Nomadic Pastoralism and Irrigated Agriculture in Somalia: Utilization of Existing Land Use Patterns in Designs for Multiple Access of "High Potential" Areas of Semi-Arid Africa:

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Abstract

The persistent interplay of food production problems, land degradation, and social and climatic difficulties on the Horn of Africa result in recurring famines in spite of vast sums of money spent on agricultural development. As land resources--which undergird both social and production systems in Africa--become increasingly degraded, development efforts, especially in problematic areas, need to become part of comprehensive resource use programs that take into account the existing regional land use ecology. Designs which disrupt the ecology of established land uses can lead to extensive degradation because such uses are linked to wider areas; and the effects of such disruption can ultimately threaten the viability of the proposed schemes themselves.

While African agriculture has traditionally met greater food needs by expanding the area under cultivation and irrigation, the increasing scarcity of new high quality arable land means that multiple use of "high potential" areas will become a priority. This paper describes a multiple land use in a "high potential" river basin of Somalia, in the context of the existing use patterns involved in irrigated agriculture and nomadic pastoralism. The spatial and temporal access and use of resources are analyzed, and recommendations made for improving the integration of these production systems.

Introduction

Recent reports that widespread famine is once again advancing across Africa highlight the intertwined nature of climate, food production, land degradation, and social problems (FEWS 1991; Economist 1991a 1991b 1991c; Ozanne 1991; Kamm 1990; Perlez 1990a; Winter and Predergast 1990; Ottaway 1990; Press 1990; Battersby 1990; Morna 1990; McCabe 1990; Biswas et al 1987; Agnew and Warren 1990; Harrison 1987; Mann 1990; Campbell 1981; Christiansson and Tobisson 1989; Hare et. al. 1977; Mabbutt 1984; Scudder 1989). While agricultural harvests in Asia and Latin America have increased over the past 25 years, in Africa it has declined (Economist 1991b). The persistence of Africa's food production problems, and the severe recurrences of famine that take place in problem areas despite the millions of dollars spent on development has prompted a shift in the focus of many development programs from increased production to relief and rehabilitation (Hogg 1987; Hitchcock and Hussein 1987; Adams 1986; Coward 1985; Snow 1984; Dorgan and Wheat 1991). It is becoming apparent that development efforts, to be successful, need to be reoriented to provide greater benefit to local and regional inhabitants--as opposed to fulfilling exclusively national goals--and should be part of a comprehensive resource use program that takes into account the existing regional land use ecology (Sokari-George 1990; Sesmou 1991; Economist 1991b; Talbot 1972; Shepard 1985; Dyson-Hudson 1985; Mann 1990; Horowitz and Salem-Murdock 1987; Box 1971; Scudder 1989; Oba 1985; Berry et al 1985; Salem-Murdock 1985).

Land use schemes in Africa have come under increasing criticism for the severe environmental and social problems which often result (Mann 1990; Scudder 1989; Bennett 1984; Harrison 1987; Mohamed 1981; McCabe 1990; Speth 1985; Walsh 1984; Sinclair and Fryxell 1985). Agricultural development projects in the arid and semi-arid regions usually take place in the most fertile and well-watered areas, often to the exclusion and/or disruption of previous uses (Scudder 1989; Swift 1977; Stiles 1983; Sanford 1983; Merryman 1982; McCown et al 1976; Jacobson 1988; Shepherd 1985; Glantz 1986). Interruption of established, time-honored production systems can ultimately lead to extensive land degradation because such systems usually have linkages to wider areas (de Troyer 1986; Ibrahim 1987; Box 1971; Omerod 1978; Riddell 1982; Johnson 1986; Glantz 1986; Economist 1991b; Campbell 1981; Little 1983 1984; McCown et. al. 1976; Harrison 1987; Talbot 1972; Shepard 1985; Mann 1990; Salem-Murdock 1985; McCabe 1990; Box 1968; Berry et al 1985). Existing subsistence production systems function because participant familiarity and knowledge of them enables established exchange relationships to operate within the variability and constraints of the local ecology. These systems usually already contain the complicated and long-evolving risk reduction and coping strategies necessary for survival in difficult environments given the reigning cultural and socio-political constraints and opportunities (Kimmage 1991; Simoons 1960; Pearce 1991a; de Troyer 1986; Ibrahim 1987; Glantz 1986; Box 1968; Dyson-Hudson 1985; McCabe 1990; Oba 1985). Likewise, the role of long standing, traditional cultural attitudes and preferences in the use of the environment in the context of development efforts, can be profound. The preferences for using specific domesticated plants and animals in specific ways in established land use practices, and the exclusion of others are major factors in the economic functioning and potential development of the landscape (Simoons 1960; Salem-Murdock 1979). Such attitudes--often rooted in history--allow the development of certain opportunities of the environment and ignore or reject others (Simoons 1960; Salem-Murdock 1979).

The introduction of land use schemes in Africa usually involves two production systems (Dyson-Hudson 1985). First there is the in-place, functioning system, which in reality comprises a set of production systems and land uses that are an evolutionary response to environmental, social, and cultural pressures and preferences. These systems are essentially patterns for survival which have proved successful in that the populations engaged in these practices continue to exist (Kimmage 1991; Horowitz and Salem-Murdock 1987; Dyson-Hudson 1985). Then there is the new production system based on technical innovations imported from the outside but which has not withstood the test of time, and to which there is often resistance by local populations. Nor has the new system been adjusted for local socio-cultural and economic factors (Kimmage 1991; Dyson-Hudson 1985; Salem-Murdock 1985), or for the regional context in which it must operate. In this regional context there is yet a third set of land uses not replaced by project implementation, but nonetheless impacted, as regional links are altered or disrupted. Because of the unpredictable and severe occurrences of drought and famine in Africa and the intricate, location specific nature of land tenure and other social/cultural - land interactions it can be very difficult to replace or change such interactions, or expect them to quickly re-evolve in the wake of project implementation (Campbell 1981; Kimmage 1991; Berry and Berry 1985; Salem-Murdock 1985).

Although recommendations for "compatible" or "complementary" land use schemes or development projects which fuse tradtitional land use practices with modern science, and operate within local and regional contexts have been made, these have usually not proceeded beyond general suggestions. This paper describes a compatible or "multiple" land use scheme in the context of irrigated agriculture and pastoralist transhumance in semi-arid east Africa. A quantitative evaluation of the existing capacity of a seasoned, time-tested small farmer irrigated area to support the large influx of transhumant herds in dry seasons of varying severity is made, and implications for improving the compatibility, and resource use and access for both nomadic pastoralism and irrigated agriculture are drawn. Following a brief description of the status of irrigation in Africa, and a more detailed treatment of transhumant pastoralism, this paper presents a case study from

Somalia in an approach which utilizes the ecological, organizational, and land use constraints and opportunities of in-place production systems, to examine the proportional area under the existing mosaic of land uses, practices, and tenure states, that is needed to absorb the observed seasonal concentration of livestock.

Irrigation in Africa

The repeated under-performance of large-scale African irrigation schemes over the last 20-30 years, together with high costs and land expropriation and resettlement problems, has resulted in a widely held perception that such projects have failed to either reduce food deficits or increase agricultural productivity (Wallace 1981Berry and Berry 1985; Pearce 1991a; Barnett 1977; Adams 1990; Adams and Carter 1987; Adams and Grove 1984; Forrest 1981; Palmer-Jones 1984; FAO 1987; Underhill 1984; Scott 1984; Carter 1986). Such land use designs are now generally viewed as being inappropriate and ineffective in alleviating the food production problems which afflict many African states (Kimmage 1991). Even improvement of indigenous, small-scale irrigation--the result of long and often bitter experience and extensive knowledge of the local ecology--can fail when in-place land use practices and patterns are not adequately fused with new technologies (Salem-Murdock 1985; Kimmage 1991 and the references cited therein). The failure of irrigation improvement efforts can have far reaching and profound effects upon the sustainability of complex farming systems, especially in climatically marginal areas (Carter 1986; Carruthers and Clark 1981; Hazelwood and Livingstone 1982). The poor record of African irrigation calls for a change to more integrated locally and regionally suited designs, which are able to make multiple use of scarce resources.

Transhumant Pastoralism and Land Degradation

The seasonal concentration and dispersal of nomadic pastoralists and their herds to and from dry season forage and water supplies located in permanently watered areas is a general phenomenon observed in arid and semi-arid environments throughout the world. Transhumant herding is an adaptation to ecosystems in which the availability of forage and water are critical parameters (Darling and Farvar 1972; Clark 1985; Talbot 1972; Box 1971; Handulle and Gay 1987; Campell 1981; Sandford 1982; Breman et al. 1979; Scudder 1989; McCabe 1987; Western 1975). It is the quantity of dry season forage within reach of dry season watering points that is the mechanism which controls transhumant populations of livestock; and when this forage is depleted or access to it interrupted, the result can be overgrazing and land degradation, large livestock dieoffs, and rapid sales (Riney 1979; Johnson 1986; Riddell 1982; Sandford 1983; Gulliver 1955; Lewis 1975; Horowitz and Salem-Murdock 1987; Talbot 1972; Clark 1985; Shepherd 1985; Toulmin 1985). The ecological condition of very large areas of the African rangeland interior, as well as the livelihood of pastoralists, and the state of the livestock industry in many arid and semiarid countries largely hinge upon the linkages associated with access to dry season and drought forage and water supplies (Campbell 1981).

The disruption of migratory patterns of nomadic pastoralists and their herds due to the location of development projects and the extension of cultivation in river basins and floodplains is one of the most widespread problems facing arid and semi-arid Africa (Talbot 1972; Scudder 1989; Shepard 1985; Horowitz and Salem-Murdock 1987; Salem-Murdock 1985; Omerod 1978; Campbell 1981; Thomas and Brokensha 1985). Agricultural projects in river basins usually exclude transhumant herds which have traditionally used the area for dry season grazing and watering (Scudder 1989; Frantz 1975; Campbell 1981 Stiles 1983; Swift 1977; McCown et al 1987; Talbot 1972; Sandford 1982 1983; Davis 1971; Omerod 1978). Unavailable or unaccessible forage in one part of the yearly travels of livestock herders can have disastrous effects on other larger areas, because the herders are then forced to use range resources that are already marginal during the dry season (Riddell 1982; Glantz 1986; Campbell 1981; Johnson 1986; Riney 1979; NRC 1984; Horowitz and Salem-Murdock 1987; Box 1968 1971). Rangeland degradation occurs as the carrying capacity of these areas is surpassed due to overgrazing caused by higher dry season livestock densities (Box 1968 1971; Salzman 1986; Stiles 1983; Sanford 1982; Johnson 1986; Lamprey 1983; Little 1984; Lewis 1975; Chatterton and Chatterton 1984; Talbot 1972; NRC 1984). Davis (1971) states that the altered movements forced upon nomadic pastoralists and the subsequent overgrazing and decline in range productivity recurs "continuously" in reports on east African rangeland conditions. Mabutt (1984) estimates that overgrazing of the world's rangelands is responsible for the largest share of the 35% of the earth's surface (4,500 million ha.) threatened by desertification. Such degradation places nomadic pastoralists, their herds, and the range, in a position of increased vulnerability to drought; the severity of drought impacts being determined by the prior condition of the rangeland (Talbot 1972; Campbell 1981; Toulmin 1985; Glantz 1986; McCabe 1990; Talbot 1972).

As pastoralists leave traditional areas that have become degraded in search of forage and water supplies, they are often obliged to migrate to areas already occupied by other herders and farmers. This results in conflict and overgrazing as more animals compete for resources that previously sustained less livestock (McCabe 1990a 1990b; Toulmin 1985; Campbell 1981; Shepard 1985; Harrison 1987; Thomas and Brokensha 1985). Agreements between clans and lineages over territorial grazing and watering rights break down as more herding groups find they cannot gain access to traditional sites, or find that these sites are becoming more crowded and/or degraded (Biswas et. al. 1987; McCabe 1990a). Likewise, herders already stressed by deteriorating rangeland conditions find that they cannot adequately defend their territories from invading groups.

Small farmers participating in agricultural schemes can suffer as well from the disruption of linkages that traditionally tie pastoralists to river basins. Perhaps the most important link for farmers is the opportunity to invest in livestock (McCown et. al. 1976; Biswas et. al. 1987; Swinton 1988; Little 1987 1983; Hogg 1983). Other negative effects include the loss of manure deposited on fields (McCown et. al. 1976; Omerod 1978; Toulmin 1985), the loss of income derived by selling crop remnants to herders for use as dry season fodder (McCown et. al. 1976), the loss of livestock products (Biswas et. al. 1987; McCown et. al. 1976; Little 1987), and the loss of pastoralist labor at critical times in the agricultural calendar (Horowitz and Salem-Murdock 1987).

Drought, Famine, and Nomadic Pastoralism

The recognition that drought and famine are not the same, and that drought does not by itself necessarily cause famine, comes as developing societies continue to be plagued by famine in spite of the advances in the technology of food production, nutrition, and communication (Glantz 1986; Ibrahim 1987; McCabe 1990b; de Castro 1952). Although drought often provides the environmental preconditions for famine, a review of the historical record of drought-prone regions reveals that famine does not necessarily follow drought (Glantz 1986). The links between drought and famine are mediated by the arrangements of society. And these arrangements can either minimize or accentuate the consequences of drought (Lofchie 1975). Resource use and access arrangements at the local and regional level in established farming and pastoral production systems are geared to protect system viability from occasional drought (Swinton 1988; Kimmage 1991; Glantz 1981; McCabe 1990a; Hankins 1974; Ibrahim 1987). Interventions which disrupt or alter traditional drought coping arrangements are often far more significant in their contribution to famine than is drought alone (Torry 1984; Ibrahim 1987; Glantz 1986). For pastoralists, one of the most important drought survival mechanisms is migration (Ibrahim 1987; McCabe 1990a; Toulmin 1985).

Famine induced destitution of nomadic populations and their herds is an enormous problem in Africa, and results in large expenditures for famine relief and refugee programs (Torry 1984; Oba 1985; Frantz 1975; Hogg 1983; Clark 1985; Zumer-Linder 1986; McCabe 1987 1990a; Toulmin 1985; Little 1984; Campbell 1981; Lewis 1975). The livestock industry--a significant, and in many cases a dominant part of the national economy in a large number of African countries--can be severely damaged by herd loss and the impoverishment of pastoralists (Clark 1985; Bennett 1984; Campbell 1981; Biswas et. al. 1987; Toulmin 1985; Box 1971; Lewis 1975). This may become especially problematic considering that rangeland livestock production will be essential to many nations' ability to feed growing populations (Biswas et. al. 1987; Campbell 1981) off of a land resource where transhumant pastoralism may not only be the only sustainable use; but may be one of the few assets possessed and easily exploited by largely agrarian economies.

Famines and famine relief can wreck or thwart development programs by altering the demographic composition of whole areas (Torry 1984). As large numbers of destitute and displaced pastoralists migrate to and settle in river basins and refugee camps (usually located near permanent water sources), conflicts and competition with farmers in these areas can increase dramatically as pastoralists consume grain in place of livestock products, and are encouraged to engage in crop cultivation (Toulmin 1985; Campbell 1981; Evangelou 1984; Little 1987; Zumer-Linder 1986). The impact on local tenure regimes, and greater competition for fixed resources in these areas can add significant stress to agricultural schemes already burdened with the task of producing food for local, urban, and overseas consumers, in addition to providing a livelihood for small farmers (Glantz 1986; Horowitz and Salem-Murdock 1987).

THE SOMALIA STUDY

Background: the Horn of Africa, Somalia

The Horn is the most severely effected of Africa's drought and famine stricken regions (Pearce 1991b; Economist 1991a). Ethiopia, Somalia, and the Sudan have in recent decades been chronically afflicted by drought, famine, and political turmoil with hundreds of thousands starving or migrating to refugee camps (Burkhalter 1990; Perlez 1990a 1990b 1991; Torry 1984;

Lewis 1975; de Troyer 1986; Clark 1985; Press 1989 1990; Fitzgerald 1990; Murphy 1990; Prendergast 1990). At present these three countries contain more than half of Africa's hungry (Economist 1991c). As of March 1991 an estimated 15 - 20 million people on the Horn face starvation (Dorgan and Wheat 1991; Theiler 1991). The situation is such that Thorvald Stoltenberg, the United Nations High Commissioner for Refugees, considers the Horn of Africa the world's most intractable problem region (Kamm 1990) and a bill has recently been introduced into the United States House of Representatives that deals specifically with the recovery and food security of the Horn (Dorgan and Wheat 1991).

With over 5.8 million inhabitants and a surface area of 637,000 km2, Somalia (Figure 1) is rather sparsely populated (Conze and Labahn 1986). Livestock production is the primary economic activity in the country, comprising approximately 50% of the gross domestic product and more than 80% of the export revenue (Handulle and Gay 1987). About 55% of the national population participates in nomadic pastoralism, while 80% of the population is engaged in livestock raising of some kind (Conze and Labahn 1986; Handulle and Gay 1987). As the most important agricultural enterprise in the country, transhumant pastoralism will be the basis for food production for future populations (Bennett 1984; Lewis 1975; Box 1968 1971; Biswas et al 1987; Conze and Labahn 1986). Irrigation however has played a large role in the increased production of cereal and export crops; and irrigation rehabilitation is a priority in Somalia (Biswas et al 1984).

In recent decades considerable rangeland degradation has taken place under year-long grazing and improper land use (Biswas et al 1987; Box 1968 1971). Along the Shabelle river, and especially near refugee camps (Figure 2a), natural resources are severely stressed by overgrazing and deforestation (Drechsel 1989). The refugee problem in Somalia is considerable. A series of droughts and wars in the 1970s and 1980s and the resulting livestock mortalities expanded refugee numbers at that time to between one-quarter and one-third of the entire population (Magan et al 1983).

Study Site

The study area is located in southern Somalia, in the lower Shabelle flood plain, approximately 100 km south of the capital, Mogadishu, and 11 km inland from the coastal city of Merca (Figure 1). The site is situated between 44o 30' and 45o east longitude, and 1o 30' and 2o degrees north latitude. The area is characterized by fairly level topography, fine textured soils, and a tropical semiarid climate (TAMS 1986). Located adjacent to the Shabelle river, the site covers approximately 8,500 variably irrigated hectares. It is bordered by coastal sand dunes to the east and south and an old river channel to the north and west (Figure 1).

Environment

Average annual precipitation for the study area is 400 mm/ year, ranging from 282.3 to 736.0 mm/year (Ministry of Agriculture Meteorological Service 1988). Precipitation is distributed in a bimodal pattern with two alternate wet and dry seasons. The Gu season is the major rainy season lasting from April to June, followed by the minor Hagai dry season (July September). The Der season follows the Hagai and is a minor rainy season lasting from October to December, followed by the major Jilaal dry season from January through March. Characteristics of the rainfall pattern in southern Somalia include scarcity, poor distribution, variability in the onset of the wet season and high variability in the amount of precipitation from year to year. This results in a drought recurrence interval of every four to five years (Handulle and Gay 1987). Potential evaporation in the interior of southern Somalia is in excess of 2,500 mm/year, where it greatly exceeds annual precipitation. Soil moisture deficits in the interior prevail for most of the year and vegetative growth is highly seasonal. The length of the growing season and the severity of the soil moisture deficit are the primary factors determining range productivity in southern Somalia (LRDC 1985).

Land Use

The study area is part of a larger irrigation complex (Figure 1) put into operation by Italian colonists in the 1920s and 1930s as a way to generate income for the colonial administration. The owners of the Italian plantations or "aziendas" (represented by rectangles of varying size in Figure 1) left in the 1960s, and smallholder subsistence irrigated agriculture has since become the dominant form of cultivation in much of the area for the past 30 years. Presently with continuing irrigation development and agricultural expansion elsewhere along the Shabelle (Figure 2b), serious seasonal water shortages are being experienced (Roth et al 1987; LRDC 1985). The population of the small farmer area is relatively high; with the land per person being approximately 0.3 ha. Presently small farmer water allocation takes place in a complex mixture of relationships and arrangements that are connected with numerous off-farm activities. Average farm size (several parcels may comprise one farm) is 2.24 ha. Small holder subsistence farms make up about 60% of the study area. The remaining area is divided among large farms and plantations.

The small farmers in the study area fall within the definition of subsistence producers according to Massey (1987). Present cropping patterns for the small farmers in the study area are dominated by maize (Zea mays) and sesame (Sesamum indicum) cultivated primarily as subsistence crops. Vegetables and other minor crops are grown only on a limited scale. Maize is cultivated primarily in the Gu season, while sesame is the dominant crop in the Der season. The little maize that is grown in the Der is dependent on available irrigation. Both the maize and sesame crop residue is cut and stacked as part of the harvesting process, in order to get it out of the way for the next season's cultivation, and to prevent livestock from trampling the field as they forage on it.

The production of fodder crops does not presently take place nor does it appear feasible. Pastoralists are usually able to obtain freely what crop residue is available in the dry season. If subsistence farmers were to grow fodder crops in a good rainfall year, when plenty of free crop residue is available and fewer transhumant livestock arrive in the irrigated area, the farmer would receive little or no money for his crop. This is a risk that subsistence farmers are unwilling to take. Large farms and plantations do not produce fodder crops for the same reasons. Government subsidy of fodder crops would entail the construction and maintenance of storage facilities, and a long term commitment for purchase and transport of the fodder harvested. While such an arrangement would be valuable for both farmers and pastoralists, the government of any developing country burdened by external debts, and pursuing agendas of greater priority, would not be able to afford to subsidize everything that fodder crop production would entail over the long term.

While the irrigated area does not presently have the capacity for production that it did when it was operated by Italian colonists for export crops, it has, under small farmer occupation, been able to evolve the necessary mechanisms and arrangements that allow it to survive the frequent difficulties of the area. Over the 30 years following the departure of the Italians, the irrigated area has survived: frequent droughts, most notably the severe Abaar drought of 1972-1975 and the resulting refugees (Lewis 1975); the settlement of additional refugees from the war with Ethiopia in 1977; occasional large scale flooding; and severe economic fluctuations, including a change from a centrally planned economy to a market economy, and the loss of Saudi Arabia as the principal livestock export market; in addition to the seasonal invasion of very large herds of transhumant livestock. These stresses of varying scale and frequency have all served to establish a highly intricate land use ecology that is tied to the functioning of the region.

Livestock and Livestock Movements

The pastoral systems of Somalia are made up of cattle, camels, sheep, and goats. Transhumant livestock are found in the Lower Shabelle region from the end of the Hagai dry season to the end of the Jilaal dry season, until the Gu rains begin. Dry season livestock migrations into the Shabelle river basin just inland from Merca (which includes the study site) result in one of the highest livestock densities in the country (Figure 3) (RMR 1984). During the Gu season these herds disperse north and northwest into the Bay region in order to take advantage of forage and surface water in the interior and avoid tsetse fly infestations which occur along the river (Salisbury 1988). The first herds to return to the irrigated area usually belong to the agropastoralists who are settled along the Shabelle river. Livestock belonging to nomads do not arrive in large numbers until late in the Der season. Herds spend the Jilaal concentrated on croplands close to the river where they feed primarily on crop residues. As the dry season continues this concentration increases, and in severe droughts livestock from other areas can be drawn to the irrigated area to compete for crop residues (RMR 1984). Figure 3 shows the livestock movements into the area prior to and during the dry season.

The numbers of livestock owned by the resident agriculturalist population which are kept in the study area varies with the season and the severity of forage and water shortages in the interior. In the wet seasons of good rainfall years, much of this livestock is kept off-scheme in the interior where arrangements are made with nomadic relatives or others to graze and water the herds in a transhumant fashion. However in years of greater water and forage scarcity, these animals may spend part or all of the wet season on-scheme where their owners are able to ensure forage and water supplies. This means that less forage will be available to nomadic herds when they arrive at the onset of the dry season.

With the expansion of agriculture and the implementation of development schemes along the Shabelle river (Figure 2b), seasonal flooding has decreased, and as a result the flood retreat pastures which traditionally served as dry season forage and water areas for nomadic herds have been greatly reduced (LRDC 1985; Conze and Labahn 1986; TAMS 1986). This exacerbates the problem of locating dry season forage and water for transhumant pastoralists.

Determination of Livestock Carrying Capacity and Proportional Area Requirements

Approach

The method used here attempts to determine the proportion of small farmer area to large farmer and plantation area that is needed in order to maintain the observed quantity of livestock that arrives in dry seasons of varying severity. Within the study area there are four separate land use interests, each with very specific and often conflicting agricultural arrangements, goals, and agendas. Those engaged in plantation agriculture usually have the backing of the national government and are engaged in the production of cash crops for export in order to gain hard currency. Large farmers not growing export crops are most often engaged in the production of much needed food for the rapidly expanding urban centers. Both the large farmer and plantation areas are located along the river and primary canals where access to water is relatively secure. The small, or subsistence farmers are the most populous group and seek to provide for themselves and grow occasional surpluses to be sold in local or urban markets. The small holder areas are located further away from the river and are more variably irrigated; meaning that a large number of farms often cultivate under rainfed conditions or with less than optimal irrigation. Nomadic pastoralists have access to small farmer areas in the dry season subject to a number of constraints, and are primarily interested in getting through the dry season and occasional droughts with as little loss to their herds as possible. These four interest groups define the variables which, together with season and time, are responsible for the livestock carrying capacity and livestock presence in the study area. These variables, which interact with each other include: 1. land area, in five different categories, each of which can be in one of three possible states; 2. livestock numbers, in varying locations and varying quantities for different lengths of time; 3. season, which changes throughout the year and between years for a total of nine different seasonal states; 4. quantity and forage value of available fodder, which changes with season, precipitation, irrigation, land use, farm owner, and livestock; and 5. time. The primary objective of this study is to outline in quantitative terms, the interaction of these variables under changing conditions in order to explore the proportional area requirements needed for integration of nomadic herds and irrigated agriculture, given existing land uses.

Data Acquisition

The data for this study were collected during 18 months of fieldwork, and consist of information gathered from questionnaire surveys, and parcel measurements, and key informant interviews.

Three formal questionnaire surveys were carried out targeting three different groups: small farmers (less than 25 ha.), large farmers (25 ha and above), and agro-pastoralists. The small farmer survey consisted of three rounds of questionnaires given to 114 randomly selected participants, and focused on a wide variety of subjects in order to reveal present land use practices. These included: demographics, agricultural practices, access arrangements to water and forage, livestock numbers and types, forage production from a variety of sources, forage and water locations, land tenure, and a range of socioeconomic topics. The large farmer survey was made up of 30 nonrandomly selected participants who were interviewed once and were asked for much of the same information. The agro-pastoralist survey comprised 123 nonrandomly selected interviews with small farmers who also owned livestock and were familiar with seasonal fodder sources and fodder requirements for livestock. The agro-pastoralist survey was carried out solely for the purpose of determining the relationship between the different types and states of land present in the study area and the length of time that livestock are able to live off this land. Of interest was the livestock carrying capacity of land under fallow, maize and sesame crop residue, riverine grassland, and areas of previous cultivation; in good, average, and poor precipitation/irrigation years.

Parcel measurements were obtained for all of the randomly selected small farmers in the study in order to accurately determine area. Because all of the area occupied by large farmers is registered and therefore had to be surveyed, stated farm sizes were quite accurate and easily verified from the local land registry.

Standard stock units (SSU)

Conversion of livestock quantities into standard stock units (SSU) was accomplished following Field (1980) using Somali specific breeds, herd age structure, feeding habits, and liveweights. For Somali conditions the standard stock unit is a mature bovine with a liveweight of 450 kg that consumes 4,100 kg of dry matter per year. In this framework one SSU is equivalent to two camels or cattle, 20 sheep or goats, or 5 donkeys.

Onscheme wet season SSU densities from the small farmer questionnaires correspond with densities estimated from overflights of the area by Resource Management and Research (RMR) (1984). Overflights were undertaken in both wet and dry seasons, facilitating the estimation of dry season SSU densities on scheme. Small and large farmer questionnaire-derived estimates of SSU presence in the study area were used for the Gu, Hagai, and Der seasons, allowing a more detailed analysis of onscheme SSU numbers in these seasons. Der season observed SSU values were used for the Hagai season because sampling did not take place during the Hagai. However Der SSU estimates are higher than in the Hagai (Salisbury 1988) thus erring on the conservative side. In the Jilaal, RMR's (1984) estimates of dry season SSU densities for the area (which includes large and small farmer areas of the scheme) for an average water year were used for each of the water quality years (good as well as poor) as these were the only data available. The SSUs owned by resident farmers on-scheme who did not allow fodder access on their land were excluded from the calculations, as it was assumed that their land is used to sustain their own livestock. Large farmer SSU quantities were constant for Gu, Hagai, and Der of all water quality years in the calculations because large farmers do not usually send their livestock to the interior in wet seasons as small farmers do. The only change in SSU numbers in the large farmer area then is during the Jilaal when RMR's (1984) livestock density estimates for the whole area were used to estimate the dry season increase in SSU numbers in the large farmer areas.

Livestock carrying capacity and land use

In order to determine the livestock carrying capacity for the different land uses (in different states in different seasons of the year, and in good, average, and poor water years) land was grouped into five categories: 1. land under maize cultivation; 2. land under sesame cultivation; 3. previously cultivated land (applicable only in the Jilaal season and includes all land previously cultivated irrespective of crop); 4. fallow land, and 5. areas under riverine grassland.

The total study area under each of these categories in each season was obtained by extrapolating from the category areas in the random sample. It is possible for a single piece of land to belong to several different categories over the course of the year, producing different livestock carrying capacities depending on the season and the use. And while carrying capacity was calculated on a seasonal basis, the carrying capacity in any one season depends on the land use in the previous as well as the present season. For example, if a parcel is cultivated with maize or sesame in the Der season, the crop residue will not be available until harvest at the end of the season. Then in the following Jilaal season the carrying capacity for that parcel would be the carrying capacity of the crop residue from the Der season cultivation (cut and stacked in the corner of the parcel) plus the carrying capacity of the parcel itself in the category of previously cultivated. While the carrying capacity of the previously cultivated category is the lowest of any category, it is still significant due to the inefficiency of hand weeding, such that the noncrop vegetation present after harvest is able to support some livestock.

Calculation of carrying capacity for the crop residue categories in good, average, and poor water years was accomplished following equation 1. The units used for quantities of maize and sesame crop residue are known locally by the terms bal, and ambul respectively.

Eq. #1.

$$Csi = SSUi * [(Xi/Rsw)/3]$$

where: Csi = the carrying capacity for SSU in season s on land category i; $SSUi$ = the number of SSU that can live off a single unit of crop remnant of category i for one month; $[(Xi/Rsw)/3]$ = the monthly quantity of crop residue units available in season s in land category i (number of maize bals or sesame ambuls),

where: Xi = the total area (ha.) under category i;

Rsw = the area producing a single unit (bals or ambuls) of crop residue in season

s, in water year w, where w is defined as good, average, or poor;

3 = number of months per season, for all seasons. Carrying capacity was calculated on a seasonal basis because season determines availability.

For the categories of fallow, previously cultivated, and riverine grassland, carrying capacities were calculated using equation 2:

Eq. #2.

$$Csi = (Xi * SSUiw) / 3$$

where: Csi = defined in equation 1;

Xi = defined in equation 1;

SSUiw = the number of SSU sustainable on one hectare of land category i in water year w;

3 = number of months per season.

Carrying capacity and observed SSU

Comparison of observed SSU with the calculated carrying capacity was carried out in order to determine if the livestock carrying capacity of the scheme could support the quantity of livestock actually present during dry seasons of varying severity. This was accomplished with equation 3:

Eq. #3.

$$Ks = (\Sigma Csi) - Os$$

where: Ks = the number of observed SSU not sustained in season s (if a negative number), or the extra number of SSU which could be sustained (if a positive number);

(Σ Csi) = the summation of all crop/land category carrying capacities i which are available in

season s;

Os = the observed number of SSU in season s.

Proportional land allocation

The area under present land use that is needed to accommodate the transhumant herds that arrive in the study area in the dry season was calculated using carrying capacities for livestock in years of varying dry season severity. These carrying capacities were used to obtain ratios of irrigated land optimally allocated to three broad land use classes: plantation agriculture, large producers, and small farmers. Transhumant livestock excluded or not supported in the large farmer areas must go to the small farmer areas, which increases the SSU density there. Plantation agriculture (such as bananas) exclude 100% of the transhumant livestock which would have occupied the area otherwise. This livestock must also go to the small farmer areas. Thus an important part of the calculation of the needed land area to absorb the transhumant herds in the dry season is the accounting for the livestock that are excluded from plantation and large farmer areas, as this is part of the existing land use practices.

Determination of the small farmer area that would be needed under present land use practices in order to sustain the observed SSU density in the Jilaal dry season was made following equation 4:

Eq. #4.

$$NHs = [(SFOs / SFA) + (LFKs / LFA) + P] / [(\Sigma\ Ci)s / SFA]$$

where: NHs = Number of hectares of small farmer area needed for every 1 hectare of large farmer area and 1 hectare of plantation area;

SFOs = the total observed number of SSU in the small farmer area in season s;

SFA = the total small farmer area (ha);

LFKs = the number of SSU not supported in the large farmer area in season s;

LFA = the large farmer area;

P = (1.273 SSU/ha excluded from plantation area * 1000 ha)/ SFA;

[(Σ Ci)s / SFA] = together the terms in the brackets give sustainable SSU density (SSU/ha) in the small farmer area in season s.

Thus the total observed SSU density from the small farmer area (SFOs / SFA) and the density from the large farmer area not supported there (LFKs / LFA) were summed together with the density from the plantation area (P) to obtain an SSU per hectare total density which ends up in the small farmer area. This density is divided by the small farmer area sustainable density [(Σ Ci)s / SFA] to give the number of small farmer hectares needed for every 1 hectare of large farmer area and 1 hectare of plantation area in the scheme, in order to maintain the observed SSU which arrive in the small farmer area in the dry season.

Fodder Utilization, Carrying Capacity, and Area Needed

Within the existing ecological and land use conditions, and the resulting crop productivity, there are a number of factors which further influence the irrigation scheme's livestock carrying capacity. The interaction of three of these factors however are dominant in the utilization of fodder resources:

temporal availability, access, and the forage value and vulnerability of different fodder types in the face of drought.

Temporal availability of fodder sources

Not all fodder sources are available at all times. The categories available to be utilized for forage in the Gu season include only riverine grassland and fallow land, as all other land is under cultivation. For the Hagai season available forage sources include fodder left over from the Gu season, plus maize and sesame crop residue from the Gu season harvest, as well as Hagai season grassland areas. Land fallowed in the Gu is accounted for in the Gu, and thus is not available in the Hagai. Der season forage sources include fodder left over from the Hagai, and Der season fallow and grassland areas. In the Jilaal, maize and sesame crop residue produced in the Der season, plus the categories of previously cultivated, (which includes Der fallow land), grassland, and any fodder left over from the Der season are available. No fodder left over from the Jilaal season is carried over to the Gu. These temporal availabilities of fodder resources are incorporated into equations 1 and 2 for Csi by taking into account season and land categories. Not considered in the calculations of the fodder left over from one season and used in the next are rates of biomass decay or the quantity consumed by insects. Thus these are intended as approximate estimates of carrying capacity.

The impact of livestock owned by resident agriculturalists on the temporal availability of fodder supplies can be considerable. In poorer water years, more farmers keep their livestock on-scheme during the wet season. This reduces the forage available later for transhumant herds in a year when fodder production is already less, and greater numbers of livestock will be arriving earlier in the study site in response to the poor forage availability in the interior. Equations 3 and 4, building on equations 1 and 2, incorporate this into calculations using season specific observed SSUs and carrying capacities.

Access to fodder resources

A portion of both large and small farmers maintain private tenure over crop residue and grazing sites in the dry season. This forage is not accessible to transhumant herds and was not included in calculations of livestock carrying capacity. Table 1 compares the percentage of total land area accessible to transhumant herds under each of the land categories, for large and small farmers. For all categories except grassland, large farmers allow much less free grazing on their land than do small farmers. This is because large farmers practice more intensive agriculture and are not as involved in exchange relationships with livestock owners. For the maize and sesame categories, small farmers allow free grazing on 81% and 70% more land, respectively than do large farmers. For the fallow land category, small farmers allow free grazing on 43% more land. In previously cultivated areas, 21% more land is available in the small farmer area. However for riverine grassland, large farmers have 62% more area open for free grazing than do small farmers.

<u>Value and Vulnerability of fodder types</u>

Tables 2 and 3 present the calculated SSU carrying capacity for the small and large farmer areas respectively in good, average, and poor water years for all seasons. These numbers represent the values for Csi in equations 1 and 2 and they give an indication as to the vulnerability (defined here as a reduction in SSU carrying capacity) of specific fodder resources to a decrease in water, i.e., a poor water year, or drought. For all categories except "previously cultivated" the SSU carrying capacities range between 49% and 58% less in a poor year compared to a good year. The previously cultivated category expressed a poor year carrying capacity that was 78% less than in a good year, meaning that as a fodder source the previously cultivated category is most vulnerable to severe dry seasons and drought. The fallow and grassland categories are less vulnerable, the carrying capacities of these being reduced by 55% and 58% respectively, in poor years. The two crop categories (maize and sesame) are least vulnerable as a fodder source, the carrying capacities of both are reduced by 49% and 50% respectively from good to poor years. While Tables 2 and 3 are useful for looking at fodder vulnerability for the study area, Table 4 presents SSU density carrying capacities on a per hectare basis for all fodder sources across good, average, and poor water years. Comparison across fodder sources for a given water year gives an idea as to the value of the source in number of livestock sustained. Comparison between water years for a given source gives an indication of vulnerability (reduction in carrying capacity). Forage value and vulnerability are intertwined, and both are important in the dynamics of livestock carrying capacity in the area. The different forage values of fodder resources in the maintenance of livestock in different water years are best illustrated with Table 4. Converting from one crop or use to another can mean a loss or a gain in livestock supported given a good, average, or poor water year and the choice made. For example, converting from fallow/idle to sesame from a good to poor year would mean that on a per hectare basis, the land involved would be able to support 8.6 fewer SSU (10.15 SSU - 1.6 SSU)(Table 4). However the water year (good, average, poor) does not alone control SSU carrying capacity. If a change from maize to sesame were made from a poor water year to a good water year, there would still be a 6.3 SSU loss in carrying capacity due to the large differences in fodder value between maize and sesame. Total carrying capacity for the area however must incorporate the total hectares under the different crops and uses at any give time. This has been accounted for in equations 1 and 2 for Csi by including the area under each land category (Xi). The twin characteristics of value and vulnerability are different for each fodder source. Thus as the severity of the dry season varies, the magnitude of the contribution of each fodder source to livestock carrying capacity also varies. This is incorporated into equations 1 and 2 by considering the carrying capacity of different land types in different "water years" (w).

<u>Livestock supported and area needed</u>

The above components of livestock fodder utilization determine the quantity of SSUs that can be supported on-scheme. Table 5 shows the quantity of SSUs in the study area which are not supported (negative numbers), as well as the additional numbers of SSU which could be supported (positive numbers). The numbers for the small and large farmer areas represent values for Ks in equation 3. Significant differences can be noted between good, average, and poor years for the small farmer area. In a good <u>Jilaal</u>, 10,220 more SSUs can be supported than in an average <u>Jilaal</u>, and 12,800 more can be supported than in a poor <u>Jilaal</u>. The values for SSUs not supported in large farmer areas (Table 5) are higher overall, reflecting the large area under permanent agriculture and thus unaccessible for livestock grazing. The SSUs not supported in the large farmer area then seek fodder access in the small farmer area. This quantity, in addition to the SSUs already in the small farmer area plus the SSUs excluded from the plantation area, represents the total number of SSUs which end up in the small farmer area in the <u>Jilaal</u>.

Equation 4 takes this total small farmer SSU density and calculates the small farmer area (hectares) necessary for every one hectare under plantation and one hectare of large farm agriculture in order to absorb the number of livestock in the study area in all seasons, in years of varying water quantity. These values are presented in Table 6. The area needed in an average <u>Jilaal</u> is 2.8 times that needed in a good year, and in a poor Jilaal the area needed is 4.6 times greater than in a good year.

Land Use Design Implications

Forage area continuum

The values in Table 6 represent a continuum encompassing the subtleties of the interplay between the existing mosaic of land use and the ecological variability inherent in the functioning of the area as a dry season forage source for transhumant herds. If expanded, the continuum would include increasingly large areas reflecting the need for more land to sustain nomadic herds during dry years of increasing frequency, length, and aridity. Maintaining transhumant herds on-scheme during most of the good, average, and poor year dry seasons, means that overgrazing in other areas of the migratory route would not occur during this time. Thus when a drought or a string of poor years does occur, the pastoralists, their herds, and the range would be less vulnerable.

In the design of an irrigation scheme a realistic point along this continuum must be chosen which will serve to maintain most of the transhumant herds in most years. In this case the value for an average Jilaal (1.17 ha) might be considered optimal. A good year occurs three years out of ten, an average year 3.2 years out of ten, and a poor year 4 years out of ten. Thus if a scheme were designed for an average water year it would absorb transhumant herds 6.2 years out of ten (good plus average). Some stress in some years with respect to available dry season forage is perhaps desirable in order to maintain relatively constant livestock numbers in the long term. If all nomadic herds visiting the study site were sustained even in poor years, the result might be large increases in herd size by nomads, similar to what occurs during a series of good rainfall years. However this is likely to vary with any given location.

The differences in value and vulnerability of fodder sources between good, average, and poor years has design implications. While fallow land has the highest forage value in any given water year, it also has the greatest vulnerability in terms of the number of SSU not supported between good and poor years. Maize on the other hand does not have as high a value as fallow land does, but has a lower reduction in livestock supported between good and poor years. The interactions between value and vulnerability are important in the displacement of livestock in poor years due to the inability of the area to support them. This displacement can then result in overgrazing elsewhere.

The spatial and temporal complexities of value and vulnerability in the context of water availability and change in crop/land use again highlights the need for looking at the broad mosaic of land uses in order to integrate livestock with agriculture. In the primary rainy season (Gu) maize does well, and in the Der sesame fares better than other crops. Land where the crop has failed due to lack of water is often idle or fallow. For a given rainy season however a farmer is unable to determine at planting if it will be a good, average, or poor precipitation/irrigation year.

Finally given the low value of riverine grassland, further research may indicate that greater priority should be given to optimal and reliable water distribution to small farmer crop production in irrigation schemes, than to providing and enforcing the maintenance of grassland commons for the grazing of transhumant livestock, given that access to crop residue is not denied.

Change in land area needed to support transhumant herds

With the utilization of in-place land use practices and patterns, the gradual development of the area may eventually result in a reduction in the area needed to support transhumant herds; allowing the area under intensive agriculture (where livestock are excluded) to expand, if this is a priority. Such a change could be possible through several processes.

First, the conversion of river basin vegetation to croplands (irrigated or rainfed) can be an advantage for transhumant livestock if crop residues are used as fodder. This is because the forage value and hence the carrying capacity of many crop residues is higher than that of natural pastures (McCown et al 1976; Charneau 1975), and because a significant amount of natural riverine vegetation is woody and unusable to livestock (Jahnke 1982). Table 4 illustrates for this study that on a per hectare basis maize/fallow cropland has a higher livestock carrying capacity than riverine grassland, even without a woody component. Meaning that for the same number of livestock less land would be needed under maize/fallow cropland than under natural riverine vegetation. Conversion from riverine grassland to maize then would allow more area to be intensively cultivated.

Second, there is a large increase in crop (and crop residue) yield with irrigation or improved irrigation in comparison to rainfed yield. At Shalambood the increase in maize yield with the proper number and timing of irrigations was estimated to be nearly double that for rainfed or unimproved irrigation yields (Roth et al 1987). Because areas presently under intensive agriculture are located along the river and primary canals it is likely that these areas already have access to water at the levels required for maximum production. Thus additional water made available by irrigation rehabilitation or improvement over time will primarily enable better timing and efficiency of water use and a greater quantity of water on smallfarmer land, and will result in greater crop productivity (Roth et al. 1987) and ultimately less small farmer area needed to support livestock, given that access to residues is not denied.

A trend that may also contribute to the decrease in land area needed for livestock involves the number of resident livestock. Presently 61% of the small farmers in the sample own livestock. However there has been a 36% reduction in the number owned between when small farmers (as a group) first started farming and the present. Should this continue, it would also mean more forage would become available for transhumant herds, and an additional reinforcement for communal tenure arrangements in the Jilaal. On the other hand Little (1987) observes that the implementation of irrigation schemes encourages the "cultivating herder" and the "absentee herd owner".

Final Notes

While substantial increases in the production of crop residues might be realized through the utilization of agricultural inputs, it would be unwise to include such increases in the calculation of the area needed to sustain transhumant herds, because use of such inputs does not presently occur, and, this would assume that such inputs will always be readily available, at a price that all small farmers could always afford, and that it is properly applied in a uniform manner over the entire small farmer area.

From a land tenure perspective, having adequate free forage available onscheme for livestock in most years may decrease the monetary value of crop residue and thereby encourage a continued communal land tenure arrangement by small farmers in the Jilaal, because little would be gained by maintaining private tenure over crop residue and other grazing sites for purposes of monetary gain. This might encourage those that presently do not allow free grazing in the Jilaal to allow it, further supporting dry season communal tenure. Ultimately this may result in less dry season area needed to support transhumant herds. Thus the above trends and processes could contribute to the increase in the capacity of the irrigated area to sustain transhumant herds as the area slowly develops. As such it may become possible to eventually increase the area under intensive agriculture while maintaining the means to support large seasonal influxes of nomadic herds. The importance of the flexible evolution of river basin development projects is laid out very clearly by Berry et al (1985), and is further evidenced by the most successful case of river basin development in Africa, that of the Nile river in the Sudan and Egypt which has evolved for over 50 years of sequential planning and development; although there are still many problems and unrealized opportunities (Pollard 1981; Barnett 1977).

In order to preserve the dynamics of the resource rights connected with in-place land use systems, existing tenure regimes must be either made legitimate at the national level, or translated into the national legal tenure system. This is because in African development projects traditional user groups often lose rights to resources when the value of these rights are inflated by pre-project speculation and/or project implementation. Project benefits can then accrue to urban investors or absentee landowners to the detriment of the previous, or traditional resource users; although the above scenario of crop residue access and utilization could conceivably occur under a number of tenure arrangements. If however it is widely known that large areas of irrigable land will remain as variably irrigated small holdings, this may discourage the acquisition of land by non-residents.

Additionally, allowing seasonal access of transhumant herds to areas of traditional dry season foraging and watering as opposed to trying to maintain these herds in the interior through the creation of boreholes and watering points, would avoid the pronounced desertification of observed in such attempts (Moghraby et al. 1987).

This paper does not present the management technicalities of increasing the area under more intensive irrigated agriculture. What it attempts to do, is present some of the factors and possible options which need to be considered for an irrigated area to absorb nomadic herds in dry seasons of varying water quantity. Maintaining regional linkages with transhumant pastoralists in the advent of river basin development is important in the functioning and potential improvement in regional land use ecology and economy. Development schemes which interrupt regional linkages, risk disruption of regional land use and often the viability of the proposed schemes themselves. Chronically problematic areas like the Horn of Africa, need to receive development programs that can productively operate within the context of the difficulties of the area, as opposed to unwieldy schemes with lofty goals that may work well in other places but can easily create or encourage donor dependency and then succumb to one of the many endemic problems of a disadvantaged area. These designs need to be fused with in-place, traditional production systems for the benefit of regional economies, instead of pursuing exclusively urban or national development agendas at the expense of regional sustainability, and even, stability.

Historically Third World agriculture has met increased food needs by increasing the areas under cultivation and irrigation, and in Africa the Green Revolution has by and large not changed this (Shiva 1991; Sesmou 1991; Goldsmith and Hildyard 1991). Today however additional fertile land is scarce. The FAO has estimated that the amount of land per inhabitant in developing countries will fall from 0.85 ha at the beginning of the 1980s to 0.6 ha by the year 2000 (Economist 1991b). Most new land being brought into agriculture is of poor quality and only briefly useful. Meanwhile as much as 175 million ha of rainfed land and 70 million ha of irrigated land could be taken out of production by the year 2025 due to overgrazing, water shortages, salinity and soil erosion. The FAO again estimates that by this time no new high quality arable land will be available (Economist 1991b). In 1989 the FAO reported that in 93 developing countries 60% of harvested land was concentrated in "high potential" areas (Economist 1991b). While there is no simple solution for Third World food production problems, it is becoming apparent that multiple land use designs need to be applied to high potential areas in order to reap maximum benefit (Economist 1991b).

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Table 1. Percent of Total Area Available
to Transshumant Herds for Large and Small Farmers
Small farmer area: 5133.0 ha. Large farmer area: 3126.7

Category	Small Farmers (%)*	Large Farmers (%)*
Maize	63.75	12.03
Sesame	38.34	11.43
Fallow/Idle	29.0	16.66
Prev. Cultivated**	66.48	20.47
Grassland	2.0	5.25

* Spatial double accounting has taken place in order to realistically account for all forage available.

** Jilaal season only.

Table 2. Calculated Fodder Carrying Capacity for the Small Farmer Area.
(Units in SSUs sustainable for the season in which the fodder is produced*)

Good Year

Category	Gu	Hagai	Der	Jilaal
Maize	7364.4		816.2	
Sesame	637.2		1436.5	
Fallow/Idle	786.3		4256.5	
Prev. Cult.			29116.4	
Grassland	39.0	39.0	39.0	39.0

Average Year

Category	Gu	Hagai	Der	Jilaal
Maize	4943.9		547.9	
Sesame	477.9		1077.4	
Fallow/Idle	569.4		308.3	
Prev. Cult.			1771.6	
Grassland	27.7	27.7	27.7	27.7

Poor Year

Category	Gu	Hagai	Der	Jilaal
Maize	3721.0		412.7	
Sesame	318.6		718.3	
Fallow/Idle	357.4		1929.1	
Prev. Cult.			635.2	
Grassland	16.4	16.4	16.4	16.4

*The Gu and Der season maize and sesame production are available in the subsequent Hagai and Der seasons respectively, and not in the season in which they were produced.

Table 3. Calculated Fodder Carrying Capacity for the Large Farmer Area.

(Units in SSUs sustainable for the season in which the fodder is produced*)

Good Year

Category Gu Hagai Der Jilaal

Maize 914.4
26.3

Sesame 3.2
373.6

Fallow/Idle 440.2
440.2 440.2 440.2

Prev. Cult.
400.2

Grassland 65.7
65.7 65.7 65.7

Average Year

Category Gu Hagai Der Jilaal

Maize 613.9
17.3

Sesame 2.4
280.2

Fallow/Idle 319.0
319.0 319.0 319.0

Prev. Cult.
243.9

Grassland 46.6
46.6 46.6 46.6

Poor Year

Category Gu Hagai Der Jilaal

Maize 365.8
13.3

Sesame 1.5
186.8

Fallow/Idle 199.6
199.6 199.6 199.6

Prev. Cult.
87.5

Grassland 27.6
27.6 27.6 27.6

*The Gu and Der season maize and sesame production are available in the subsequent Hagai and Der seasons respectively, and not in the season in which they were produced.

Table 4. Comparison of Forage Values and Vulnerability for Fodder Sources in Good, Average, and Poor Years. (Values are in quantity of SSUs sustained from one hectare of fodder resource for 30 days.)

	Fallow/idle	Maize	Riverine Grassland	Sesame	Previously Cultivated
Good yr.	10.15	7.5	4.6	3.16	1.87
Average yr.	7.35	5.04	3.2	2.3	1.14
Poor yr.	4.6	3.79	1.9	1.6	0.41
Fodder reduction from good to poor years (%):	55	50	59	49	78
SSUs/ha displaced from good to poor years:	5.55	3.71	2.7	1.56	1.46

Table 5. Results of Comparison Between Observed SSU and Calculated SSU Carrying Capacity for Small and Large Farmers (Units in additional SSU sustainable (if positive) or the number of observed SSU not supported (if negative))

Small Farmer Area

	Good year	Average year	Poor year
Gu	792.3	29.3	-728.8
Hagai	8797.6	4881.0	2895.8
Der	13057.9	4619.3	3681.1
Jilaal	11857.8	1640.7	-939.5

Large Farmer Area

	Good year	Average year	Poor year
Gu	370.6	230.4	92.1
Hagai	1658.8	1076.9	551.4
Der	2029.5	1307.3	643.5
Jilaal	-644.8	-1765.5	-2821.8

Table 6. Hectares of Small Farmer Area Needed in Years of Varying Water Quantity for Every Hectare of Land Under Plantation and Large Farmer Agriculture

	Gu	Hagai	Der	Jilaal
Good yr.	1.58	0.15	0.10	0.46
Average yr.	3.08	0.34	0.36	1.17
Poor yr.	6.36	0.60	0.50	1.92

Figure Captions

Figure 1. Location of the Study Site in Southern Somalia, and within the irrigated area. (Adapted from Prothero 1969 and Italian irrigation map, c. 1920) (Location of boundaries does not imply endorsement by the author).

Figure 2. (a) Refugee camps and resettlement schemes in southern Somalia; (b) Location of development projects and areas under cultivation. (Adapted from Prothero 1969; RMR 1984; and Conze and Labahn 1986).

Figure 3. Dry Season Livestock Movements in Southern Somalia. (Adapted from LRDC 1985).