments of the region often identify with the farming population, viewing nomads as strangers, transients, and non-citizens with no legitimate claim to property rights to natural resources. The effect of this persistent "farmer bias" is that changes in property rights regimes introduced by these states have usually completely annulled pastoral property rights. Nomads were simply expropriated by the declaration that all *terres libres* (most of which were, in fact, grazing lands) were to be considered national property.[xi] In this context, a common assertion is that the "nation" owns all the land and that therefore the nomads have to compensate the "nation" for use of the grass. This compensation rule is then typically used to justify the imposition of a plethora of taxes on livestock ownership and marketing, ranging from a variety of sales taxes to taxes for "use of the road". On the other hand, one finds such reasoning conspicuously absent in the case of farmers' cultivation or fuel wood collection.

Reduced flexibility increased livestock losses during periods of extreme environmental variability, such as the prolonged drought period of 1968-1976. At the height of the drought (1973) losses were estimated at 20 to 70 percent [Konczacki, 1978]. Although some losses might have been exaggerated, it seemed that the capacity of the nomadic system to manage the effects of the drought had been greatly reduced, compared with earlier droughts such as the one in 1930 [Grégoire, 1982a].

At the same time, however, population growth in the wider West African region increased the price of meat relative to labor. Sahelian herds grew steadily--further adding to the tensions between nomads and farmers [Konczacki, 1978; Crotty, 1980].[xii] Increased profitability of livestock ownership also led more and more farmers to invest in herds of their own. These herds were not always given in custody to the nomads following the traditional institutions. Thus emerged new contenders for water and grass with no linkage to the pastoralist regulatory mechanisms.

Development policies with respect to livestock production in the Sahel have generally not countered the above negative trends because they were often based on paradigms that did not stress the value of flexibility with respect to natural resource use in arid and semiarid environments. Examples of paradigms that underestimated the value of flexibility were sedentarization, group ranching, and the promotion of on-farm integration of agriculture and livestock production. The majority of such well-intended development programs have largely failed [Hogg, 1987; Sandford, 1983].

Sometimes nomads settle spontaneously and apparently voluntary. However, as shown by the "Cain and Abel" model, any increase in transaction costs necessary to uphold nomadic property rights reduces the value of flexibility and thereby induces the sedentarization of nomads, *ceteris paribus*. Thus, an apparently "spontaneous" transition from specialized herding to farming need not be interpreted as an optimal evolution but may represent a constrained, and impoverishing, response [Smith, 1978; McCown, Haaland, and de Haan, 1979]. In general, sedentarization--spontaneous or as part of a resettlement scheme--has produced negative economic, social and ecological effects, as the many attempts at sedentarization of pastoralists in Africa show [Konczacki, 1978: 59].[xiii]

Other once-popular livestock sector projects included the establishment of ranches. The development of ranching assumes that the local ecosystem is capable of supporting herds year-round when

these herds are confined to a specific territory. However, the limitations of the ecosystem to support cattle on a permanent basis caused many ranching projects to fail or to resort to additional feed inputs by importing grain or the by-products of certain agro-processing industries (e.g., cotton mills, sugar cane processing factories, beer industries) from more southern regions at considerable cost [Crotty 1980].

The "integration" of crop and livestock production has also been emphasized as a preferred agricultural policy. However, integration has nearly always been pursued at the farm level rather than from a wider regional perspective. For the semiarid tropics, the importance of integration of livestock and crop production at the farm level--the key factor in the transformation of European agriculture--has been largely overstated [Breman and De Wit, 1983]. Such integration of farming and livestock production at the farm level is often constrained by unfavorable combinations of agro-climate, soil conditions, population density, and labor demands [Delgado, 1979]. The opportunity to keep livestock year-round on the farm--the potential for sedentary mixed farming--is severely limited by natural fodder supply per unit of land in the Sahelian and northern Sudanian regions.[xiv] Moreover, while potential feed supply per acre increases towards the south, opportunity costs of feed production also increase because of the increase in land scarcity. Consequently, the introduction of animal traction in the Sahel has not only suffered from very low adoption rates[xv], it has also often failed to produce the expected intensification effects. Rather, being a labor-saving technique, animal traction has led to area expansion [Jaeger and Matlon, 1990].

Given the agro-climatic conditions in the Sahel, increasing population pressure does not automatically induce the transition to agricultural intensification and an increase in output per unit of land as described by Boserup [1965]. Increases in population pressure, if not reduced by high out-migration rates, may result in an expansion of cultivation onto marginal lands, thereby raising the opportunity costs of grazing land. By increasing cultivation at the extensive margin, farmers encounter increased competition with nomads. This induces a phenomenon known as "preventive" clearing. When the nomads are absent, farmers "preventively" clear land in order to secure property rights, given that both nomads and farmers will normally respect the security of usufructuary property rights. Upon their return, the nomads are confronted with a *fait accompli*. Such encroachment by farmers is often backed by formal legislation. Niger's agrarian reform of 1977 specified that fields left fallow for more than nine years were considered "free." The tenure

insecurity created by this legal reform led farmers to reduce fallow periods and embark upon strategies of "preventive" clearing. We may think of this as farmers "gathering" fields for possible future use. Accelerated environmental degradation and an intensification of conflicts between nomads and farmers were the results [Thomson, 1982].

Above the farm level, however, the wider regional environment offers several opportunities for crop-livestock integration--but integration based on economic exchange. Various traditional types of contracting attest to the benefits of such exchange opportunities [Bromley and Chavas, 1989]. The widespread phenomenon of farmers renting their cattle to nomads under a variant of the sharecropping contract is a good example of an economic exchange based on the comparative advantages of the two production systems. The nomad herds the farmer's cattle in exchange for a share of the outputs, usually specified in terms of calves and/or milk. Informational and incentive problems are reduced under such sharecropping contracts. Nomads profit from the increased access to capital, while farmers profit from a diversification of their assets across ecological zones. Such investment opportunities are also highly valued by urban investors [Kintz, 1982]. Another type of contract is known as the *contrat de fumure*, under which a farmer allows the nomad to graze cattle on the crop stubbles left after the harvest when the animals can no longer damage the crops, in exchange for the benefits of animal manure. Outside of the growing season, both farmer and nomad benefit from the establishment of a different set of property rights [Dahlman, 1980; Wade, 1992].

Some of the more recent pastoral policies attempt to restore indigenous common property regimes by creating exclusive pastoral zones. "Territorialization" of pastoralists has been advocated by a number of observers [Adams, 1975; Gallais, 1979]. However, typical pastoral property regimes were not defined in terms of a specific territory. In fact, property regimes in line with the economic theory outlined above enabled continual mobility without restricting nomadic groups to a particular zone. The delimitation of pastoral zones, or the establishment of "group ranches" under territorially exclusive property regimes, does not constitute an appropriate policy for resource use in the semiarid tropics. Empirically, such policies have often been associated with overuse of the resource base, amplification of negative effects of drought periods, and increased conflicts between nomads and farmers, among nomadic groups, and within nomadic groups

[de Haan, 1990; Little, 1987; Mortimore, 1989]. Moreover, such policies sometimes end up merely allocating exclusive grazing rights to groups of sedentary farmers at the expense of pastoralists [Grégoire, 1982a].

The transfer of property rights over pastoral resources to the state--ostensibly to reduce conflicts over such resources--often results in even more ambiguity and insecurity. For instance, the installation of deep tubewells opened up areas previously too arid for grazing, but local pastoralists did not obtain property rights to the new wells. Rather, the wells became state property, and quickly turned into open access resources. New immigrants were attracted by the wells, and refused to abide by the old rules of the traditional common property regimes. The "bore-hole paradox" was born: before the introduction of bore holes, shortage of water precluded degradation of the grasslands, while access to water was subject to social control. After the introduction of bore holes, grazing could continue for longer periods, while access to water was deregulated and became effectively "open access." At the same time, herd sizes increased through an increase in labor productivity: less labor was now necessary to water the animals. The combined effects resulted in serious overgrazing of the areas in the vicinity of these wells, e.g. [Crotty, 1980; Kintz, 1982].

Equity, efficiency, and environmental sustainability strongly suggest that much can be gained from the restoration of non-exclusive property rights to pastoralists, and from the (re)creation of property regimes that allow for the exploitation of the comparative advantage of different production techniques in a regional context. In particular, measures should be taken to reduce transaction costs associated with herd movements within and across national boundaries[xvi].

5. CONCLUSIONS

Nomads and farmers seem to have been in conflict throughout history and throughout the world. One Hebrew version of the Biblical story of Cain and Abel provides the first recorded clash between a nomad and a farmer. In some respects, conditions today are not much improved. Conflicts between nomads and farmers continually recur. However, next to conflict, complementarily is also a structural characteristic of the dual economy represented by Cain the farmer, and Abel the pastoralist. The two economic systems complement each other with respect to the exchange of outputs but seem to be continually at odds with one another over inputs, especially over the control of land use. Without a fundamental change in development

policies for the Sahel, the gloomy scenario of Cain and Abel may be brought to its ultimate conclusion. Myth and reality have already become dangerously close in the recent history of the region.[xvii]

Abel's problem is seen to be one of explaining to Cain that if the latter would claim exclusive property rights, both would be worse off. In other words, Abel seeks to prevent a Pareto-inferior outcome. We have argued that the prevention of such an outcome should also be the focus of current development policies with respect to the agro-pastoral production systems of the West African Sahel. Policies should, first, acknowledge the structurally different techniques that underlie the agricultural and pastoral systems, respectively. Second, this recognition should then lead to the formulation of policies that further the establishment of an institutional setting within which both sectors can flourish. In particular, the acknowledgement of the structural differences in production techniques should have direct implications for the formulation of improved property regimes.

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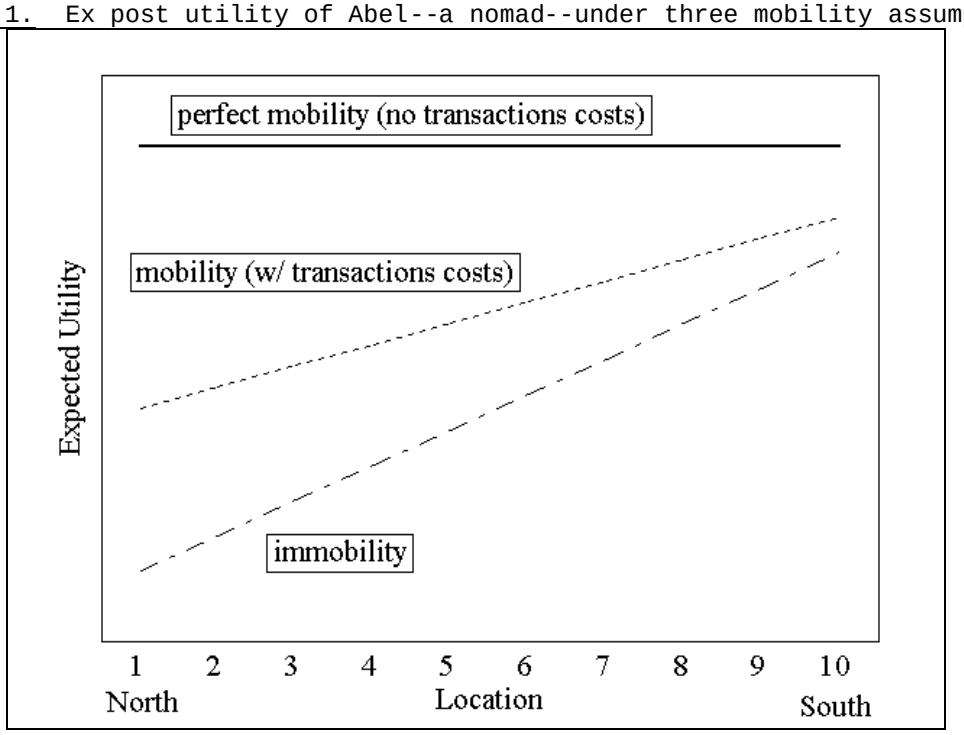
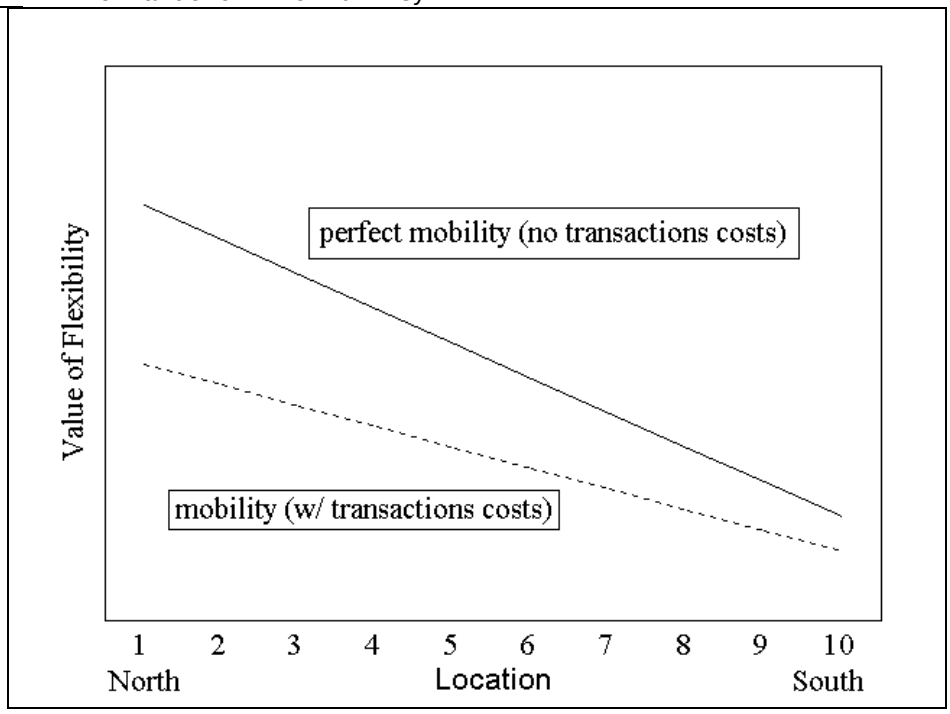
NOTES

Figure 1. Ex post utility of Abel--a nomad--under three mobility assumptions.



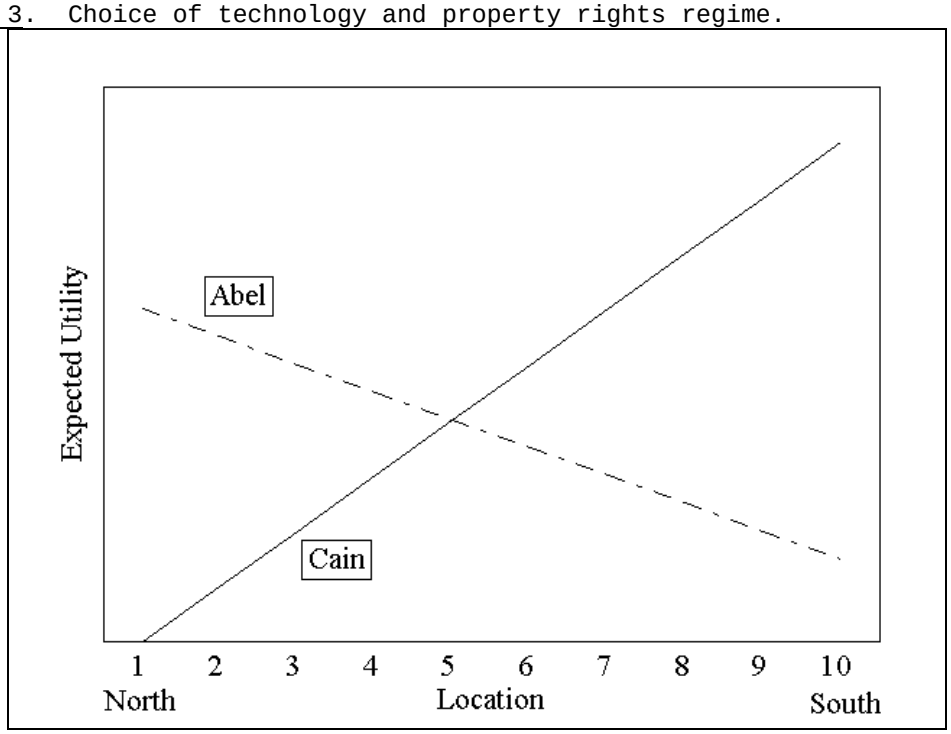
Source: see endnote 3.

Figure 2. The value of flexibility



Source: see endnote 3.

Figure 3. Choice of technology and property rights regime.



Source: see endnote 3.

i On the concept of flexibility and the economic analysis of risk in an intertemporal setting, see [Dreze and Modigliani, 1972; Epstein, 1980].

ii Moreover, risk preferences have played a prominent role in economic studies that focused on ex ante risk reduction, notwithstanding the difficulty of the direct measurement of risk preferences. One advantage of the formulation of economic theory under temporal uncertainty is that it establishes the value of information or the value of an adaptive strategy under general risk preferences.

iii To simulate results, a computer model was developed using the matrix language Gauss. The graphs that accompany the main text are based on this model.

iv The rainfall regime described above was simulated using Gamma distributions. A random variable **e** has a gamma distribution with parameters a and $ß$ ($a \geq 0$ and $ß \geq 0$) if **e** has a continuous distribution for which the probability density function

$$h(\mathbf{e}|a,ß) = \{ß^a/G(a)\}\mathbf{e}^{a-1}\exp^{-ß\mathbf{e}} \quad \text{for} \quad \mathbf{e} \geq 0$$

$$0 \quad \text{for} \quad \mathbf{e} \leq 0$$

The first and second moments are:

$$E(\mathbf{e}) = a/ß$$

$$Var(\mathbf{e}) = a/ß^2$$

For the computer simulation (as presented in the graphs), a pattern which was linear in $E(\mathbf{e})$ and $Var(\mathbf{e})$ with respect to movements along

the North-South axis was chosen.

v The transactions costs associated with mobility are assumed to take the following form:

$$TC = d|x_2 - x_1|$$

TC = transactions costs

d = transactions cost parameter.

vi Given a certain period 1 location, the expected value of the ex post utility function was numerically calculated by an iterative simulation method. A logarithmic utility function was used. Many of the results presented below will hold *irrespective* of the nature of risk preferences.

vii For instance, nomads may sow some plots at the beginning of the rains and move north with their herds in search of pasture, leaving the sown plots unattended until their return at the end of the season. Alternatively, a section of the nomadic population may cultivate some crops on valley-bottom lands during the short rainy season, while the other section accompanies the herds on their seasonal movements.

viii In Botswana, comparisons with ranching show that the production of protein per hectare under the traditional production system is significantly higher [de Ridder and Wagenaar, 1984].

ix At the same time, pastoralist mobility was the basis for the development of various long-range trading networks. This is particularly true for the caravan trade across the Sahara with the Mediterranean region, and the sub-Saharan trade with the southern savannah and forest zones of West Africa.

x For instance, movements further south often led to increased taxation by the different farming populations along the way.

xi Even in the rare cases where legislation seemed to favor pastoralist property rights, the de facto enforcement usually favored the farmers. Thus, in Niger, all lands north of the cultivation limit (approximate latitude 15° 10' north) were officially declared pastoralist zones. However, this legal restriction did not prevent farmers from entering these areas in the 1960s. They were: "...effectively supported by government administrators apparently unwilling to carry out the legal restrictions on the northern limits to cultivation [Franke and Chasin, 1980: 98]."

xii Increases in herd size may have been a combined response to both relative prices and to the reduction of flexibility of the pastoralist system. Several authors have argued that a large herd size *per se* can function as a risk-reducing strategy. It constitutes an insurance in times of excessive mortality induced by drought [Monod, 1975; Van Raay, 1974; Sandford, 1982]. Others argue that state-sponsored vaccination campaigns have also significantly increased herd size, but that herds are now of a poorer quality, because of a decrease in natural selection and an increase in overgrazing.

xiii For East Africa, Hogg [1987] shows that sedentarization of nomads around an irrigation scheme had detrimental ecological effects. Moreover, the pastoralists who were settled closest to the center of an irrigation scheme eventually ended up the poorest, while the pastoralists on the fringes of the scheme were able to increase their wealth through a combination of access to the irrigation scheme and continued access to the grazing areas on the fringes and outside of the scheme.

xiv It is here that the fundamental difference lies between the West African savannah and the high-altitude grasslands of East Africa, where population pressure often does induce a pattern of intensification based on an on-farm integration of agriculture and livestock production. In many regions of East Africa, such integration has far greater potential to be realized within the same farming system, mainly because of better soils. Consequently, the agroclimates of the East African high savannah and highlands have produced a whole series of societies whose economic strategies were based on the integration of crop cultivation and herding. Thus, typical "pastoralist" peoples of this region may in reality be more cultivator than pastoralist (Oliver, 1992).

xv Many development programs in the Sahel have promoted animal traction by distributing subsidized packages consisting of animals (cattle and donkeys), ploughs and weeders. The subsidized access to animals has of course been very popular among the farmers of the region. However, the actual use of the equipment, as measured by acreage ploughed and weeded, is often very low, with the exception of certain cotton-growing areas.

xvi For instance, West African states should consider the adoption of a uniform and simple taxation system. Even if the total tax load per animal remains unchanged, any reduction in the

mere number of different taxes and bureaucratic requirements would significantly reduce transaction costs.

xvii The recent "wars between brethren" (viz. the violent conflicts between Mauritania and Senegal and between Mali and Burkina Faso) were directly linked to the herder/farmer problem and may serve as ominous examples. Touareg rebellions in Algeria, Niger and Mali erupted shortly after we started work on this paper.