FARMING SYSTEMS IN AREAS OF FARMER-HERDER INTERACTION IN SEMIARID AFRICA: TOWARDS AN APPROPRIATE MODEL FOR INVESTIGATION

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INTRODUCTION

Over much of semiarid Africa agricultural systems are characterized by significant interaction between livestock and cropping systems. FSR/E currently has an identifiable bias towards cropping systems to the neglect of livestock systems. This is understandable in that for a variety of reasons research into increasing crop production has been deemed more important: there are more farmers than herders; crop production is usually a greater contributor to GDP than of livestock; the sedentary nature of farming makes research easier; farmers have been viewed as being more amenable to change; it is easier to conduct research among farmers than among herders; and there has tended to be an institutional bias against herders which discourages research into livestock systems (Bernstein, 1982; Eicher and Baker, 1982).

The relative neglect of livestock systems assumes critical importance in the context of cropping systems research where there is considerable interaction between farmers and herders. In these circumstances a farming systems model is needed which has a structure with the versatility to incorporate the characteristics of each production system and the complexity of the interaction between them.

The objective of this paper is to propose a model for examining African production systems in which cropping systems and livestock systems overlap spatially and interact economically, socially, politically, and environmentally. The purpose is to develop an approach which might be more appropriate to the study of interactive systems. This may provide a basis for devising FSR/E strategies more relevant to the design of suitable technologies for Africa's semiarid lands.

The paper will first briefly discuss similarities and differences between cropping systems and livestock systems and describe their interaction. Subsequently a model for studying cropping systems and livestock systems interaction will be discussed.

INTERACTION BETWEEN LIVESTOCK SYSTEMS AND CROPPING SYSTEMS IN SEMIARID AREAS OF AFRICA

The semiarid areas of Africa are characterized by significant interaction between livestock systems and cropping systems (Matlock and Cockrum, 1976; McCown, et.al., 1979; Wilson, et.al., 1983). Livestock systems, be they transhumant such as the Fulani (Hopen, 1958; Stenning, 1959; Dupire, 1962, 1972; Gallais, 1969, 1979) and the Maasai (Jacobs, 1963, 1975; Galaty, 1980) or migratory such as the Tuareg (Rognon, 1962; Nicolaisen, 1963; Mortimore, 1972; Swift, 1975; Bernus, 1979; Bourgeot, 1979), and Somali (Lewis, 1961; Swift, 1977; Box, 1971), are closely adapted to the constraints of a highly seasonal distribution of water and pasture. While dispersed

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during rainy seasons, herders concentrate during dry seasons and droughts around permanent sources of water and pasture. These are located where rainfall is heavier and more reliable or around perennial rivers or swamps. The reliability of the water source provides many of these dry season retreat areas the potential for crop production and farming communities are frequently found within them. During dry periods significant interaction between herding and cropping systems takes place. These two systems differ in such aspects as their production strategies, production cycles and use of land but interaction with respect to trade, land use, and animal management renders them interdependent. In order to understand the distinctiveness of each system and the nature of their interaction, salient features of cropping systems and livestock systems will be discussed.

Livestock Systems

Livestock systems in Africa are predominantly oriented towards subsistence production. A variety of animals (cattle, camels, sheep, and goats) are kept and managed to produce different outputs, milk, meat, and hides, in areas with severe environmental constraints (Pratt and Gwynne, 1977; ILCA, 1983). Rainfall is low in amount and is unreliable over time and space. This imposes limits on the availability of water and pasture such that migrations over wide areas are necessary to ensure the productivity of the herd throughout the year.

To provide for the needs of their populations, herding societies have developed complex management strategies (Widstrand, 1975). These involve keeping a herd of different species with a composition and size which can provide for the various requirements of the community. The herd must be of a size sufficient to meet subsistence needs, needs associated with trade and social obligation, and to allow for a risk factor to cope with the effects of disease or drought (Baker, 1974; Dahl and Hjort, 1976; Hickey, 1976). This herd must have access to an area which provides grazing and water throughout the year without endangering the long term productivity of the land resource (Western and Dunne, 1979).

The livestock represent the capital of livestock systems. Investment decisions regarding the herd can only pay off once animals become productive. Given the length of time between conception and productivity, decision-making among herders necessarily has a longer time horizon than that of farmers. It also involves higher risks. The necessity to minimize risk within a long term production cycle has implications for land use and for the allocation of labor. Labor requirements vary from season to season and are at a peak in the dry season and during droughts when the herds have to be split into smaller units. The allocation of labor is the responsibility of individual families but will often involve sharing of resources from the extended family and the established linkages between clans, age sets and other social units.

The use of land is, in contrast, controlled on a communal basis. The rangeland territory contains specific sites where dependable water and pasture can be found in dry periods. At these times other scattered but unpredictable areas will also be available. These resources are valued by the whole society and the movement of herds has to be managed communally to

prevent both privatization and over exploitation (Gilles and Jamtgaard, 1981).

The difficulty of management is increased by the nature of the principal product of the livestock systems, milk, which has to be harvested daily and is highly perishable. To maintain a regular supply of food, the inputs, water and pasture, have to be readily accessible and careful management is essential to achieve this.

The basic components of a livestock management system are presented schematically in Figure 1. When consideration of the system is made over an appropriate multi-year time frame, over a large area, and when each component is elaborated upon, the full complexity of livestock systems becomes apparent. It represents an interaction between social, economic, political, and environmental factors. At the social level the different needs of family and group have to be balanced; the economy has to provide for both subsistence and exchange; the long term productivity of the environment has to be maintained; and political issues between different herding groups, between herders and farmers, and between herders and government authorities have to be resolved. Over much of Africa the transition through the colonial period from pre-colonial times to the present resulted in major disruption of livestock systems and many can be viewed as in a state of continuing adjustment to the opportunities and constraints of colonial and post-colonial circumstances (Gallais, 1972; Bugnicourt, 1974; Bourgeot, 1981; Galaty, et.al., 1981; Sandford, 1976, 1983).

Cropping Systems

Cropping systems in semiarid Africa are also complex. They are subject to similar environmental constraints as livestock systems and farmers have become more directly affected by and involved with colonial and post-colonial political, social, and economic trends than herders (Nicolas, 1960; Raynaut, 1971, 1975; Bernard, 1972; Knight, 1974).

The climatic constraints identified for livestock systems also affect cropping systems in semiarid areas. The rainfall is limited either to one rainy season, as over much of west and southern Africa, or to two shorter ones, as in parts of east Africa. Crop production has therefore to take place within the limited period for which moisture is available for plant growth (Cochemé and Franquin, 1967; Porter, 1979).

The choice of cash and subsistence crops is limited by both rainfall and soil conditions. The variety of soil types within the catenas of semiarid lands represents different crop production potential over a relatively confined space. As farmers seek a variety of resources, farms are frequently composed of a number of non-contiguous plots distributed across the catena. On these plants suited to the particular soil will dominate within a mixed cropping system (Ruthenberg, 1980).

Recent social and economic changes have resulted in a move away from farms owned by the extended family towards nuclear family ownership (Eicher and Baker, 1982). This, together with population growth, has led to

subdivision of farm plots into very small units on which cash cropping has often increased at the expense of subsistence crops.

The pattern of land use in cropping systems is made up of a mosaic of farms. Cropping decisions, made by individual farmers, reflect the socioeconomic standing of the farmer, the environmental potential of the land, and the traditions of the society. The farmers' strategy is not one of continuous production for subsistence but rather is based on the harvest cycle. The harvest has to supply food throughout the year but crops, as opposed to milk in livestock system, are less perishable. Further, the long term productivity of the main capital resource, the farm land, is achieved by an active transformation and management of the physical environment on a fixed land area.

The major components and interactions of cropping systems are clearly illustrated in farming systems studies (Gilbert, et.al., 1980; Norman, 1980; Norman, et.al., 1982; Shaner, et.al., 1982). The area of a farming system is defined on the basis of similarities in farm practices, social circumstances, and ecological conditions. In practice the basic spatial unit in terms of production decisions is that of the farm and the time frame over which the system acts is the harvest cycle.

Similarities and Differences

The rudimentary sketches of livestock systems and cropping systems outlined above signal commonalities and differences important to a discussion of the agricultural systems found in semiarid areas of Africa. The major similarity is the dynamic interaction each has with the environment. It can be argued that herders have adapted their livestock systems <u>to</u> the environment more than farmers who adapt the environment to their needs by replacing the natural vegetation with crops, by terracing or ridging and by manuring. However, both farmers and herders attempt to maintain the quality of their land over time by managing their crops and livestock in ways which reduce the risk of environmental deterioration. These management practices reflect an organization of the livestock systems and cropping systems which has been learned and adapted over centuries.

While these similarities exist there are also differences which are important to an understanding of their interaction. The most important is the question of time. In livestock systems the time between birth and production varies between a year for sheep and goats and about four years for cattle (Wilson, et.al., 1983). Once productivity is attained then the output, milk, can be stored for only a very short time as it is highly perishable. In addition, the seasonal fluctuations in availability of water and pasture impose a medium term time constraint upon livestock systems. Herders, therefore, have to manage their activities with a complicated and interrelated system of short, medium, and long term requirements. These recognize long and medium term environmental variability which imposes a need for mobility, access to resources over a wide area, and risk minimization skills. These in turn create variable labor inputs over time with the maximum being required during dry periods when access to water and pasture is most difficult.

Cropping systems are also vulnerable to long term environmental variations but the production cycle is much shorter, being associated with the annual highly seasonal rainfall distribution. In that the time from sowing to harvest is relatively short, the labor requirements are more predictable and are applied to a fixed and known land area. The crops are not as perishable as milk and so the daily production required of livestock systems is replaced by a daily allocation of harvested products which have to be stored to provide year round nourishment.

It is evident therefore that environmental, temporal, biological, and organizational factors are relevant to a consideration of agriculture in areas of interaction between cropping systems and livestock systems. The nature of the interaction can be characterized by three types of linkage: ecological, exchange, and competition (McCown, et.al., 1979).

Ecological linkages develop as a response to the mobility of herds which brings them into cultivated areas during dry seasons and droughts. Access to these better watered rangeland margins is essential to the survival of the livestock systems. The annual basing of livestock in farming areas not only assures their survival as they graze stubble and fallow but, through the dropping of manure, improves the fertility of soil. Herders benefit by having access to residues which are of higher nutritive value than the dry natural pasture and the farmers have their fields fertilized.

Exchange linkages relate to transactions by which livestock products are traded for farm products. These mostly involve the trading of milk, meat, and hides for grains. In areas where there is a land shortage and fallowing is no longer possible, a farmer may be willing to pay to have animals graze in the fields to obtain the manure. Contrarily, if there is not enough pasture available, farmers may charge herders for the right to graze on residues.

Many of the ecological and exchange linkages mentioned above are of long standing and form an integral part of both livestock systems and cropping systems in semiarid areas (Dubourg, 1957; Mainet, 1965; Bernstein, 1976; Ware, 1979). A number of authors have noted a change away from this traditional interaction as population growth, land pressure, and increasing animal ownership by farmers have altered the population/resource balance. Increasingly relations between cropping systems and livestock systems are characterized by competition and, in some cases, conflict (Dresch, 1959; Diarra, 1975; Weicker, 1981; Campbell, 1981; Campbell and Riddell, 1982).

In the past many herding groups were able to control by force access to dry season retreat areas in farming zones. During the colonial period power was transferred from herders to farmers and this control was ended. An expansion in the cropped area consequent upon population growth and cash crop production encroached upon lands formerly exclusively used as pasture (Berry, et.al., 1977; Franke and Chasin, 1980; Clanet, 1982). The situation is further complicated where farmers invest in livestock and restrict the access of nomadic herds to their fields and where herders become sedentary (Toupet, 1974; Cissé, 1980; Salzman, 1980). In a number of areas, conflict between farmers and herders over access to grazing land is not unusual.

Such competition reflects the different nature of livestock systems and cropping systems. These differences have to be comprehended and incorporated in an interactive model if it is to have utility. The following section proposes a framework for modeling such interactive systems.

TOWARDS A MODEL OF CROPPING SYSTEM/LIVESTOCK SYSTEM INTERACTION IN SEMIARID AFRICA

In any area production systems are influenced by endogenous and exogenous factors. The earlier discussion highlighted similarities and difference between cropping systems and livestock systems and where they interact the configuration of a descriptive model will be complex as the system-specific and interactive elements have to be understood.

Critical to a definition and operationalizing of an interactive model are an understanding of spatial and temporal elements. Livestock systems operate over larger areas and are managed within a longer biological time frame than cropping systems. The interactive model should therefore have among its basic parameters an area of focus and a time scale appropriate to the livestock systems under consideration. As the cropping systems will usually function over a smaller area and within a shorter cropping cycle they will be able to fit within the broader framework defined by characteristics of the livestock systems.

It is argued, therefore, that whereas the dominant farming systems model has as its focus the farm, an interactive model would focus upon a dynamic land use system in which interaction between social, political, economic, and environmental elements over time would be the major focus. Such a model would allow for within and between subsystem interaction to be described and would thus be more applicable to areas of cropping systems/livestock systems interaction than existing farming systems models.

One possible configuration of an interactive model is shown in Figure 2 which highlights the different relations which exist between pastoral and farming communities in a semiarid environment and their impact over time upon each community and the broader society. The feedback from the interaction between herders and farmer over time is greater upon land use systems than on societal norms or the broader society. This is illustrated by the difference between the solid and broken lines in Figure 2. The central element in the model is the land use system which defines the allocation of the land and determines the nature of the relationship between the two communities.

The land use system arises from the interaction of system components some of which are common to both herders and farmers and others which are different. Components influencing the system are both exogenous and endogenous. For example, the five exogenous components, climate, law, history, economic policy and politics, contribute to the definition of the land use system and while both societies are affected by them their impact may differ.

Within each society common components with very different forms include land rights, community beliefs and norms and institutional knowledge. Finally, the societies' technology, the manner in which the resources are

managed, applied to the land area completes the definition of the land use pattern of each society. As discussed above, these land use patterns are not only the product of the nature of each individual system but of the interaction between them. Both farmers and herders engage in secondary activities, either off-farm or livestock for farmers or, less frequently, off-farm and/or cropping for herders. These activities produce physical output and define linkages between the two groups. The physical output may be divided into subsistence and surplus. The subsistence is consumed by the farming or herding household. In the case of farmers, the surplus is channeled through the market, exchange linkage, where it may be bought by a member of the herding community. In the case of herders, part of the surplus is directly reinvested as capital by retaining new born stock. Surplus by-products of each production system, namely manure and fodder, are used to great benefit by the other group. This constitutes the ecological linkage which is reabsorbed as an input into the production system. The competitive linkage, unlike the other two, increases inversely with the amount of available land suitable to both groups as well as the amount of capital. These linkages define the nature of socioeconomic relations which may change through time and may even come to influence the exogenous variables.

The product of the interaction between herding and farming societies can be assessed through examination of the resultant land use system. The spatial and temporal scales at which they are defined would be determined by the longest time frame and largest area over which either the livestock systems or cropping systems under study function. Generally the livestock system would define both. These scales would have the advantage of incorporating the essential elements of both subsystems. Further, the time scale would enable the cropping system to be analyzed over a longer time than is incorporated in most FSR/E models and thus permit assessment of longer term issues affecting farm production (Lev and Campbell, 1985).

IMPLICATIONS FOR RESEARCH AND EXTENSION

The models which currently dominate FSR/E have contributed significantly to an understanding of cropping systems. Cropping systems over much of semiarid Africa cannot, however, be understood without reference to adjacent and closely integrated livestock systems. Livestock systems have yet to be modeled as effectively though studies conducted, for example by ILCA, the International Livestock Center for Africa, will contribute to this.

This paper has argued that FSR/E in semiarid areas might benefit from adopting an approach which explicitly recognizes cropping systems/livestock systems interaction and attempts a broader conceptualization of agricultural production systems. Fundamental to this would be a focus upon land use rather than the farm and upon a multi-year period rather than upon annual cropping cycles. While livestock systems and cropping systems can be effectively modeled as separate entities it has been argued that in areas where there is significant interaction between them a different, more comprehensive approach may provide a better basis for FSR/E. An interactive model which focuses upon land use systems rather than on the functioning of production units, the herd or the farm, allows for the distinctive and common elements of cropping and livestock systems to be addressed at appropriate temporal and spatial scales.

There are many situations where one group, farmers or herders, has taken actions to promote its own interests which, while succeeding in the short term, have had negative consequences for the interactive system as a whole over the long term. Had an appropriate interactive model been available then these consequences might have been predicted and remedial action taken.

A recurrent example in semiarid Africa is the expansion of cultivation into drier lands, to the wetter margins of the rangelands on which nomadic systems depend for their dry season and drought period pasture and water. This process increases the potential for exchange and ecological linkage but these possibilities are frequently obscured by the increased competition over access to land which ensues. In a number of cases the expansion of cultivation had little negative impact in the short term. If rainfall conditions were favorable and the process of expansion slow then competition between herders and farmers was slight and exchange linkages, in particular, began to develop. However, with the onset of less favorable rainfall conditions the farmers found themselves unable to maintain crop production and herders' access to drought retreat areas was restricted by the expanded area of cultivation (Dresch, 1959; Campbell, 1981; Santoir, 1983). Measures which succeeded in increasing crop production in the short term proved to be detrimental to the long term viability of both farming and herding systems.

FSR/E in areas of interaction might not be in a position to recognize the potential for such issues were the focus to be restricted to one group and a short time perspective adopted. For example, a recent study of farming systems in northern Cameroon (Zalla, et.al., 1981) was initially designed to examine measures for increasing food production among farmers. The scale of analysis was to be the individual farm and initially it was assumed that production patterns during the year of study were representative.

In the course of analysis it became evident that food production varied from year to year as a result of variable rainfall, the incidence of crop disease and the effects of weeds and insects. The year under study was not completely representative of the production regime and innovation and extension activities based upon the findings of that one year would thus not have been as appropriate as others based upon a longer term perspective.

Further, historical and demographic analyses demonstrated that the land use pattern among the farmers was in the process of change. While farmers had in the past been restricted to the mountains by the presence of hostile neighboring herding groups contemporary conditions were different. The government had reduced the level of hostility and the agricultural area was being extended beyond the mountains into adjacent, lower lying areas (Boulet, 1971; Boutrais, 1978; Mohammadou, 1981).

This change in land use had implications not only for the long term productivity of agriculture but also for the availability of bushland grazing for herders (Campbell and Riddell, 1982, 1984). The Fulani herders, whose raiding activities had formerly restricted the farmers to the mountains, used the lowlands adjacent to the mountains for dry season grazing. The increasing cultivation of these areas thus represented a significant threat to the viability of their transhumant economic system. One consequence was an increase in hostility between the farmers and herders of the area.

The realization that processes of change in the farming system were having repercussions over a wider area and on adjacent production systems led the FSR team to consider a broader spatial scale of analysis, to examine longer term issues and to focus upon regional land use systems as well as the individual farm.

One outcome was an understanding that the process of expansion of the cultivated area into what had been bushland posed a threat to the viability of one of the major strategies which people of the region relied on to reduce the impact of food shortage consequent upon drought or disease. Bushland and fallow areas are the source of a number of foods such as berries, roots, wildlife, and insects which are consumed only in times of difficulty. In addition, for herders, they are often vital sources of grazing during periods of adversity (Campbell and Trechter, 1982).

The process of cultivation of these areas, which was being promoted by extension services, may well have reduced population pressure in the mountains and increased overall food production during times of adequate rainfall. However, it may also have the unintended outcome of increasing peoples' vulnerability to recurrent but unpredictable periods of food scarcity by reducing the availability of wild food sources.

Resort to hunting and gathering is one of a number of strategies which societies in semiarid areas in Africa have developed to reduce the incidence of food shortage (Lallemand, 1975; Bernus, 1980; Watts, 1983; Campbell, 1984). These are integral components of the socioeconomic systems of both farmers and herders and, where they interact, involve reciprocal linkages. Identification of such coping strategies would enable extension activity in FSR/E to avoid weakening the ability of local systems to compensate for declines in production by advocating innovations which might have the unintended consequence of undermining effective coping strategies.

These examples demonstrate the importance of the interactive land use model and of the selection of relevant spatial and temporal scales in FSR/E research and extension. The methodological issues illustrated above apply equally to the other ecological, exchange and competition linkages which exist between farming and herding communities in semiarid Africa. Their nature and importance vary from year to year depending upon the intensity of interaction between the communities. During droughts it is at its most intense while during periods of plenty competitive linkages, in particular, may be less strong. This flexibility in response to environmental variability is an essential characteristic of each production system and of their interaction which enables them to respond to fluctuations in the production environment.

The model presented in this paper illustrates the complexity of interaction between herding and farming systems in semiarid areas of Africa. It provides a basis for the formulation of FSR/E methods which explicitly examine the nature of this interaction at appropriate spatial and temporal scales. Further, in terms of extension, it highlights the necessity of assessing the impact of innovations proposed for one production system, not only on that system, but also on both the system with which it interacts and on the interaction between them over the short and the long term.

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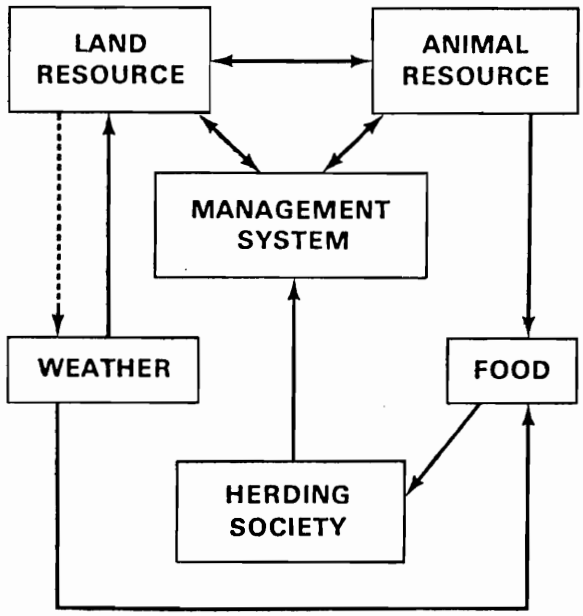

Figure 1. The Livestock Management System.

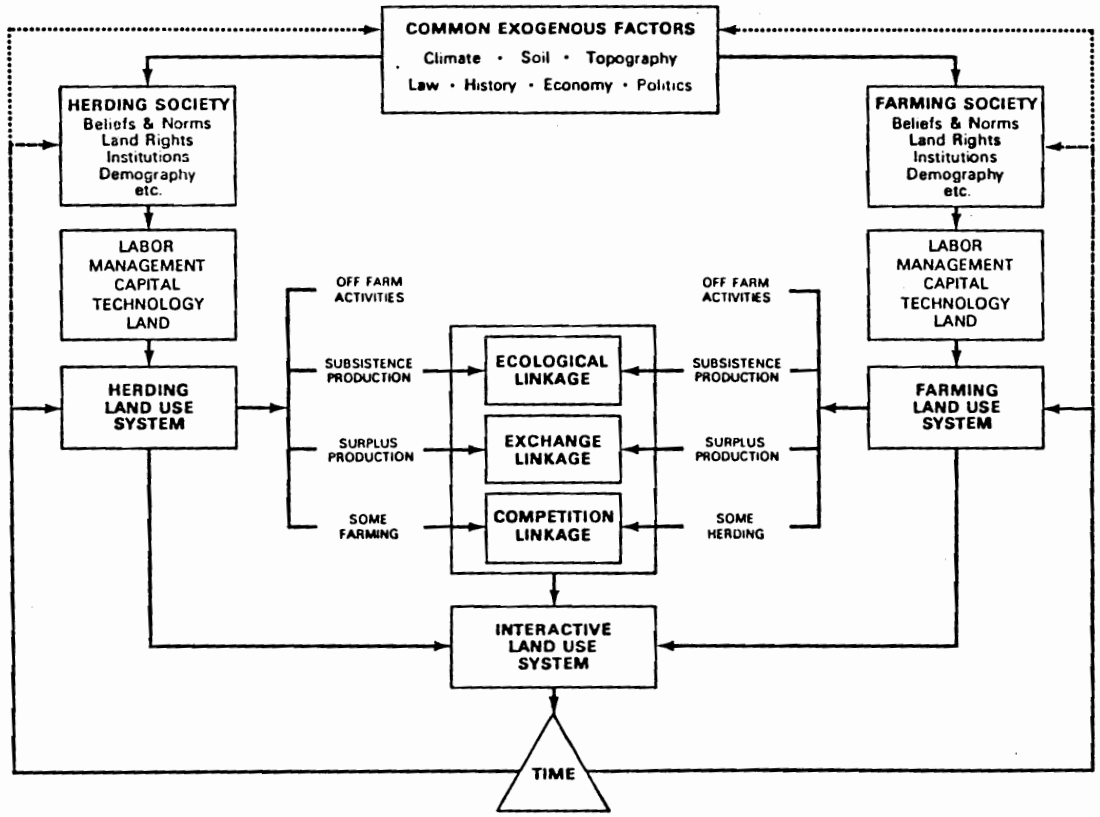

Figure 2. Interaction between livestock and cropping systems in semiarid Africa.