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AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

WORK PLAN

VOLUME I

GENERAL RESEARCH PROGRAMS AND PLANS

WSARP PUBLICATION No. 13

OCTOBER, 1982

AGRICULTURAL RESEARCH CORPORATION
WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

The Government of Sudan
United States Agency for International Development
The World Bank
Consortium for International Development
Washington State University

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is supported by

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The Agricultural Research Corporation

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INTRODUCTION

This document is a draft of the research work plan for the WSARP Kadugli Station for the period of October 1, 1982 to June 30, 1984. Although station work plans will be prepared on an annual basis, it was felt that this effort, the first to be implemented since relocation to the completed station facilities, would best be developed to cover 20 months. This decision reflects current staffing plans and the consideration that the initial crop season in which agonomic experiments will be conducted on the WSARP research station will begin in 1983 and extend into 1984.

This document is organized in five sections. The introduction briefly reviews the WSARP in general terms, the Kadugli Station staff, organization, and physical facilities, the station training and associated activities, and the concept of Production Systems Research. For further details, see Volume I and Volume II of the WSARP Work Plan 1982 - 1985. Section 2 describes the physical and biological resources, the target groups and what is currently known about the production systems and constraints in South Kordofan. Section 3 contains the projected research activities with relation to the overall research objectives and discusses integration of these activities. Section 5 is an appendix containing detailed descriptions of planned research

activities presented in a traditional research proposal format. These constitute initially prioritized activities within the overall research plan directed toward achievement of project objectives. The format review procedure given in Volume II will finalize the approval of these activities.

Review of WSARP Development

The Western Sudan Agricultural Research Project (WSARP) formally began in July, 1978 with the signing of a loan agreement between the Government of Sudan and International Development Agency (IDA) of the World Bank. This loan was intended to fund the establishment of an Agricultural Research Corporation (ARC) research network in Western Sudan including modernization of existing buildings and construction of new research facilities in Northern and Southern Kordofan and Nothern and Southern Darfur and initiation of research activities. As planning continued it become evident that the loan funds would be inadequate to meet implementation needs and the US Agency for International Development (USAID) became a companion donor. Capital construction costs of re-establishing research stations at Kadugli and El Obeid and establishing new stations at Ghazala Gawazet and El Fasher purchase and operation of the project aircraft are funded primarily under the loan agreement. USAID contributes a portion of capital construction costs and provides funds for technical assistance, training, purchase of equipment and commodities, salaries and operational costs. The Government of Sudan also

contributes to capital costs, salaries and operational costs. AID funded technical assistance is implemented through a Title XII Collaborative mode agreement signed in August, 1979 between USAID and the Consortium for International Development (CID). Washington State University was chosen by CID as the lead university from among its nine (currently eleven) member universities, and is responsible for project management and implementation.

The existence of partially contructed research facilities at Kadugli lead to the strategy of prioritizing construction at this station to enable a pilot WSARP station to be functional prior to completion of the total construction program. Karplen Consultants of Khartoum provided the architectual and engineering services and Contracting and Trading Company of Beirut contracted for the construction. Work began in early 1980 and is currently nearing completion.

Project research activities in range and livestock, social science, and agronomy were initiated in 1980 (see Annual Reports, Bunderson and Araujo 1980-81), but lack of housing for additional staff limited the scope of research activities. The early studies and the work of predecessors and colleagues in other organizations in Southern Kordofan form the foundation on which the current research plan is based.

Station Staff, Organization and Physical Facilities

For administrative purposes the scientific staff at the Kadugli

Research Station has been grouped as follows:

Station Director - Mr. Mukhtar Kenani (Arrived 1979)

Socio-Economic Section:

Dr. Joel Teitelbaum -Sr. Social Scientist (Arrived January 1982
Dr. Neil Patrick - Sr. Agricultural Economist (Arrived April 1982)
Ms. Barbara Michael - Research Associate in Social Science (Arrived October 1982)
Mr. Mahmud Aya Mekki- Assistant Scientist in Social Science (Scheduled for graduate education in the U.S. in Sept. 1983)
Mr. Mohamed Azim Abu Sabah - Assistant Scientist in Social Science (Scheduled for graduate education in the U.S. in June 1983 and not currently resident in Kadugli)
Mr. Mohamed A. El Feel - Assistant Scientist in Economics (Scheduled for graduate education in the U.S. in Sept. 1983)
Mr. Siddiq Muraar - Assistant Scientist in Economics (Scheduled for graduate education in Extension in the U.S. in Sept. 1983 and not currently resident in Kadugli)

Range and Livestock Section

Dr. Trent Bunderson - Sr. Scientist in Range (Arrived September 1980)
Dr. Babo Fadlalla - Sr. Scientist in Animal Nutrition (Arrived 1980)
Dr. Richard Cook - Sr. Scientist in Animal Production (Arrived Sept. 1982)
Mr. Abdul Gadir - Assistant Scientist in Animal Production (Scheduled for graduate education in the U.S. in Sept. 1983)

Agronomy and Soils

Dr. Joe Gingrich - Sr. Scientist Production Systems Agronomist (Arrived May 1982)
Mr. Mukhtar Kenani - Sr. Scientist Agronomy (see Station Director)
Mr. Ibrahim El Madina - Assistant Scientist in Agronomy Scheduled for graduate education in the U.S. in January 1983)
Mr. Babiker Abdulla Ibrahim - Assistant Scientist in Soils (Scheduled for graduate education in the U.S. in January 1983)

A U.S. Sr. Scientist in Soil and Water Conservation and Management is expected in 1982

Pest Management Section

No current staff, but (1) Sr. Sudanese Scientist in Plant Protection (Enytology) is expected to join the project in February 1983.

The physical plant consists of a research farm of 1811 feddans (approximately 1880 acres) located approximately 2 km east of the research station. This farm is approximately half fenced and has been arbitrarily divided with three-fourths set aside for animal and range research and one-fourth for agronomic and forestry research. No agronomic research was conducted on the research farm during the 1982 crop season due to the lack of fencing and difficulties in reaching the farm during the rainy season.

The research station is located about 7 km south of Kadugli on the Talodi road. At the time of this writing construction activities have been completed on the ten senior staff houses, the office/administration building and the electrical, water and sewer facilities. The balance of the station buildings and facilities are expected to be completed sometime in November, 1982. They consist of the laboratory building, middle and junior houses, graduate house, senior guesthouse, common rooms, vehicle maintenance shop, crop and forage harvesting and laboratory preparation building, fertilizer and chemical storage building, warehouses, generator house, fuel storage facility, canteen and clinic. Immediately adjacent to the research station is a fenced all weather airstrip.

Training Activities

A major objective of WSARP at the Kadugli Research Station is to provide training for Sudanese scientists, technicians and support staff at all levels. Senior scientists will have the opportunity to work with modern research equipment using latest techniques with the assistance and tutelage of well trained and experienced expatriate and Sudanese scientists. Opportunities will be provided for attendance at short courses and professional conferences that contribute to the objectives of the project. A seminar program will be developed to provide an opportunity to share information and training experiences within the station.

Junior scientists will receive on-the-job training in research and data analysis methods. Selected individuals will have the opportunity to further their formal education through Masters or Ph.D programs at U.S. educational institutions. Whenever possible these students will return to western Sudan to conduct research leading to their dissertation. Senior scientists, both Sudanese and American, will be involved in the supervision of these research efforts.

Technical, skilled and administrative support staff will receive on-the-job training to upgrade their skills. It is proposed that a training officer be identified immediately to coordinate and assist in implementing training activities.

Production Systems Research

From the outset the WSARP has approached its objective with a Production Systems Research orientation. This approach most closely resembles what is commonly termed Farming Systems Research (FSR) in current literature. However, the term Production

Systems is used to differentiate this approach, where pastoral livestock producers migrate over extended geographic areas and where separate production systems with differing and sometimes conflicting priorities coexist, from the classical Farming Systems approach. Shanner et al (1981) describe FSR in the following terms:

> Farming System Research considers the farmers and their problems in a comprehensive manner using an interdisciplinary approach that complements existing research and development activities, and is interative, dynamic and responsive to society.

The Production Systems Research is an approach to agricultural research and development that:

- views the whole production unit (sedentary, transhumant, or nomadic) as a system.
- focuses on (1) the interdependencies between the components under control of members of the producer household and (2) how these components interact with the physical, biological and socio-economic factors not under the household's control. (Shaner et al (1981)

WSARP research at Kadugli Station follows the "downstream FSR" model. This model begins with an understanding of the existing production systems and the identification of key constraints, and then proceeds to develop solutions to the constraints through on-station and on-farm trials. This is in

contrast to the "Upstream" model which develops solutions and then searches for systems where they are applicable. Upstream models are common at international agricultural research centers (IARC's).

Gilbert et al (1980) indicate a four stage process(*) for downstream FSR programs.

1. Descriptive and Diagnostic State: where the objective is to select target areas, describe the present production systems, ascertain major constraints on farming in the area and discover the degree of flexibility in modifying the farming systems.
2. Design Stage: where priorities for research are developed and improved practices ready for on-farm testing are identified.
3. Testing State: where an evaluation is made of improved practices flowing from the design stage to the farm.
4. Extension Stage: where appropriately tested improved practices are extended to all producers within the target area.

With the exception of 2 positions in Research/Extension Liaison, the WSARP, as originally developed, does not include resource nor programs for the Extension Stage. This is a serious omission that should be corrected in the near future.

(*) For a more complete discussion see Farming Systems Research: A Critical Appraisal, by E.H. Gilbert, D.W. Norman and F.E. Winch, Michigan State University, MSU Rural Development Paper No. 6, 1980.

PRODUCTION SYSTEMS AND CONSTRAINTS IN CENTRAL SOUTH KORDOFAN

PRODUCTION SYSTEMS AND CONSTRAINTS IN CENTRAL SOUTH KORDOFAN

Description of the Physical and Biological Resources and Inherent Constraints to Production Potentials

Location of Study Area and Extent of Project Activity

During this phase of the project, emphasis will be focused on the central region of south Kordofan, or more definitely, the Nuba Mountain area encompassed by the Northern and Southern Districts sometimes referred to as the Central Districts (Figure 1). This region occupies approximately 30,000 km^2, and was selected for its proximity to the research headquarters at Kadugli, and because it represents a major component of the environment and agricultural systems present in south Kordofan. Moreover, the logistical constraints posed by the vast size and remoteness of south Kordofan and its lack of communications precluded any feasible attempt for covering the entire province at the present time. It is anticipated that as production systems in the Nuba Mountain region are better understood and improved upon, research will be expanded into other districts. The information provided below is the result of work carried out by a number of organizations as well as WSARP and ARC.

Climate

The Central Districts of south Kordofan lie within the savanna belt of the Sahelian zone, and can be classified as having a hot, semi-arid climate. Rainfall is dependent on the Inter-tropical Convergence Zone where moist air from the equator meets dry air from permanent high pressure areas over the Sahara. The amount and

distribution of rainfall at a particular locality depends on how far north the convergence zone penetrates.

Isohyets and mean annual rainfall for major towns and villages in the region are shown in Figure 2. Rainfall varies from about 550mm in the north to over 800mm in the south. The rains occur in a single season called hareef from June to September, although some rain falls in May and October at the beginning and end of the wet season respectively. Unseasonal rainfall is rare. A short hot season, deret, from October to November occurs after the rains, followed by a cool, dry season, shitta, from December to February, and the main hot season, seif, from March to early June.

Temperatures(*) are associated with the annual migration of the zone of maximum insolation, but modified by rainfall. The hottest months in Kadugli are March and April, with daily means of 30°-32° C (monthly maximums of 39°-41° C and minimums of 22°-24°C). The coolest months are December and January with daily temperature means of 25°-27° C (monthly maximums of 34°-35° C and minimums of 17°-18° C).

Relative humidity and potential evaporation rates vary with rainfall and temperature. In the dry season at Kadugli, humidity reaches a low of 15%-20%, and evaporation a high of 250mm/month. During the wet season, humidity rises to 80%-90%, and evaporation drops to about 150mm/month. Annual evaporation rates are

(*) Climatic data presented were obtained from HTS (1980) and GtZ (1977) who used records from the Government of Sudan as well as their own data.

between 2,000mm and 2,500mm.

Rainfall and evaporation rates have been used as a basis for classifying rangelands and appropriate forms of land use in East Africa (Pratt, et al 1966) because of the great influence these factors have on soil moisture, and the resulting effect on plant and animal ecology, as well as the various activities of man. Of these factors, rainfall has been described as the most important in terms of an area's ecological and agricultural potential (Brown, 1963; Woodhead, 1970; Pratt & Gwynne, 1977).

Geology and Geomorphology

The area is characterized by flat or gently undulating plains of cracking and non-cracking soils, interspersed with hills of jebels of basement complex rock and their associated footslopes. Topographically, elevation varies from about 500m in the plains to 800m at tops of hill ranges (maximum range from 435m-1,190m).

The jebels form part of the Nuba Mountain system and consist mainly of granites, mica schists and quartzites. In the region studied by Hunting Technical Services (1980), which closely follows the Central Districts' boundaries, the jebels and their footslopes account for about 40% of the land surface with the plains occuping the remaining 60%.

Erosion is the primary geomorphic process in the area, particularly from water runoff which causes moderate to high erosion and shows a potential for further increase due to poor agricultural practices (FAO, 1981).

Pattern of Drainage

Drainage, which is seasonal in nature, originates in the jebels and gradually merges in to the cracking clays of the surrounding plains. Some of the lower and flatter areas become inundated during the rainy season, but these are generally small and localized in distribution. Major drainage units in the southern region are the Khor el Berdab and Khor el Afin which were former tributaries of the Bahr el Arab system. Both drain southward, terminating in broad depressions of alluvial clay, namely Lake Keilak and Lake Abyad. These lakes are the only perennial sources of natural surface water, although their water levels vary considerably through the year. Farther north, the pattern of drainage is northeast towards the Khor Abu Habl which flows eastward to the Nile, but stagnating somewhat before reaching its delta east of Umm Ruwaba. Principal tributaries draining into the Khor Abu Habl, are the Wadi Abu Seiba, the Khor Sungalla, and Khor Umm Berembeita.

Water Resources

Apart from the perennial lakes of Keilak and Abyad, sources of water include hafirs (excavated depressions in clay soils for collecting surface runoff), wateryards (consisting of one or more bore holes equipped with mechanical pumps and steel storage tanks), hand pumps, and various types of traditional hand dug wells, ranging in depth from 0.5m-12meters. The hafirs, which total about 90 in the area, were constructed in the 1950's, but due to situation

and lack of maintenance, their useful storage capacity of some 2 million cubic meters has been reduced by over 35%. A hafir rehabilitation program is now well underway by UNICEF and the National Administration for Water.

Only about 15 wateryards exist but they provide an important water source for both people and livestock, particularly in some of the larger settled areas such as Kadugli, Dilling, Lagowa and Hamra. Hand pumps, designed specifically for human needs in rural areas, are being increased by the UNICEF project previously mentioned.

Traditional wells dug by hand to varying depths on the jebel footslopes and the beds or banks of seasonal streams, (khors) form the major supply of water for human and animal needs, particularly during the dry season. These wells are limited in distribution to areas with high water tables. Thus, apart from a few scattered hafirs and occasional streams, the clay plains are virtually devoid of perennial water supplies due to the nature of the soils and underlying geology.

Due to topography and dominant soil types, water retention is limited with runoff creating swamps and pools of standing water during the wet season which are important sources of insect borne diseases. Malaria, in particular, affects a large proportion of the rural population most significantly during the peak labor demand periods of intense cultivation. Domestic water supplies, polluted with contaminates from livestock, cause intestinal problems

and parasitic infections the year round.

It is clear from the foregoing that the availability and distribution water is an important constraint to crop and livestock production because water availability restricts the extent and quantity of cultivation and grazing to areas within reach of adequate water supplies. This is not to say that existing water services should be improved and expanded upon without detailed studies of the environmental and socio-economic impacts of such a program; rather, it suggests that under proper management planning, there is considerable scope for improvement.

Soils

The types and distribution of soils in the Nuba Mountain region is complex. Hunting Technical Services (1981) identifies six broad soil types based to some extent on land-ferm topography. Thus, it should be pointed out there is a fairly high degree of variability within these soil-topographic zones.

A summarized description of soil types is presented below based on Hunting's broad classification but with notes on important variations.

Jebel Soils

Most of the slopes and tops of jebels 7122km^2 consist of bare rock and shallow, skeletal sands and sandy loams. A small portion is characterized by somewhat deeper profiles of brown, coarse textured, colluvial sands and sandy loams. These soils typically occupy wetter sites on fairly flat surfaces such as on the tops of jebels, or in sumps between peaks and ridges. Jebel soils tend

to be infertile with low organic matter content, and dry out rapidly. They are also highly susceptible to erosion, particularly after the elimination of ground cover by dry season fires. Never-the-less, the nature of the soils permits ready penetration of water and plant roots which often tap water from depressions on the underlying bedrock surface.

Although generally unsuited to cultivation, jebel colluvial soils are cropped regularly in some areas, especially where human population densities are relatively high. Terracing is widely used to improve soil moisture by preventing excessive runoff, and manuring is often practiced to raise fertility. Jebels are also used for grazing livestock, particularly in the wet season.

Overall, jebel soils have low agricultural potential due to their steep slopes, high erodability, irregular distribution, and low fertility.

Footslope Soils

Jebel footslopes 4333km^2 are composed of reddish-brown soils derived from weathering processes on the hills. They vary from light sands to coarse textured sandy loams and sandy clays, usually overlying a layer of gravelly loam close to the surface. Rocks and stones are frequently scattered through the profile. A major variant is a stony, sandy clay on strongly dissected slopes or undulating plateaus. This could reflect the result of severe erosion where the topsoil of sandy loam has been removed.

Footslope soils are generally low in organic matter, poorly structured, and erodable due to their slope, poor water penetration and heavy land use pressures. These soils typically form a continuous

ring(from a few meters to several kilometers in width) around jebels. It is here where a large portion of the human population is settled, and where most of the groundnuts are grown. The resulting pressures (i.e. from cultivation, year-round grazing by sedentary livestock as well as dry season grazing by transhumant herds, burning, and the cutting of trees for wood and charcoal) have further degraded the footslope soils, yet the demand for these soils continues to increase.

Plains-Residual Soils

These soils 3189km^2 occur in the plains and are red and red-brown, medium to fine non-cracking clays and clay loams, supposedly derived from prolonged in-situ weathering of basement complex rock and ironstone. They are moderately deep with varying amounts of ironstone nodules through the profile, and a hard, compact surface(sometimes stony) subject to sheet erosion due to poor water penetration.

The principal use of these soils is grazing by livestock, particularly transhumant herds early during and shortly after the rains. Cultivation is insignificant, despite favorable attributes of flatness and moderate fertility, because their hardness reduces water infiltration and makes them difficult to cultivate. In many instances, they are also remote from village centers.

Eroded, Shallow and/or Gravelly Cracking Clays

The soils 2537km^2 range from brown, lightly cracking clays to dark gray cracking clays, all with variable proportions of gravel

and stones on the surface and in the profile. They tend to be fairly shallow and occupy the more dissected and undulating parts of the plains where lateral runoff is considerable. Consequently, they are more susceptible to erosion and dry out rapidly after the rainy season. Some of these soils, particularly the lighter clays, appear to be a transitional form between the red non-cracking clays and the darker, heavier clays, described below.

Cultivation is virtually absent for reasons that are obvious from the foregoing discussion. Livestock grazing represents the primary use of these soil types.

Dark Cracking Clays

These clays 10,260km^2 contain an average of 60% clay, dominated by montmorillonite, which causes expansion when wet and contraction when dry. The nature of this process, and the presence of deep cracks, give the soil a certain ability toward self-mulching.

Dark cracking clays occur over more than half of the plains area, mainly on the middle and lower slopes, and in valley bottoms. Two major sub-types are distinguished. The most common is dark brown in color and 2m in depth with cracks extending up to 1.5m. The other is a grey-black clay in low lying area subject to seasonal inundation and with higher contents of clay. The former type is well suited to cultivation, while the latter is marginal due to a high incidence of waterlogging. In both types, land preparation is often difficult (particularly with machinery) because the soils

are either too dry and hard, or they are too wet and plastic. Erosion may be also a problem in more undulating parts of the plains, especially after the cracks have sealed up. Excess water accumulation on the surface during heavy rainstorms may cause substantial lateral runoff, and loss of topsoil.

Other important factors affecting crop production are low levels of nitrogen and available phosphorus. Low nitrogen content appears to be an inherent characteristic of the soil, but are seriously aggravated by poor cultivation practices. All cracking clays provide valuable grazing to both sedentary and transhumant herds of livestock, especially during the dry season.

Alluvial Complex Soils

These soils 1410km^2 show wide variability which is associated with the topographical gradient between steep jebel slopes and flat, low lying plains. In the upper catchments close to upland areas, soils range from coarse sandy loams to fine cracking clays. Toward the plains, flooded areas are restricted to narrow belts of cracking and non-cracking clays along major drainage lines. These are best developed where drainage terminates in broad, flat depressions of heavy cracking clays subject to extensive season flooding.

The principal use of alluvial soils is for mid-to-late dry season grazing. Cultivation is largely confined to scattered pockets of irrigated horticultural crops adjacent to the banks of season streams. Some grain is grown where flooding is light

or absent. More extensive cultivation, as well as earlier grazing, is limited by severe periodic flooding.

Range Resources

Vegetation in tropical Africa is typically heterogeneous and complex, especially where a wide range of environmental conditions exists. Apart from climatic and soil variability, major geographical features, such as mountain ranges and rivers, cause local changes in the vegetation.

In the Nuba Mountain region, a basic distinction can be made between the vegetation of the jebels, their footslopes, the surrounding clay plains, and riparian situations associated with seasonal drainage lines and flooding. Within each of these regions are found several major vegetation types. Although it is beyond the scope of this work plan to detail the characteristics of each vegetation type, a description along general lines is considered useful. (For more specific information see Bunderson, 1981, and 1982(in preparation). This is presented in Table 1 where rangeland vegetation is described, according to major land forms, in terms of broad physiognomic characteristics and plant species dominance and constancy.

Range Condition and Productivity

Descriptions of rangeland communities should be accompanied by assessments of range condition and of past and present land use. Simply stated, range condition is an expression of the current state and productivity of the range in relations to its potential, i.e., what it is capable of producing for specific purposes, under prevailing environmental factors and optimum management practices.

Table 1: Classification of Vegetation Types

General Topography and Soils	Physiognomy	Dominant and Constant Species	
		Trees and Shrubs	Grasses and Herbs
Jebel Soils Shallow, rocky coarse textured sandy loams and clays on steep slopes	Deciduous Broad-Leaf Savanna composed of medium to dense woodland and open wooded, medium to tall grassland	Combretum hartmannianum Boswellia papyrifera Lannea fruiticosa Sterculia setigera Terminalia laxiflora	Hyparrhenia confinis Panicum sp. Pennisetum pedicellatum Loudetia togoensis Andropogon gayanus
Footslope Soils Gently sloping red-brown sandy loams and clays, sometimes rocky or stony	Deciduous Thorn and Broad-Leaf Savanna composed of open to lightly wooded, short to medium height grassland	Albizia amara Combretum hartmannianum Balanites aegyptiaca Sclerocarya birrea Piliostigma reticulata Anageissus leiocarpus Acacia nubica	Setaria pallide-fusca Hyparrhenia confinis Brachiaria xantholeuca Dactyloctenium aegyptium Aristida hordacea Schoenefeldia gracilis Loudetia togoensis Cassia occidentalis
Dissected Slopes and Plateaux Gently sloping dissected stony sandy loams and dark sandy clays	Deciduous Thorn and Broad-Leaf Savanna composed of wooded, medium height grassland	Boswellia papyrifera Acacia gerrardia Combretum hartmannianum Anogeissus leiocarpus Dichrostacys cinerea	Schoenefeldia gracilis Setaria pallide-fusca Hyparrhenia confinis Schizachrium exile Aristida hordaceae
Plains Soils Red and brown non-cracking clays sometimes stony with ironstone nodules in the profile	Deciduous Thorn and Broad-Leaf Savanna composed of wooded, short-medium height grassland	Albizia amara Lannea humilis Acacia gerrardia Acacia senegal Dichrostachys cinerea Combretum hartmannianum	Setaria pallide-fusca Hyparrhenia confinis Schoenefeldia gracilis Loudetia togoensis
On wetter sites	Semi-evergreen trees and Deciduous Broad-Leaf trees dominate with the other species	Sclerocarya birrea Tamarindus indica Terminalia laxiflora Lannea schweinfurthii Diospyros mespiliformis	Andropogon gayanus Oxythenanthera abyssinica

Table 1: Classification of Vegetation Types (cont'd)

General Topography and Soils	Physiognomy	Dominant and Constant Species	
		Trees and Shrubs	Grasses and Herbs
Plains Soils (cont'd) Brown lightly cracking clays	Deciduous Thorn Savanna composed of light to densely wooded, medium-tall grassland	Acacia seyal Acacia gerrardia Acacia polyacantha Anogeissus leiocarpus Combretum hartmannianum Dichrostachys cinerea Combretum aculeatum	Hyparrhenia confinis Hyparrhenia pseudocymbaria Cymbopogon nervatus Aristida hordaceae
Dark Cracking Clays some shallow, eroded and/or stony and gravelly; others deep with large cracks sometimes low lying and subject to inundation	Deciduous Thorn Savanna composed of light to dense woodland, and open to lightly wooded, tall grassland	Acacia seyal Acacia polyacantha Dichrostachys cinerea* Balanites aegyptiaca+ Ziziphus spina-christi Combretum aculeatum* Maltheria indica	Sorghum purpureosericeum Hyparrhenia pseudocymbaria Brachiaria obtusiflora Cymbopogon nervatus Sehima ischaemoides** Aristida hordaceae** Pennisetum ramosum++ Setaria incrassata++ Ischaemum afrum++
Riparian and Alluvial Soils Drainage channels and Khors	Semi-Evergreen Woodland in upper reaches of drainage lines merging into Deciduous woodland in the plains	Anogeissus leiocarpus Tamarindus indica Diospyros mespiliformis Combretum spp. Ficus sycomorus Acacia polyacantha Acacia nilotica Acacia seyal Balanites aegyptiaca Ziziphus mucronata	Pennisetum pedicellatum Heteropogon contortus Hyparrhenia confinis Sorhum verticilliflorum Hyparrhenia pseudocymbaria Rottboellia exaltata

* Species common on lighter cracking clays
\+ This is the only tree species present in recently abandoned cultivated land
**Grass species usually occuring on grey-black clays susceptible to seasonal inundation
++Grass species generally found on lighter or eroded cracking clays, or where the density of bush is high

Table 1: Classification of Vegetation Tyres (cont'd)

General Topography and Soils	Physiognomy	Dominant and Constant Species	
		Trees and Shrubs	Grass and Herbs
Alluvial Valley Soils Coarse and fine tex - tured sandy clays and dark cracking clays	Semi-Deciduous Savanna composed of open wooded medium-tall grassland	Acacia albida Balanites aegyptiaca Piliostigma reticulata Ziziphus spina-christi Ficus spp Acacia sieberiana Cordia africana Borassus aethiopum* Hyphaenae thebaica*	Pennisetum ramosum Thelepogon elegans Chloris prieuri Cynodon dactylon Hyparrhenia pseudocymbaria Sporobolus pyramidalis Heteropogon contortus Panicumspp.
Heavy dark cracking clays	Seasonally inundated or flooded Swamp Grassland with few trees and tall grass	Acacia sieberiana Acacia nilotica Swamp fringes also contain: Piliostigma reticulata Ficus spp. Balanites aegyptiaca	Echinochloa pyramidalis+ Echinochloa stagnina+ Crysa longistaminata Vetiveria nigritana Echinochloa colonum Setaria incrassata Hyparrhenia rufa Andropogon gayanus

+ Swamp areas tend to be dominated by only one these Echinochloa species
* Borassus andHyphaene palm trees dominate certain alluvial valleys replacing Acacia albida

Evaluations of range condition and patterns of rangeland use are a necessary first step in understanding range-livestock systems, and the various constraints which affect them. Determinations of range condition should be followed by an analysis of trend, or direction of change in condition since this describes how range is affected by current land use practices. Adequate monitoring of these parameters provide the basis for agricultural development planning for they describe the responses of rangeland to different forms of use, and ascertain whether principles of proper range management have been applied under various programs of improvement.

Preliminary investigations in south Kordofan strongly indicate that, with the exception of swamp grassland, all range communities are in only fair condition. More specifically, these communities are at various states within this general category, some being worse than others. This assessment of condition is basically attributed to the following factors:
(1) over 94% of the herbaceous vegetation in the region is composed of annuals. From a standpoint of animal nutrition and palatability, only 5%-15%(*) of these are considered desirable species. Although the herb layer is relatively productive in terms of plant biomass, their coarseness and fast maturing nature greatly reduces their nutritional value even before the end of the rains. By this time, the majority of plants have completed their life cycle, remaining either in the form of standing straw,

* The variability is due to differences in composition between vegetation types.

or as fallen litter in various stages of decomposition. Because both of these states are highly susceptible to burning (with possible detrimental effects to the soil and plant cover), their value for grazing is further reduced.

(2) The wooded savannas of the region contain a significant proportion of productive woody vegetation, particularly in the jebels and clay plains where dense woodland thickets are common. Yet because the ungulate biomass is largely composed of cattle with relatively small proportions of sheep, goats and camels, most browse production goes unused. With the current mix of domestic stock, the browse potential of the area is wasted. When left unchecked by adequate browsing, the increase in the density of woody vegetation leads to a serious problem of bush encroachment. Such areas adversely affect the growth and development of herbaceous vegetation which significantly reduces the carrying capacity of the range for livestock, especially for regions dominated by cattle.

(3) The erodability of soils is a major factor influencing range condition. Areas which are susceptible to erosion clearly reduce the site's potential for good forage production, and hence affect range condition. In the Nuba Mountains, erosion is high in the hills and footslopes, and low to moderate in the clay plains. The amount and the extent of erosion is greatly affected

by the nature and distribution of plant cover through the year. Thus, the preponderance of shallow-rooted annuals, which die and all but disappear in many areas, leaves the soil highly susceptible to erosion at the onset of the rains. The situation is further aggravated by burning which essentially eliminates all ground cover and exposes the top soil not only to runoff but also to wind erosion and dessication.

While the foregoing outlines some of the physical characteristics associated with the assessment of range condition, the actual factors responsible for the current state of the range have not been described.

In the Nuba Mountains, the principal factors affecting range condition are burning and grazing practices, although cultivation also becomes important when large tracts of cropland revert to range after being abandoned or left fallow for long periods of time.

Except in the immediate vicinity of densely populated sedentary villages and permanent water supplies, there is little evidence of deteriorated range due specifically to overgrazing. This is related to the fact that an estimated 70%-80% of the livestock using the region are present only in the dry season (personal observation) although Resource Management and Research (RMR) (1975) estimates a figure of 50%. Harmful effects caused by grazing during the dry season are minimal because most plants have either entered dormancy, or have already completed their life

cycle as in annuals. Thus, ranges in south Kordofan are effectively rested every growing season.

In contrast, areas in north Kordofan which receive one-third to two-thrids as much rainfall, are being grazed heavily and continually during this time of year which is the most critical in terms of physiological damage to the plant. Consequently, the north shows marked signs of misuse such as low forage productivity, depleted ground cover, invasion of undesirable species, and severe wind and gully erosion. Range deterioration is further aggravated by the spread and intensification of cultivation in marginal areas which has forced increased grazing pressures on the remaining rangelands.

In summary, unless savanna regions in the south are natural annual ranges, which would be unusual for this eco-climatic zone, then it is probable that the existing status of the vegetation was caused more from the effects of widespread and frequent burning than from grazing (for further details see Bunderson 1981, and 1982).If this is true, then the practice of burning, for whatever reason, is the primary constraint affecting the productivity of rangeland which in turn directly influences animal nutrition and the potential for increasing livestock production.

Crop Resources

In their July 1981 report, Hunting Technical Services estimate that approximately 10% of the area (3020km^2) is cropped annually in the Nuba Mountain region. Almost 70% of this area is planted to sorghum and/or sesame. Cotton makes up the third largest cropped

area, but from 75%-80% of the cotton is grown on the mechanized schemes. Estimated cropped areas presented in the HTS report are:

Crop	Area(Km^2)	% of Cropped Area
Cotton	390	13
Sorghum	1590	52
Sesame	480	16
Millet	110	4
Groundnuts	300	10
Other	150	5
Total	3020	100

Most of the population live on the jebels or on the jebel footslopes where the soils are coarse to medium textured. Although these soils are low in fertility and organic matter and do not have a high water holding capacity, home farms of vegetables, maize (grown as a vegetable), and some millet and sorghum are located on these particular soils. Groundnuts, millet, and sorghum are grown on larger plots of these same soils on what are often referred to as"near farms". As groundnuts require coarse to medium textured soils, farmers have found them to be the best cash crop for the jebel footslopes. Some millets are grown on these lighter soils because they are a little more drought tolerant than sorghum.

Most of the cultivation in the Nuba Mountain region occurs on the dark cracking clay soils. These soils have only a slight slope and have a high water holding capacity. Consequently, they probably have the best moisture regime of any soil of the region.

Most of the major food crops (sorghum and cowpeas) and most of the major cash crops (cotton and sesame) are produced on these soils. Although the cracking clays are low in fertility it is probably their soil moisture-plant relationships that make them the best agricultural soils of the area.

There is some cultivation of sorghum and sesame on the shallow and/or gravelly cracking clay, which make up about 9% of the region, and they could be cultivated more if population pressure increases. However, at the present time annual grasses, shrubs, and cattle grazing dominate these soils.

Livestock Resources

The following data summarizes the numbers of cattle, sheep, goats, camels, and donkeys present in the Nuba Mountain region:

Species	Dry Season Numbers	Wet Season Numbers
Cattle	320,762	172,306
Sheep	92,234	84,202
Goats	190,009	295,488
Camels	33,025	66
Donkeys	5,254	9,642

The data were calculated from Resource Management and Research (RMR,1975) as reported by HTS (1981). The value of these census data should be treated with considerable reserve as inadequate information is given regarding methods used in conducting the surveys (i.e. variance and confidence limits). These factors are necessary for determining the usefulness and reliability of animal population estimates. Without this information, the difference between dry and wet season counts cannot be assumed

to represent the number of migratory animals, as is done by HTS (1981) for cattle.

Some of the more common types of cattle, sheep, goats and camels found in the area are discussed below:

1) Cattle: The principal breeds of cattle found in the Nuba Mountains region include a typically red, short-horned zebu called the Western or Baggara cattle, and a Nuba Mountain breed of varying colors known as the Koalib Hills cattle. The former are traditionally migratory animals belong to Arab speaking nomads and transhumants who move seasonally between the southern ranges in the dry season and the more arid ranges to the north during the rains. Koalib cattle are mostly owned by sedentary Nuba tribes and appear to have developed from crosses between various other breeds, such as the Baggara and Sanga (Nilotic).

Two other breeds occur in the area. The Umm Bororo cattle are an exotic breed brought into Sudan from West Africa by the nomadic Fellata people. This is a large, long-legged animal, usually dark red or black in color with huge, lyre-shaped horns. The numbers of Umm Bororo cattle are relatively low. The other type of cattle is a light colored Nilotic-Sanga breed which is usually observed during treks through the area from southern Sudan to the northern markets. Some of these cattle are also kept by a few Dinka and Shilluk who have settled in south Kordofan. All of these breeds tend to be low producers of milk relative to the Kenana and Butana of the Northern river areas.

2) Sheep: The dominant sheep in the area are the Desert long-tailed sheep which are commonly found among the Baggara-owning transhumants as well as the sheep and camel nomads. These type of sheep are also raised to some extent by the sedentary tribes in the Nuba Mountains.

Some Nilotic sheep belonging mainly to the Di.ka also occur toward the flood region in the extreme south of Kordofan. Nilotic sheep are considerably inferior in productivity to the desert sheep, but survive better in more humid climates.

3) Goats: The short-eared goat is the major breed in the Nuba Mountains region, and is raised by the sedentary peoples as well as the nomads and tranhumants. This animal is quite distinct from the Nubian long-eared goat commonly found in the northern towns and villages. The short-eared goat is smaller, with short hair and various colors. It is also lower-yielding in milk but is never-the-less an important source of this product.

As with sheep, there are some Nilotic goats in the extreme south, and they tend to be less productive than the more northern goats.

4) Camels: The main camel found in Kordofan is considered to be a pack type animal rather than a riding one. Most camels in the Nuba Mountains are owned by various nomadic tribes who migrate into the area from the north during the dry season. Many of the male animals are used in transporting goods to towns and markets including grass thatching and firewood. The Baggara cattle tribes also own a few camels which are generally used as pack animals during seasonal migrations.

Description of Human Resources: Traditional Farmers and Pastoralist Target Groups

Demography of the Study Area

Central Districts Population

According to Hunting Technical Services Report (Annex 5,1981) the Central Districts of south Kordofan cover 20.7% of the land area of the four southern districts. This area has the densest population of south Kordofan with 46.2% of the population concentrated on one-fifth of its area. Using a straight line extrapolation of demographic data from the 1973 Census at the average annual rate of increase of 2.9%, the mid-1982 south Kordofan population would be approximately 1,408,000 persons of which 603,000 live in the Central Districts. The Southern jebels (Southern District) has the densest concentration of all districts in south Kordofan with 22.7 persons per square kilometer, the Northern District is next with 11.7, while the Western and Eastern Districts average only 4.8 persons per km^2. Average density for all of south Kordofan is 16 persons/km^2 (Sudan Government Census, 1973). The population of the Central Districts has doubled in 23 years, causing increased pressure on land and water resources yet the human population size alone is not a significant constraint on production.

Urbanization

Inhabitants of towns increased through rural migration and rapid development of government and market activities to more than 10% of the population by 1973; urban dwellers probably form 15% of

the residents in 1982. Meanwhile out-migration has accounted for a loss of approximately 16% of indigenous people, while in-migration to the region accounts for 7% of the censused population in 1973. The net loss of about 9% is mainly of able-bodied men. The rural population continues to dominate numerically, but has suffered a loss of labor supply for agricultural production (HTS, Annex 5).

Households

In the 1975 dry season head count (Government of Sudan, 1975) 89% of the rural population were found to be sedentary, and 11% consisted of migratory nomadic groups. In the following wet season of 1976 only 1.5% of the residents were classified as nomadic as most had moved northwards with their livestock to north Kordofan for the season.

The age-sex composition of households and communities shows a heavy concentration of juveniles, and more women than men. According to the 1980 village study by Hunting Technical Services, over half the sedentary villagers were under 15 years of age, and only 8% were over 60 years. Hence there were at least three dependents for every two working age adults. The sex ratio favors adult women as many men have left on labor migration or for military service. Household size averaged 7 persons, and most households consisted of a married couple, their dependent children and close kin. Larger households usually had more than one wife present.

Among migratory groups, household size varied from small elementary units to larger compound units grouping two or more nuclear families. Juveniles out-numbered adults, but there were fewer elderly people and a more even distribution between men and women than among sedentaries.

Rural Communities

The two major types of rural life styles are sedentary farmers and transhumant pastoralists. There are also some fully nomadic cattle and/or camel herders who enter the area from north Kordofan during the dry season. Transhumants make up approximately 10% of the rural population of the Central Districts, but they own a large proportion of the livestock, their main economic activity. (See Bunderson, WSARP, 1981).

Sedentary farmers contitute about 9/10ths of the rural population, living in village communities concentrated along the footslopes and hills of various chains of the Nuba Mountains. There is a strong ethnic tendency among these two styles of life. The major tribes in the transhumant groups are Muslim, Arabic-speaking Baggara, especially the Hawazma and Missirlya Zuruq tribes. Most of the sedentary farmers belong to one of many Nuba tribes of various African origins; each tribe of which has its own language, customs, etc., and occupies a demarcated area of mountains and plains. These include the Moro, Biri, Mesakin, Koroggo, Shatt, Miri and other tribes in the Southern District; the Nyimang, Kalga, Kugghul, Otora and other tribes in the Northern District. Together, the Nuba tribes constitutes over three-fifths of the population; Baggara and other Arabic

speakers make up about one-fifth of the population, and smaller ethnic groups make up the rest.

Most of the plains farmers of this region have migrated to settle in their current locations within this century. The Nuba tribes have experienced "downhill" migration from their mountain retreats since the establishment of the Anglo-Egyptian Condominium at the turn of the century. A majority of Baggara transhumants also sedentarized on the plains areas during the past 50 years.

Today more than half the Baggara tribal members farm for a living as do the vast majority of Nuba groups. Of those who engage in transhumance, Baggara predominate. Some sedentarized Baggara have re-entered the transhumant stream in recent years as cattle raising become more lucrative due to rapidly inflating prices in northern markets. Also, some previously settled Nuba households have accumulated livestock and become transhumants, part of a process known as 'nomadization.'

Infrastructure Resources

The infrastructure of south Kordofan is not adequately developed to stimulate optimal agricultural production in the province. Roads, communications, markets, labor resources, land tenure, and agricultural inputs and governmental services do not meet the needs of farmers and herders, especially in the traditional sector.

Transportation

From the railway station at Dubeibat in the north a two-lane

paved road extends some 180 kilometers over mountain passes and plains through the Northern District center of Dilling to Kadugli. This road is the main link between the south and the regional government and market town of El Obeid, and the rest of northern Sudan. Other roads are dirt tracks, unimproved and often impassable during the rainy season.

A railway runs east-west across the northern top of the Central District, but trucks and buses are the main means of transporting goods. Inadequate roads and transport are a major impediment to increased production in south Kordofan especially in isolated rural areas. Shortages of motor fuels and spare parts for vehicles increase isolation and raise costs significantly for all goods and services. Farmers and herders rely primarily on beasts of burden and travel by foot.

Communications

Mail is delivered by surface transport to post offices located in administrative centers. Telephone service exist within the two major administrative towns. Government agencies maintain communications to other cities in Sudan by use of shortwave radios. Radio and television emissions from Khartoum are received by a sophisticated microwave system. Rural areas have no public electric power.

There are no scheduled airline services to south Kordofan. However, major administrative centers have unpaved landing fields with occasional flights.

Agricultural Markets

In smaller towns and villages agricultural products are

purchased by the same merchants who supply farm households with staple food products. These products are then either transported to larger market towns for sale or held for resale to the farm households at a later date when food supplies in the home are low. Significant profits are usually earned by the merchants during this process.

Larger towns have central market places with separate facilities for livestock and crop sales. These agricultural markets generally consist of open areas where sellers can display their offerings to prospective buyers, many represented by commission earning middlemen. Purchase price is determined by bargaining between buyers and sellers. Sales are recorded by a government agent and a transaction tax is paid. Many sales of both crops and livestock are made outside the market to avoid payment of the tax. Crop products are sold by weight with no overt quality grading system. Livestock are priced by the head with age and sex being the major price considerations.

The Ministry of Agriculture operates several specialized service agencies located in major administrative towns in the Central Districts. These include:

The Crop Protection Service
The Soil Survey Administration
The Forestry and Pasture Administration
The Range Department
The Veterinary Service
The Land Survey Department

The Agricultural Extension Service

The Agricultural Research Corporation's Research Station
The Nuba Mountain & Mechanized Farming Corporations

Most government service agencies require better equipment and transportation and need strengthened training and incentive programs. Historically, agricultural research has been focused on the development of mechanized farming and only recently has attention been given to the problems of traditional farmers and herders. Improved extension services to the traditional agriculturalists could stimulate increased productivity of crops and livestock.

Agricultural Inputs

Traditional agriculturalists in south Kordofan use few purchased inputs. Hand tools are purchased from local blacksmiths. Chemicals, used primarily to protect grain after harvest, are purchased from local merchants or government agencies, if used at all. Most seed is kept from the previous year's crop with small quantities of improved varieties available for purchase from private and/or governmental sources. Livestock health supplies are sometimes available from similar sources.

The Sudan Agricultural Credit Bank and other lending institutions have branches in the major towns of south Kordofan but lend only to farmers who have sufficient collateral. Traditional farmers use very minimal amounts of credit in production activities, Cash advances, using the expected crop as security

are often obtained from local merchants to purchase food items when household stores are exhausted. The high interest rates charged sometimes result in a state of continuous debt.

Peak labor demands among sedentary farmers occur during planting, weeding, and harvest activities. Among transhumants peak labor demands are toward the end of the dry season when watering must be accomplished from dug wells and grazing must take place at continuously increasing distances from the water points. Additional labor is also required during the migratory treks. Traditional agriculturalists use family labor when available and supplement with individually hired, daily paid labor, labor crews (nafir) or seasonally hired laborers. In general, agricultural labor is in short supply due primarily to the out-migration of able-bodied workers.

Land Tenure

The Government of Sudan holds residual rights to all unsurveyed and unregistered land. Public forests and ranges are entrusted to the management of the Forestry and Pasture Administration. However, due to lack of manpower and operational funds these vast resources are deteriorating from over-grazing, erosion, fire, and bush encroachment.

In most villages cultivable land is plentiful even when considering that the traditional practice of bush fallow requires land in amounts two to three times what is actually planted. Individuals claim heritable use rights to farmland

which are maintained as long as the traditional crop/fallow management practices continue. In areas where cultivable land is scarce use rights are sometimes rented or purchased, but usually additional land is obtained by clearing previously uncropped areas. These new areas are usually quite distant from the villages creating long walking times to care for and to transport the crop.

In recent decades, government corporations and private investors have established mechanized farming schemes usually on the cracking clay soils. This has resulted in a reduction of land available to traditional farmers. Often farmers will become tenants on these schemes as a means of maintaining their food productivity, or work for daily wages. In some cases the schemes tend to limit access to livestock grazing areas and often interfere with transhumant trek routes. These factors result in reduced animal production and exacerbate conflicts.

Leadership and Stratification

A Provincial Commissioner, appointed by the Regional Governor, resides in Kadugli. The Commissioner is assigned police powers and is responsible for maintaining order and promoting development such as roads, water, communications, medical services, etc. The Commissioner is also responsible for tax collection and appoints a person in each village to conduct this activity.

In geographically demarcated areas, composed of several

villages, rural councils are elected by the residents. These rural councils are responsible for all local governmental activities (except tax collection). Included in these responsibilities is adjudication of disputes which occur within the boundaries. Traditional local leaders, such as Omdas no longer hold official positions. However, many have been elected to rural councils or appointed as tax collectors.

Transhumant camps, composed of several related households, are led by a senior man (Sheikh) who is responsible for settling disputes and collection of taxes within the camp. Transhumants are represented on the rural councils of their homeland (dar) by elected individuals, but fall under the jurisdiction of the rural councils of each geographic area as they trek.

With the elimination of the Nazir system of tribal leadership, transhumants have lost tribal authority over rangelands and migration routes previously maintained. This change has led to increased range deterioration and inter-tribal conflicts.

South Kordofan is dominated by urban power structures linked to the regional and national governments through commercial and bureaucratic networks. Inequities associated with political influence create elites in the towns that cut across tribal and rural community affliliations. This creates a stratified social and economic structure in which traditional agriculturalists comprise the least advantaged group.

Definition of the Production Systems and Specification of Constraints

The Transhumant System

Livestock and Crops Raised

Cattle are the most important livestock among transhumant groups in the Nuba Mountain region, but considerable numbers of sheep and goats are also raised. Donkeys and camels are used as beasts of burden along with the more traditional oxen. In addition a few chickens and dogs are almost invariably found with transhumant groups.

Cropping plays a relatively minor though important role in transhumant societies. Major crops grown include sorghum, sesame and cotton (as a cash crop) on cracking clays, with millet and groundnuts on lighter, sandier soils. In general, it appears that only some of these crops are grown by any one household depending mainly on whether land holdings are on clay and/or sandy soils.

Patterns of Transhumance and Range Utilization

The general pattern of transhumance involves a migration of varying distances to the arid, sandier ranges of the north during the rains, returning to specific areas in the clay dominated ranges of the south where people and animals settle for the long dry season. The actual distances travelled vary with the particular group or camp(*fariq*) involved, and the area to which they traditionally migrate. The limits of the northern

trek are also affected by the amount and distribution of rainfall which decreases in quantity and becomes less reliable as one progresses north.

Movement northward begins after the start of the rains, usually in early July. The pattern of movement is closely associated with the availability of water and grazing. The major components of this pattern are briefly described below:

Once the rains have begun, the decision regarding when to leave the dry season camp is dependent on sufficient rainfall for temporary surface pools to form outside the normal dry season grazing areas. Plant growth lags considerably behind rain and little advantage would be gained by moving to a new source of water within an area where grazing has already been extensive. Thus, the usual strategy of a fariq is to locate new sources of water within 40km from the dry season settlement where grazing has not been exploited and move to that area.

Initially, cattle depend on the previous season's forage which is most abundant on cracking clay. As new grass becomes more plentiful, grazing faster growing species on non-cracking soils becomes important. Sheep and goats feed off the already abundant production of browse available on these soils, as well as on the sparse cover of new grass.

The trek usually continues within two weeks, after the initial move, but again is dependent on rainfall farther north and the subsequent availability of water and green forage.

Under favorable conditions, movement north continues at a rate of 5-10km every second or third day, with stops for rest and grazing at traditional locations. Along the trek a longer stop is made to plant crops on land to which the camp holds rights (see following section). Additional stops are usual in areas where kinship ties are found. Approximately 25-35 days are needed to complete a journey for a fariq travelling to the north during an average rainfall year.

The time spent grazing on the sandy and non-cracking clay soils to the north may vary from as little as four weeks to as many as eight. As supplies of livestock food and water are depleted the return trip south begins, usually in mid to late September. The majority of fariqs depart early enough to ensure adequate watering and grazing resources en route.

Transhumants begin arriving in the Kadugli area from mid October through November. Full use is made of grazing around sources of temporary surface water. This ensures that forage around more permanent water is reserved for grazing later in the dry season when water supplies are more limited. The migration is completed by mid December or early January when most transhumant groups have settled for the remainder of the dry season, unless forced to move because of range fires or insufficient grazing. These areas are often situated close to shallow dug wells on the footslopes of jebels, dry beds of khors adjacent to cracking - clay plains, or seasonal swamps

upon which animals depend for late dry season grazing. Fariqs tend to use the same sites year after year indicating certain rights over water and grazing at specific localities.

Cultivation Practices in Relation to Transhumant Movements

Cultivation of subsistence food crops is a subsidiary but important part of the transhumant way of life. Cropping activities are restricted by the territorial mobility and labor demands of migratory herd management. Livestock owners typically maintain rights to cultivate on areas of sandy soils in north or south Kordofan or on cracking clays in south Kordofan, along or near their seasonal migratory routes to the north. Transhumants may sell livestock to raise cash needed to pay laborers who are supervised by household members or close kin. Yield is sacrificed to reduce management and labor unputs during cultivation.

Crop owners return from their transhumance for an early harvest and, depending on the rainfall regime, may graze their herds on the field stubble during the migration back to south Kordofan. However, crops and livestock are not integrated in this system: the goal of cultivation is to reduce household expenditures for staple grain foods during the dry season, rather than to generate income from sale of surplus crops.

Organization of Households/Camps for Transhumance

A typical transhumant household consists of a male adult head, his wife or wives and their unmarried children. Households related by patrilineal ties share a camp, but often graze their livestock independently. The household unit subdivides labor activities into animal husbandry and domestic chores by age, sex and status. Depending upon the location of the animals, herd boys and/or women participate in the milking operations and look after young calves, but men and boys manage the herd movements and range and water use, as well as livestock marketing. Most livestock sales and purchases are planned to occur during the rainy season migration to the north where supply and demand are stronger and prices and availability of types of animals are greater. Some livestock traders visit transhumant camps to purchase meat animals for resale in the north.

The values of a transhumant household, such as the Baggara of south Kordofan, include male-dominated decision-making, high esteem for cattle and a preference for milk drinking although the main food staple is grain. Household goods are limited to those which can fit in a woven grass tent and be carried on the back of oxen during seasonal migrations. The household head invests in livestock as a "walking bank" and manipulates the composition of his herd through sales, purchases, gifts, and slaughter within the bounds of reproductive performance and mortality.

The main aim is to maximize herd increase at minimal cost while providing adequate numbers of milking animals for home and calf use, and for sale of milk products during the wet season. Oxen are prized for their size and economic value, and as riding animals.

Small livestock, especially goats and sheep, are also raised by transhumants and are herded by younger children. Goats supply meat, milk and skins, and sheep are slaughtered for meat on occasion. Both may be sold to meet current expenses or accumulated and sold in order to purchase a cow to increase the cattle herd. Livestock breeding, health care, feed supplements, grazing patterns, watering and transhumant movements are controlled by male householders, while their wives manage butter preparation and domestic duties. Hired herdboys may be hired and paid one cow per year to carry out herding, milking and other activities.

Households cooperate during transhumant movements in camps led by a senior man. It is customary for a household to remain with the camp even at the death of the male head if his children are still young. His close patrikin assume responsibility for his herd and family members, enlarging their households to accomodate the widow. Part of the herd may be given to sons as they marry, and the remainder divided among the wife, children and other heirs according to Islamic inheritance rules, but kept in trust by adults for immature children. Thus the lineage group is held together and transhumant camps retain their structure even as households change in size and composition over the years.

Transhumant households are also tied to sedentarized households through kinship links. Some sedentary families entrust livestock to the transhumants for migration to the north during the wet season while keeping a small number of dairy animals for a local milk supply. The transhumants use the milk and control the former animals, but are not held accountable for animals loss. Sedentary households may contribute labor to the transhumant herd. Children from migratory households often lodge with sedentary relatives while attending village schools during the dry season.

Factors Preventing Change in the Transhumant System

Two major factors that help maintain transhumance as a way of life include access to "free" pasture and water across ecological zones, and the values of the herding households who use livestock as a specialized mode of economic enterprise. The key incentives that tend to maintain pastoralism as a way of life are the low cost grazing and water, low level of household resources required, low labor inputs and tradition (culture). Transhumants treat mud and flies that develop in the cracking clay plains of south Kordofan during the wet season as an incentive to move,while the relatively insect and mud free sandy soils of the north attract them as do easier cultivalable soils and the dars.

Northern markets offer strong demand for livestock from urban-based merchants to supply Khartoum and overseas markets.

Large numbers of cattle sold in the north allow for purchase of new cows and heifers to replenish herds. Cheese factories draw transhumants by providing a market for milk. When the rainy season ends, surface waters dry out and grazing becomes inadequate. The transhumants then return to the south where there is more grazing and water during the dry season.

Transhumance is a total way of life, given up by those who sedentarize because they are unable to maintain a sufficiently large herd, or have other fixed resources of greater value to manage. Under the pressures of deteriorating range conditions some transhumants seek changes which could lead to a more sedentary and profitable form of animal management, if ecological and cultural constraints can be overcome.

Key Constraints

Among the constraints preventing greater livestock growth and increase for offtake are low reproductive performance, low milk output, slow weight gain, late maturation, and high mortality rates among young livestock. The main cause of these factors are poor nutrition and infectious diseases. Primary constraints to better animal production are: migration over long distances; poor range conditions in the north; daily grazing and watering patterns during the dry season; restricted water availabilities; flies and mud in the south; low quality and quantity of forages during the dry season; poor veterinary management; and the division of cows milk between calves and human consumers. Other constraints involve conflicts between transhumants

and settled farming populations. These conflicts are associated with livestock depredations of crops, and burning of rangelands by sedentaries reducing palatable grasses.

The Sedentary System

Crops and Livestock Raised

In the sedentary farming system of the Nuba Mountains the majority of households raise sorghum as the primary field and staple food crop. Varieties of sorghum are raised which vary in grain size, maturity period, color and texture. These are used to prepare different types of meals or sold at market. Sesame is second to sorghum in area planted. The two crops are often intercropped. Cowpeas are also intercropped in smaller quantities. Cotton and groundnuts are pure stand cash crops.

In house farms a variety of garden vegetables are grown including okra, cucumbers, squashes, tomatoes, melons, eggplant and leafy vegetables, as well as early grains (eaten as vegetables) including maize, sorghum, millet, and sesame. Other small-scale crops include kerkadeh, peppers, radishes, purslane, gourds and Jute Mallow.

In irrigated areas onions, tomatoes and leafy greens, and in some areas orchard fruits such as limes and mangos are grown.

The livestock include mainly chickens, guineas, pigeons, ducks, goats, occasional sheep, and a few cattle per household. In non-Muslim households pigs are also raised.

Patterns of Cultivation

Sorghum and sesame comprise about 70% of the cropped area of the Nuba Mountain Region. Hunting Technical Services estimates average sorghum yields range from about 450kg/ha in the northern part of the region to about 700kg/ha in the south. Average yield of sesame in the region is estimated to be about 450 kg/ha. The traditional sedentary farmers usually grow sorghum, sesame, and some cowpeas on cracking clay soils. Groundnuts are usually grown on the coarse and medium textured soils of the jebel footslopes. From 75% to 80% of the cotton is grown on schemes with the remainder on traditional farms. Some millet, approximately 4% of the cropped area, is grown on the coarse textured soils of the near farms in the Nuba Mountain region but most of the millet in south Kordofan is grown in the Western District.

Field crops are usually grown continuously until soil fertility becomes depleted, or, in case of sorghum, until Striga becomes so severe that further cropping is no longer feasible. The land is then left to bush fallow for a number of years until soil fertility is restored and/or the Striga population is reduced. Systematic crop rotations are essentially non-existent.

Planting of all crops in house gardens and nearby plots begins around June 1. Planting of all crops on far farms begins around June 15 but depends primarily on when the rainy season

actually begins. Sorghum, because of its high priority as a food crop, is usually planted first. Planting is usually completed by August 1, unless rains are late.

If cropping is to begin following a fallow period the land is cleared and burned to remove debris and/or burned following rains to remove weed growth. On land that was cropped the previous year, weeds are often removed with a push hoe (jeraia) prior to planting.

Most crops are planted by making a hole in the ground with a pointed tool (silukob). For sorghum, an over-abundance of seed is then thrown toward the hole and an attempt made to cover the seed with some soil using the foot as the "planter" takes one step forward. No special attempt is made to plant in rows. Hills are made every step or pace, around 80 to 90 cm. Greater care is given to planting groundnuts and cotton and these particular crops are usually planted in rows.

When intercropped, sesame is usually broadcast at the time of planting sorghum. Sorghum and sesame are usually weeded twice and any thinning is usually done during the first weeding. Often weeding comes too late when early growth has already been depressed by the first weed competition. In spite of the high seedling rates, sorghum and sesame plant populations at harvest time are usually low. Groundnuts and cotton are usually weeded only once. Cowpeas are almost always intercropped and are usually planted and weeded at the same time as the major crop.

Buda (Striga hermonthica) is the most serious pest of sorghum. The density and severity of this parasitic weed increases with the number of years of continuous sorghum. The land must then be left idle for a number of years to reduce this infestation. Other pests are stem borers(Chilo partellus, Busseola fusca, Sesamia cretica), army worms (Spodopters exempta), and antat bugs (Agnoscelis versicolor). In certain areas the weaver birds (Quelea quelea) also pose a serious threat. The most serious sorghum disease is covered smut (Spacelotheca sorghi).

Sesame seems to have only a few pests and diseases, none of which are extremely serious. Webworm (Antigastra catalannis), gall midge (Asphandylia sesami), and sesame seedbug (Aphanus littoralis) are the most common pests. Leaf spot (Cercospora sesami, Cercoseptoria sesami) and bacterial leaf blight (Pseudomonas sesami) are the most common diseases. Cotton is attacked by a wide range of pests. Common among these are jassid (Empoasca lybica), white fly (Bemisia tabaci), aphid(Aphis gossypii), flea beetle (Podagrica puncticollis), and several types of bollworms. The most serious of these are the flea beetle in the early stages and bollworms in the later growth stages. Black arm is probably the most serious disease and all stalks by regulation, are to be uprooted and burned by May 21.

Groundnuts are thought to be relatively free of pests and diseases. However, some incidences of leaf spot (Cerocospora arachadicola and Cerocospora personata), stem rot (Macrphomina phaseoli), and root rot (Sclerotium rolfsii) are known to

occur. Termites and cutworms are the major insect problems. Cowpeas (lubia) are severely attacked by pollen beetles (coryna and mylabris), the giant coreid bug (Anoplocnemis curripes), and red and black bug (Llgaeus elegans). The stored seed is also subject to attack by Bruchidea spp.

Sorghum harvest begins between 90 and 130 days after emergence depending on the variety. All heads are usually cut by hand and and stacked on the field. Threshing is by hand and the grain is stored in the home compound. The stover is occasionally harvested. Sesame harvest usually begins around mid October. Either the whole plant is cut off or just the branches containing the pods and are left in a safe place for one to two weeks. Threshing is by tapping the dried plants or branches and letting seeds fall on a piece of cloth or plastic sheet. Cotton harvest normally begins in December and contiues into February. For the most part harvesting is by a single picking by hand. Yields have averaged about 250 kg/ha during the past 10 years. Hand pulling of peanuts usually begins in late September and continues into November. The harvested plants are stacked so that the nuts may dry. They are then stripped, cleaned, bagged, and sold. Average yields probably are between 350 and 400 kg of unshelled nuts per ha. Groundnut stems and leaves are usually harvested, dried and stored for livestock feed.

Livestock Husbandry and Grazing Practices of Sedentary Farmers

Livestock are of only secondary importance to sedentary

farming groups since the livelihood of these people is centered on the cultivation of crops. As a result, the care and herding of animals is generally entrusted to children and adolescents, particularly during the cropping season, when men and women are involved with various cultivation activities. The principal responsibility of herding at this time of year is to keep livestock from cultivated crops.

In general, animals belonging to several families are herded together in the interest of saving time and labor when moving them to and from food and water. Small stock are rarely moved more than a few kilometers from individual homes, though cattle may travel as far as 10km-15km. in search of grazing at certain times of the year. Sheep and goats are almost always herded separately from cattle because of their different behavorial and feeding characteristics. Goats in particular require little herding management once they are taken away from cultivated areas. Pigs are often kept close to the house compound where small rock shelters are often built to protect them from the sun, and to keep them out of the crops since they are extremely difficult to herd. In addition to grazing and scavenging, pigs are usually fed grain, crop residues or remnants of meals. All animals have access to water every day, either from natural surface pools and streams, or from hand dug wells and hafirs depending on the time of year.

For cattle and small ruminants, the seasonal pattern of grazing involves the jebel and footslope vegetation during the rains

and early dry season, followed by the use of the cracking clay plains later in the season, particularly after the main field crop harvest in December and January. In some areas such as Damba, Koya, Korunga, Baraka, and Teis, cattle are moved will into the hills during the rains when plentiful supplies of water and grazing are available. Here they may be kept in small enclosures at night and grazed in the surrounding region during the day. In other cases, more use is made of the footslopes where these are more extensive in size.

As the rainy season ends, animals are brought out of the hills nearer to the permanent villages. Fodder from crop residues in the house gardens and nearby fields is often conserved for later use in the dry season (eg. groundnuts), or it is grazed on site soon after harvest (eg. maize, and short-maturing varieties of sorghum). Crop residues, particularly from sorghum and cowpeas, become an important source of food for livestock in the dry season.

Organization of Households and Communities

The basic production and consumption unit among sedentary farmers in south Kordofan's Central Districts is the elementary family household or the compound family household. The unit typically consists of the male household head, his wife (or wives) unmarried children and immediate dependent kin such as siblings, a parent, etc. Farm households divide into those

in which the adults share farm work, such as most Nuba households, and those in which women are restricted to work around the house, as in most Arab households.

Juveniles engage in limited amounts of farming work, including planting field crops with their parents. Adolescents generally do not work in the cracking clay fields; boys take care of livestock and girls perform household chores and carry water for domestic use. Among some Nuba tribes, mature boys and expected to devote most of their energy to physical culture and athletics such as wrestling matches rather than farm work. Heavy farm work is considered a male occupation, but women participate in planting, weeding, thinning and winnowing of grain crops. Women provide the management and labor for most of the house farms and garden plots near the village. Men retain control over land tenure and food stores.

Because of the emphasis on housefarms, known as "jubraka" compounds are dispersed within the village communities, rather than nucleated, and small livestock are kept inside the household compound and grazed on the housefarm soils.

Many unmarried young men pursue secondary education or outmigrate to wage labor opportunities. Although they and others who join the military cannot participate directly in farm work, they send home money for the household head to use in hiring farm labor and or buying needed inputs. More customary sources of peak season labor are communal work parties (nafirs) in which neighbors combine to weed or harvest a field for the sponsoring household in return for food and drink, reciprocated later on their land.

Farmers in the Nuba Mountains region have progressed from being purely subsistence oriented to a partial market orientation. Most of the crops and livestock sold represent surplus production of traditional products and introduced cash crops, mainly cotton and peanuts.

Households can be separated into two types depending on the relative isolation and their cultural characteristics. One type is represented by households located near market towns, along all weather roads or in the vicinity of mechanized schemes. These households tend to be Islamic, have more market-oriented production systems and consumption patterns, concentrate production efforts on cropping activities, and have greater rates of out-migration.

The second type is characterized by isolation from markets, subsistence oriented production systems that include greater numbers of livestock, participation in communal labor exchange, non-Muslim, inclusion of women in crop production, and are less likely to out-migrate.

Despite the above tendencies, household types are not mutually exclusive as many display characteristics of both types. All produce similar crops and livestock(with the exception of pigs) using similar methods. Capital accumulation is limited and increased production is constrained by these production methods, shortage of resources and social pressures within the village communities.

Factors Preventing Change in the Sedentary System

Farming remains the main source of subsistence for rural families in south Kordofan. The existing constraints on production operate to limit the output of surplus which would allow for more cash sales keeping most farmers in a state of relative poverty. Rural isolation, inadequate knowledge and insufficient resources keep farmers in a primarily subsistence mode of production. Undeveloped infrastructures including roads, water management and markets also hinder output. Other factors impose limited alternatives on farm households. These include poor access to credit or capital, few technological inputs including improved seeds, agricultural chemicals and fertilizers, and the absence of labor-saving devices.

Farmers lack knowledge of agronomic practices needed to maintain or increase soil fertility and production. They are inhibited from taking risks to produce more crops by adverse terms of trade, unreliable transporation and insecure land tenure. Seasonal labor scarcity also limits the extent and intensity of farming. Traditional labor such as communal work parties ten to keep production consistent across households rather than encourage more enterprising farmers to produce more. As population pressures increase, the slash-and-burn and bush-fallow system of cultivation require the opening up of new land/or fallow periods. Intervention by cash-crop oriented mechanized farms has removed potential cracking clay soils from traditional farms further

lowering production opportunities.

Specifications of Constraints

The main constraints lowering farm output in south Kordofan's Central Districts include poor soil fertility, insecure land tenure, inadequate water management, lack of crop protection unimproved seed stock and labor shortages. The general category of inefficient cultivation practices and land use includes the absence of complementarity between cropping and livestock raising.

Out-migration, especially among younger able-bodied men, has created additional labor shortages for traditional farmers who lack labor-saving technologies. Poor transport, market facilities, and adverse terms of trade between produced commodities and purchased goods discourage production increases.

Other contraints include the absence of research in agriculture focused on traditional farmer's problems and virtual absence of government agricultural services including extension information and assistance.

Summary of Constraints

The traditional agriculturalists of south Kordofan conduct their crop and livestock production activities with the major goal being to minimize risk. This is a proper and rational response to the existing conditions but is a serious deterant to increasing productivity.

Farmers plant crop varieties which produce low but consistent yields. Planting is done on scattered plots and is accomplished over a three month period to spread labor demands and to reduce risk associated with highly variable rainfall. Varieties of varying maturity periods are mixed during planting in consideration of a possible short rainy season. Seeding rates are excessive to cover the possibility of low germination and improper seed placement.

Livestock owners attempt to reduce the risk of losses due to deaths, theft, or bloodpayments by maximizing herd size. Small ruminants are kept as sources of meat, milk or cash to reduce these demands on cattle. Cattle are often loaned to other herders to extend grazing over a larger geographic area. Transhumants cultivate crops in an effort to minimize the necessity of purchasing expensive foodstuffs.

Land tenure is insecure, supplies of labor and other agricultural inputs are unreliable, and transport to and from the villages is dependent on weather conditions and availability of vehicles. It can be argued that the most important single constraint to increased productivity is the high level of risk

associated with traditional agriculture. The constraints listed below have been identified as major contributors to this overall constraint in south Kordofan.

1. Low soil fertility
2. Poor animal health and nutrition
3. Inefficient land and water use management and cultural practices
4. Poor genetic stock of crops and livestock
5. Inadequate infrastructure
6. Conflicts among target groups
7. Crop pests and diseases
8. Labor
9. Limited availability and high variability of water resources

RESEARCH PROGRAMS (Constraints to be Addressed Initially)

Scientific manpower and other resources are scarce and not all constraints identified can be approached within the time frame of this work plan. The constraints receiving high priority for research at this time are:

1. Low soil fertility
2. Poor animal health and nutrition
3. Inefficient land and water use management and cultural (and husbandry) practices
4. Poor genetic stock of crops
5. Inadequate infrastructure
6. Conflicts among target groups

Table 2 shows the source of each research proposal and the constraints addressed.

In this section the research to be accomplished at the Kadugli Research Station is summarized under the headings of the six production constraints listed above. It should be noted that a research work plan is a continually evolving entity. As staff are added and/or depart, as the constraints are more fully understood, and as current research progresses, new research may be initiated and existing research may deviate from prestated objectives and procedures. This document is the current Kadugli Research Station Work Plan. Figure 2 illustrates the interdependence of the constraints and the interwoven nature of the anticipated research activities. The following proposed research activities are discussed in relation to the above identified constraints.

Low Soil Fertility

Crop screening trials on sorghum, sesame, soybeans, cowpeas, beans, guar and forage legumes will be implemented on the research farm starting in 1983. Several of these trials will be conducted in association with INTSOY, AVRDC, ICRISAT, INTSORMIL and others and represent continuing efforts that began some years ago at Kadugli. The purposes of these trials is to select non-leguminous food and cash crops that produce satisfactory yields in south Kordofan and to identify legumes that can be utilized to increase soil nitrogen while producing grain or forage crops that can be utilized as cash crops or feed for humans and/or livestock.

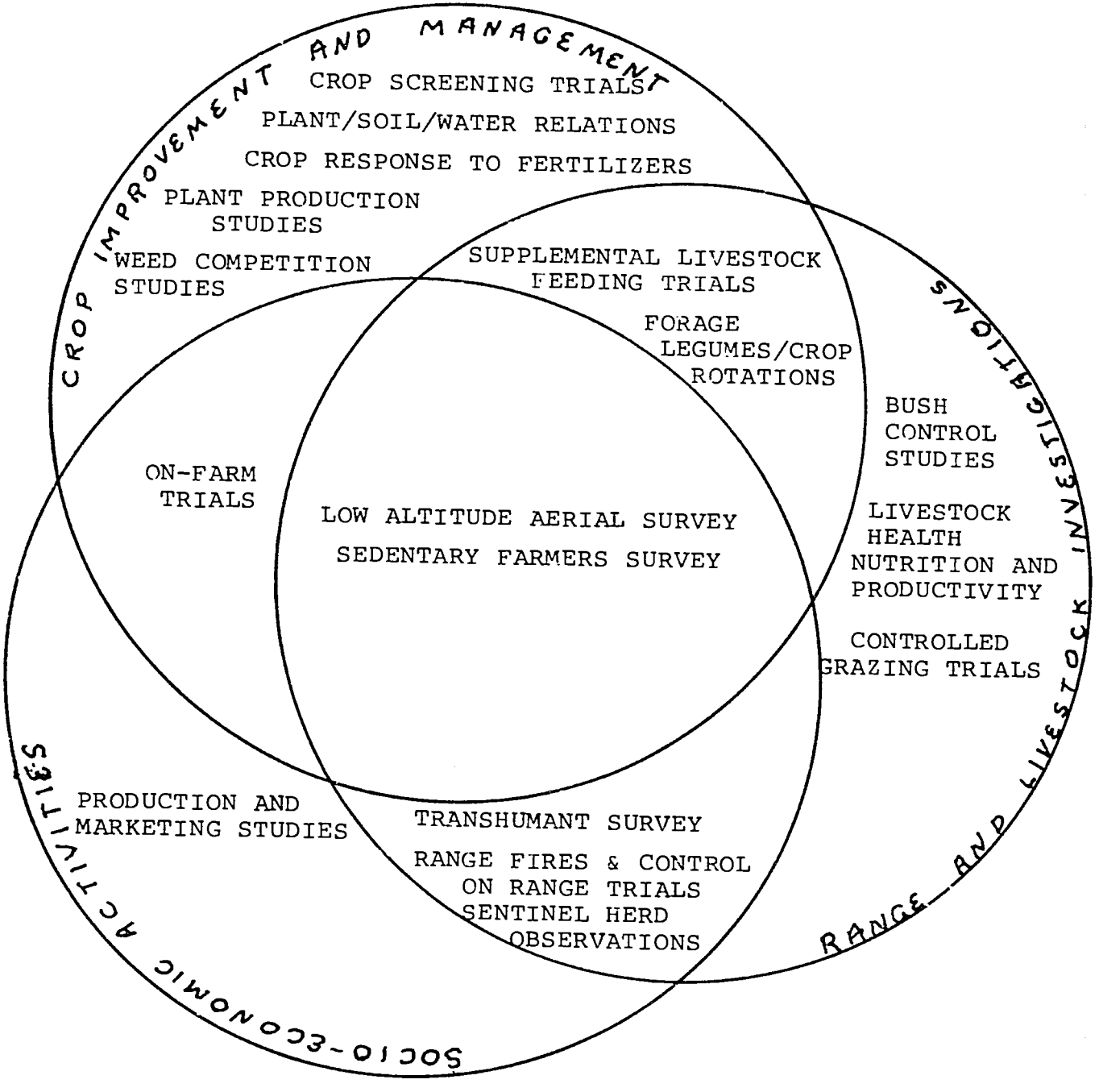

FIGURE 2 INTERELATIONSHIP BETWEEN INITIAL RESEARCH PROGRAMS OF THE KADUGLI RESEARCH STATION

RESEARCH ACTIVITY	CONSTRAINT ADDRESSED								
	1	2	3	4	5	6	7	8	9
ON-FARM TRIALS	X		X					X	
PRODUCTION AND MARKETING STUDIES					X			X	
TRANSHUMANT SURVEY		X	X			X		X	
RANGE FIRES AND CONTROL	X	X	X			X			
ON-RANGE TRIALS		X	X						
SENTINEL HERD OBSERVATIONS		X							
BUSH CONTROL STUDIES		X	X						
LIVESTOCK, HEALTH, NUTRITION AND PRODUCTIVITY		X	X	X					
RANGE RESOURCE EVALUATION		X	X						X
CONTROLLED GRAZING TRIALS			X						
LOW ALTITUDE AERIAL SURVEY		X			X				X
SEDENTARY FARMERS SURVEY				X	X	X	X	X	
FORAGE LEGUMES/CROP ROTATIONS		X	X						
SUPPLEMENTAL LIVESTOCK FEEDING TRIALS		X	X						
CROP SCREENING TRIALS	X		X	X			X	X	
PLANT/SOIL/WATER RELATIONS			X						X
CROP RESPONSE TO FERTILIZERS	X			X					
PLANT POPULATIONS STUDIES			X				X		
WEED COMPETITION STUDIES							X	X	

CONSTRAINT KEY

1. SOIL FERTILITY
2. ANIMAL HEALTH AND NUTRITION
3. LAND AND WATER USE MANAGEMENT
4. GENETIC STOCK CROPS AND LIVESTOCK
5. INFRASTRUCTURE
6. CONFLICTS
7. CROP PESTS AND DISEASES
8. LABOR
9. WATER RESOURCES

TABLE 2 INITIAL RESEARCH ACTIVITIES AND CONSTRAINTS ADDRESSED AT THE KADUGLI RESEARCH STATION, KORDOFAN 1982 - 1984

In close conjunction with the above, trials will be run on many varieties and species of legumes, both annuals and perennials to identify grain and forage types that can be incorporated into crop rotations. If crops can be identified that have the capacity to maintain or increase nitrogen fertility then continuous cropping of a given piece of land may be possible. This could have far reaching economic implications by decreasing or eliminating the need for bush fallow.

As fertility levels of soils are increased either through the use of nitrogen fixing legumes or through the application of fertilizers the demand for responsive varieties of grain crops will also increase. On the other hand optimum levels of fertility must also be ascertained. A trial will be run using sorghum (the most prevalent grain crop) to determine fertility levels. Soil tests indicate that phosporous may also be a limiting nutrient. This thesis will also be comprehensively tested.

Poor Animal Health and Nutrition

Several studies, to be conducted over the next 20 months, will provide data to further describe and quantify this constraint. The Transhumant Production Systems Study will seek information regarding the extent of the health and nutrition problems in migratory livestock herds. It will define what the perceived problems are and what is currently being done about them. The Sedentary Farmers Production Systems Survey will accomplish the same objective in sedentary livestock herds.

An in depth study of health and nutrition will be conducted using three sentinel herds. Two herds of cattle are currently owned by the project and a third will be selected from sedentary farming villages near Kadugli.Production and health data will be collected quarterly and blood, insect and other relevant samples will be analyzed in the laboratory.

Once a problem is identified for which a feasible solution exists, attempts will be made in collaboration with herders, veterinary/animal production staffs and research station scientists to implement adaptive research trials. For problems where adaptive technology does not appear feasible, applied research trials will be conducted on the research farm.

An evaluation of the prevalence and significance of pests on livestock will be made. There is apparently a certain amount of mythology regarding the fly problem and it is important to sort out the facts. Traps will be tested to determine if fly populations can be decreased and slow insecticide release formulations will be investigated for insect control on individual animals.

The Rangeland Classification and Evaluation Study will be completed in a few months. The final report will provide information regarding the types, quantities and distribution of various herbage prevalent on the rangelands of the Nuba Mountains region in relation to its potential.

Two studies will examine grazing practices and their effect on livestock health and nutrition. One will inventory present

present rangeland use and grazing practices and the second will test supplemental feeding grains and dry forage using an on-farm trial approach. Supplemental feeding of hays may improve nutrition during the dry season and subsequent changes in grazing patterns may result in less demand on rangeland and improved animal health and production. Efforts will be made to identify appropriate forage legumes for crop rotations and for supplemental feeding programs.

There is considerable evidence that wide spread range fires cause extensive damage to desirable plant species in the herbaceous component of the vegetation. Fast-maturing, fire-tolerant annuals which tend to be impalatable and of low nutritional value develop in their place. Measures to contain and control the human causes of fires will be examined and the extent of burning will be determined.

As already noted, disease and nutritional problems likely work in concert to severely debilitate livestock during the dry season. An improvement in the plane of nutrition during this period is of fundamental importance in improving livestock productivity. Within the sedentary system, constraints posed by required and desired agronomic activity may preclude the producer from undertaking a supplemental food/storage program when forage is at its nutritive peak. Therefore, to better utilize available forage in south Kordofan and to undertake adaptive supplemental feeding trials, it is essential that commonly available forage species and crop residues be analyzed for their TDN value, calcium and phosporous content at various stages of bloom.

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The insidious nature of phosphorus deficiencies can have a dramatic impact on herd productivity; i.e. small weak calves, high neonatal mortality, poor fertility rates, long calving intervals, etc. It is likely that the poor production parameters recorded for local livestock are the result of multiple etiologies; however, phosphorus deficiency is suspected to be a major cause. If phosphorus proves to be a problem (as indicated by forage analysis) attempts will be made to initiate an adaptive

research trial with a domestically available phosphorus supplement. The logistics for such a trial should be relatively easy, since many livestock owners supplement their cattle with salt. Other suspected deficiencies include vitamin A, vitamin E, selenium, and possibly zinc.

Inefficient Land and Water Use Management Cultural and Husbandry Practices

The Sedentary Farmers Production Systems Survey and the Transhumant Productions Systems Study will more fully specify land use and cultural practices involved in both crop and livestock production. Identification of weaknesses and strengths of these existing practices and of factors inhibiting change will assist researchers to develop on-station and/or on-farm trials. These will have significant impacts on productivity in a short time frame. The studies will also identify long term research priorities, and second generation constraints.

Current range conditions reflect past and present land-use mamangement. It is important to understand the patterns of range utilization, as well as its current status in order to fully and adequately identify constraints influencing range and livestock productivity. Once this infomation is available, appropriate strategies can be tested for improving range and livestock production through more efficient resource utilization.

The encroachment of bush, particularly on the clay soils, tends to reduce the cover and productivity of the herbaceous layer, thereby effectively reducing the carrying capacity for livestock.

On the other hand abundant sources of productive woody vegetation largely go unused because of low numbers of browsing ungulates. Bush control methods will be tested in an attempt to improve the utilization of range resources while simultaneously improving range productivity. Control of range burning should also reduce the loss of valuable grazing thereby making it possible to support higher densities of livestock.

Screening trials will be continued to identify both food and cash crops that are high yielding and thus efficient in regard to land use. Legumes, both grain and forage types, will be evaluated as to their adaptability to rotational cropping systems in the Nuba Mountains as a means of maintaining, or increasing, soil fertility and as a supplemental livestock forage. Success with this trial could have revolutionary effects on land-use management and cultural practices of both crops and livestock.

Crops suffer each year from moisture stress. A study will be instituted on cracking clay soils to evaluate methods of increasing water availability to the crop through vertical multching.Nitrogen,.phosphorus and potassium, as commercial fertilizers, will be applied to sorghum in a factorial experiment to determine the response. Experiments will be established to determine the most desirable row spacing, spacing within rows and plant populations for both sorghum and sesame. This work will be in cooperation with SATEC to determine the most efficient plant populations.

An efficient exploitation of the forage/range resource base is fundamental to improving livestock production in southern Kordofan. Considerable forage goes unutilized by livestock. The lack of available water prevents extensive use of these range areas during the dry season. The disease/parasite/pest syndrome plays a very important role. First, it discourages traditional transhumants from grazing their cattle in the south during the rains. Second, it forces sedentary livestock owners to utilize poorer grazing areas, away from the cracking clay plains, where forage quality is inferior. Through an integrative animal health/nutrition effort which reduces existing risks, producers will more likely implement changes which will more efficiently utilize the total resources base.

Low-level aerial surveys of the Nuba Mountains region are designed to complement research on the ground by providing extensive quantitative information. The aerial technique used will gather baseline data on various aspects of the sedentary and transhumant systems of production, including:densities and distributions of sedentary and transhumant settlements as well as livestock species; area and distribution of crops grown; potentially cultivable land; extent and distribution of vegetation types, soils and water; bush encroachment problems; patterns of grazing and range use; and the nature and extent of burning.

Poor Genetic Stock of Crops

Screening of higher yielding, better adapted varieties or lines of sorghum, sesame, cowpeas, soybean and guar will continue. Testing will begin on grain and forage legumes. Multiplication of outstanding varieties and provision of them to farmers will be encouraged.

Inadequate Infrastructure

In October of 1982, USAID will initiate a major marketing, extension and transport study in Kordofan. The team, consisting of five individuals, will work out of El Obeid, but spend a portion of their time in Kadugli. The staff of the Kadugli Research Station will work closely with this team since these are areas of major concern in south Kordofan.

It is hoped that the above mentioned USAID study will suffice for Phase I of the WSARP Agricultural Market Study (see Appendix). Phase I of this proposal calls for a study of the operation and location of grain and livestock markets in south Kordofan. Phase II of this proposal involves the collection on a regular basis of market data from a selected number of agricultural markets. Improved market information, when passed on to the producers, will have a positive effect on farmer incomes.

The Sedentary Farmers Production Systems Survey and the Transhumant Production Systems Study will ascertain weaknesses in the infrastructure that keep productivity at a low level.

The fire control study will examine cultural and legal means of reducing the extremely wasteful and ecologically damaging practice of burning crop residues and rangeland.

If the fertilizer trials on sorghum show the use of commercial fertilizer to be economic, then the next problem is one of supply. The USAID study, mentioned above, will provide some indications regarding this problem. Further research may be required.

Conflicts Among Target Groups

The Sedentary Farmers Production Systems Survey and The Transhumant Production Systems Study will identify the sources and the degree of conflicts within and between the two target groups. The impact on the productive capacity of each system will be assessed. Identification of sources of conflicts is a prerequisite to developing methods for over coming other production constraints.

Conflicts between target groups often result in the inefficient use of resources and environmental degradation and also impair the potential for improvement. Studies will examine the extent of this inefficiency. An illustrative example is the practice of burning of potential grazing areas by sedentary farmers in an effort to discourage transhumant livestock herds from grazing around villages and on crop land. Thus, burning not only wastes valuable grazing resources, causes a deterioration in range conditions to a point where reclaimation is difficult and costly, but also increases conflicts between the two groups.

Aerial surveys will attempt to identify the actual and/or potential of conflicts between target groups in the Nuba Mountains region such as over the use of land for grazing, traditional cultivation, and mechanized farming (eg. mechanized farming in an area may exclude the use of that land for grazing or for traditional types of cultivation). Also the expansion of either type of cultivation may block transhumant patterns of movement and grazing. Other examples include the assessment of burning practices around sedentary villages and crop land to discourage transhumant settlements and/or grazing, thereby minimizing the risk of crop damage. Aerial surveys will also help to quantify the complementarity between crops and livestock in terms of the extent that crop residues are used by livestock in harvested fields.

RESOURCES REQUIRED

Resources Required

In this section an inventory of the resources required to conduct the research and training program discussed in previous sections of this document. The requirements are presented by section following a general requirements listing.

General Requirements

1. Operating library and librarian
2. Vehicle and machine maintenance
3. English-speaking secretary and typewriter
4. Training officer
5. Radio operator
6. Office and research supplies
7. Equiped audio-visual center with operator
8. Four sets of camping/field survey equipment
9. Farm Manager and operational research station farm (completion of fencing, road, water and other facilities)
10. Home/business type computer
11. Copy machine
12. Operational laboratory
13. Aircraft availability for delivery of supplies and personnel, specific research activities and collaborative activities.

Socio-Economic Section

1. Senior Scientists	31 person-months
2. Senior Technicians	40 person-months
3. Junior Technicians	40 person-months

4.	Research Associate	24 person-months
5.	Trainees	4@9 months each
6.	Field Research Assistants	40 person-months
7.	Short-term Consultants	6 person-months
8.	Four-wheel drive vehicles	3 units
9.	Motorbike	1 unit
10.	Hand-held calculators	10 units
11.	Typewriter (portable)	1 unit

Range and Livestock Section

1.	Senior Scientists	72 person-months
2.	Senior Technicians	51 person-months
3.	Junior Technicians	60 person-months
4.	Trainees	21 person-months
5.	Drivers	60 person-months
6.	Assistant drivers	60 person-months
7.	Herdsmen/helpers	168 person-months
8.	Laborers	120 person-months
9.	Research Station Land	500 hectares
10.	Water supply to Research Station	
11.	Buildings: feed store, equipment/office, housing for farm laborers, holding pens for livestock, 4-6 roofed pens for research animals.	
12.	Portable generator	1 unit
13.	Four-wheel drive vehicles	4 units
14.	Large trucks	2@ 20% each

15. Portable livestock scale	1 unit
16. Hand calculator	1 unit
17. Dirty lab facility	50%
18. WSARP Entomologist	6 person-months
19. WSARP Social Scientist	3 person-months
20. WSARP Agronomist	1 person-month
21. WSARP Agricultural Economist	2 person-months
22. Cattle	140 head
23. Goats	50 head
24. Sheep	50 head

Agronomy, Soils and Water Section

1. Senior Scientists	40 person-months
2. Senior Technicians	40 person-months
3. Junior Technicians	60 person-months
4. Trainees	4 person-months
5. Laborers (permanent)	100 person-months
6. Laborers (temporary)	90 person-months
7. Drivers	40 person-months
8. WSARP Social Scientist	2 person-months
9. WSARP Agricultural Economist	2 person-months
10. Four-wheel drive vehicles	2 units
11. Farm machinery and field equipment sufficient to prepare and maintain reserach farm	
12. Research Station land	50 hectares
13. Seed, fertilizers, chemicals and research supplies (as required by research conducted)	

14. Dirty lab facility	50%
15. Large trucks	2@ 30% each
16. Hand calculator	2 units

Pest Management Section

To be determined after staffing of section.