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AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

WORK PLAN

VOLUME III

RESEARCH PLAN FOR KADUGLI AND OTHER STATIONS

WSARP Publication No. 15

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

The Government of Sudan

The Agricultural Research Corporation

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FOREWORD

The Western Sudan Agricultural Research Project (WSARP) is mandated by the donors and GOS to prepare a work plan for years 4-6. This work plan is in addition to the previous planning and research activities already completed or underway and will serve as an overall guide for research during the ensuing years. Previous planning has been incorporated into the present documents.

The documentation is presented in three volumes. Volume I serves as an overview of the project, research approaches, resources, constraints, etc. that have general applicability for the whole project area. Volume II contains background information, administrative and planning structures, staffing, training, time frame and other topics.

Volume III contains the detailed work plans for each station. It should be noted that the detail provided primarily addresses the Kadugli Station, with detailed and specific plans for the other stations to be prepared as the stations come on line and the scientists have an opportunity to examine constraints, priorities, etc. and develop such detailed work plans. These will be added to Volume III as addenda, as will annual updating of research at all stations.

The World Bank provides funds via a loan agreement with the GOS for construction and purchase and operation of the project aircraft. The GOS provides construction, salary and operational funds. Technical assistance and construction support for the project is provided by a contract between USAID and the Consortium for International Development, with Washington State University designated the Lead University. Dr. Dafalla Ahmed Dafalla serves as the Project Director and Dr. Gerald Owens is the Deputy Project Director. Dr. M. Bakheit Said is the Director General of the Agricultural Research Corporation.

WSARP RESEARCH APPROACH

WSARP RESEARCH APPROACH

Agricultural research may take on many forms (Table 1.). Each suited to a particular purpose. Discipline-oriented research at universities and national research stations has been responsible for most of the contributions in the scientific literature. Commodity research at the International Agricultural Research Centers has been successful in overcoming genetic barriers to yield to produce numerous high yielding crop varieties responsible for the "Green Revolution" in tropical agriculture. Examination of the effect of growing one crop with or after another, as in Croping Systems research, has led to the discovery that some crop combinations reduce disease incidence or insect infestation while others improve soil or crop nutrition. Similarly, Livestock Systems research examines a wide range of factors affecting livestock productivity.

The complexity of the traditional rainfed agricultural production systems in Western Sudan led to the conclusion that none of the above approaches would be appropriate for the WSARP. The Farming Systems approach came the nearest to meeting the needs of the project in that it focused on the farmers and their farms rather than on a single crop or group of crops. But the agricultural activities of the transhumant and nomadic communities in Western Sudan are not limited to a farm or a single geographic location. They migrate long distances to make maximum use of available resources. Consequently,

TABLE 1 CHARACTERISTICS OF SEVERAL APPROACHES TO AGRICULTURAL RESEARCH

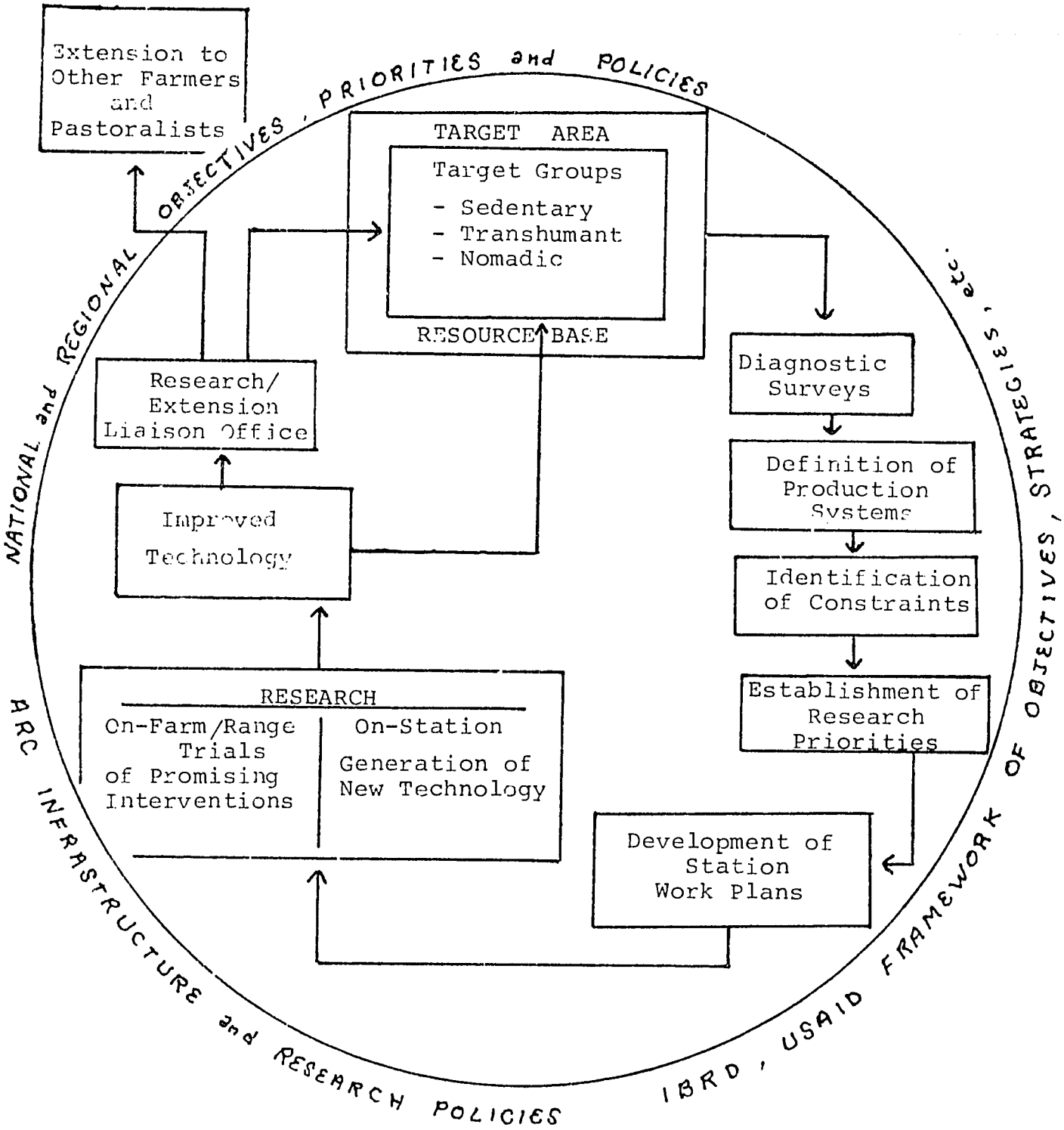
APPROACH	FOCUS	TYPICAL TYPES OF STUDIES	INSTITUTIONAL EXAMPLE
Discipline	Plant Pathology Entomology Physiology	Diseases vectored by white fly	Cornell University
Commodity	All aspects of single commodity	Rice consumption and production in Malaysia	International Rice Research Institute
Cropping Systems	Interaction of crops grown together or in sequence	Advantages of inter-cropping groundnuts and sorghum	International Crops Research Institute for the Semi-Arid Tropics
Livestock Systems	Factors affecting livestock product-ivity	Importance of animal nutrition to disease	International Livestock Center for Africa
Farming Systems	Farmers and their farms	Allocation of labor on Eastern Kenyan farms	CIMMYT Economics Program Nairobi
Production Systems	Agricultural Producers (Farmer, Pastoralist, Gatherer, etc.)	Crop and livestock production by trans-humants	Western Sudan Agricultural Research Project

WSARP has adopted a modified Farming Systems Research approach which we term Production Systems Research to reflect its encompassment of pastoral as well as farming activities.

The farm or pastoral household or group of households among sedentary, transhumant and nomadic groups in Western Sudan are considered to be the basic production unit. Although the sedentary producers in the northern provinces differ from the farmers in the southern provinces the similarities between these settled cultivators are greater than the differences. Consequently, we have classified the production systems according to the characteristics of the target groups (i.e., sedentary, transhumant and nomadic) rather than based on geographic location or type of soil.

The sequential operations of production systems research at a typical WSARP research station is shown schematically in Figure 1. In this approach it is fundamental that research begin and end on the farmer's fields or in the pastoralist's herds. Research needs and priorities are initially defined and continually updated by interaction between researchers and producers to assure that research is attuned to the producers needs. The major constraints to production become evident during the investigations of the target group(s) and their agricultural production systems. Potentially successful interventions based on experience under similar physical/social environments, may exist and their applicability to a given

Figure 1 SEQUENCE OF RESEARCH ACTIVITIES AT A TYPICAL WSARP RESEARCH STATION



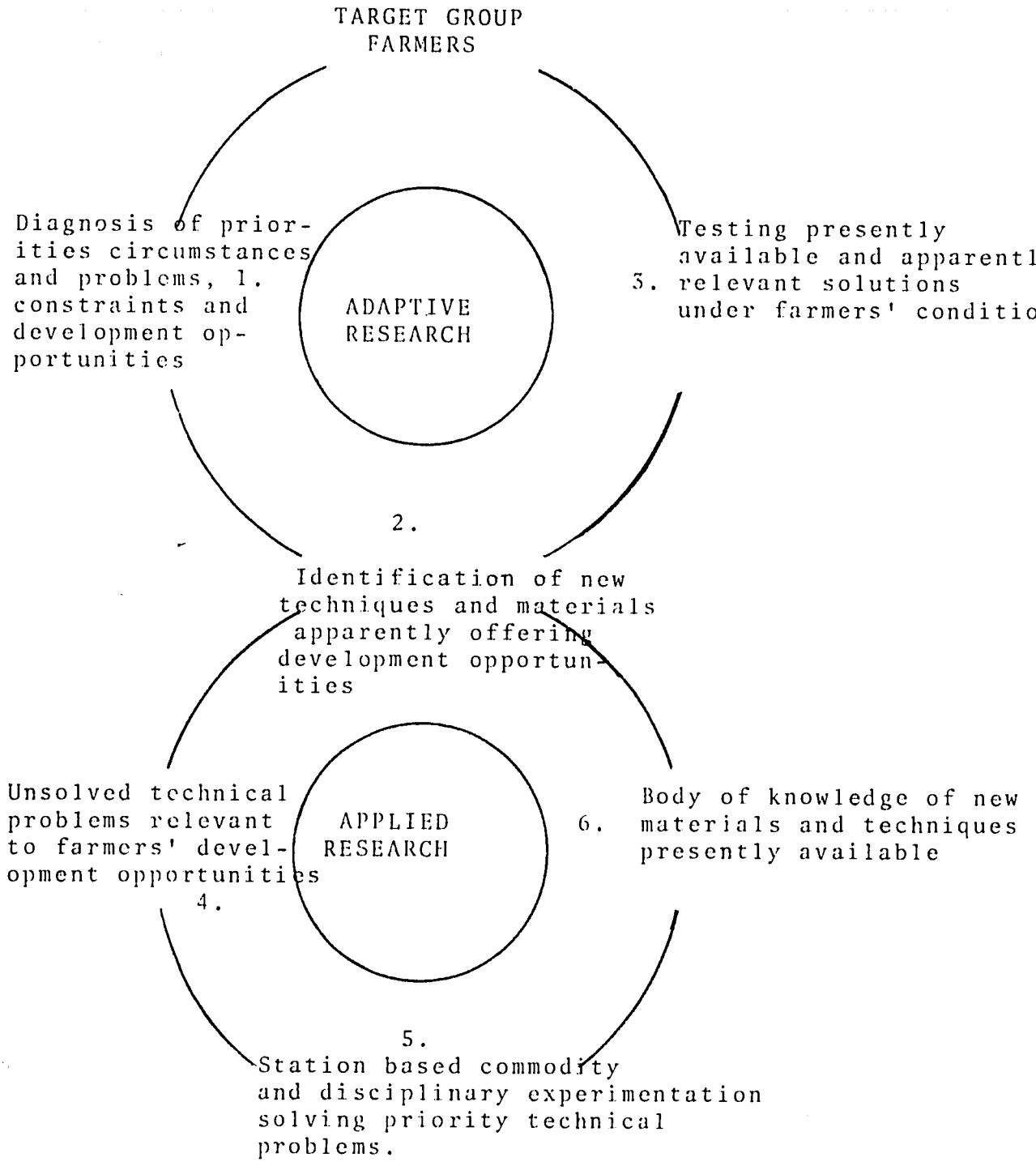
locale is evaluated immediately in "on-farm" or "on-range trials. However, the nature of the land and/or the people may be sufficiently different from previously studied regions that "on-station" research is required to find solutions to area-specific problems. In this case, techniques found to be promising on the station are candidates for evaluation in "on-range" or "on-farm" trials. Research conducted on the experimental station grounds approximates as closely as possible the actual conditions of the production system(s) of the target-group(s). Input to "on-station" research trials are kept within a range affordable by farmers or pastoralists, now, or in the near future.

Production Systems Research can be classified into two categories, namely: Applied Research and Adaptive Research, the difference being whether the research activity is conducted directly in conjunction with the target-group producers (Adaptive Research) or whether it is in the nature of a generation of new technology, primarily, but not necessarily limited to "on-station" research (Applied Research). The importance of the intermeshing of these two activities is illustrated in Figure 2.

The limited number of scientists at national research stations dictates that most senior staff split their time between Adaptive and Applied Research. This is of benefit

Figure 2

INTERACTIONS BETWEEN APPLIED AND ADAPTIVE RESEARCH



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because the two program activities work together in a complementary fashion.

The above is indicative of the general project philosophy in the definition of constraints and conduct of research by the WSARP. It should be emphasized that the orientation is toward the farmer/pastoralist; seeks to solve producer problems; is comprehensive in terms of looking at complete production systems; is interdisciplinary in the utilization of several disciplines effectively amalgamated into a single team; seeks to complement activities of others; and is designed to be responsive to the societies being served. Accordingly, station staff are in continual contact with farmers and pastoralists; surveying and assessing their needs and constraints; testing promising ideas or germplasm in their fields or pastures; developing new technology suitable to their limited resources; and conveying methods judged improved by the producers themselves to extention personnel for more widespread application. It is this dynamic interaction with producers and their environment that differentiates Production Systems Research from the more traditional approaches. Therefore, keeping research attuned to the producers' needs is an essential part of the daily operational activities of a Production Systems oriented research station.

TARGET AREA AND RESOURCE BASE

TARGET AREA AND RESOURCE BASE

Location and General Agricultural Characteristics

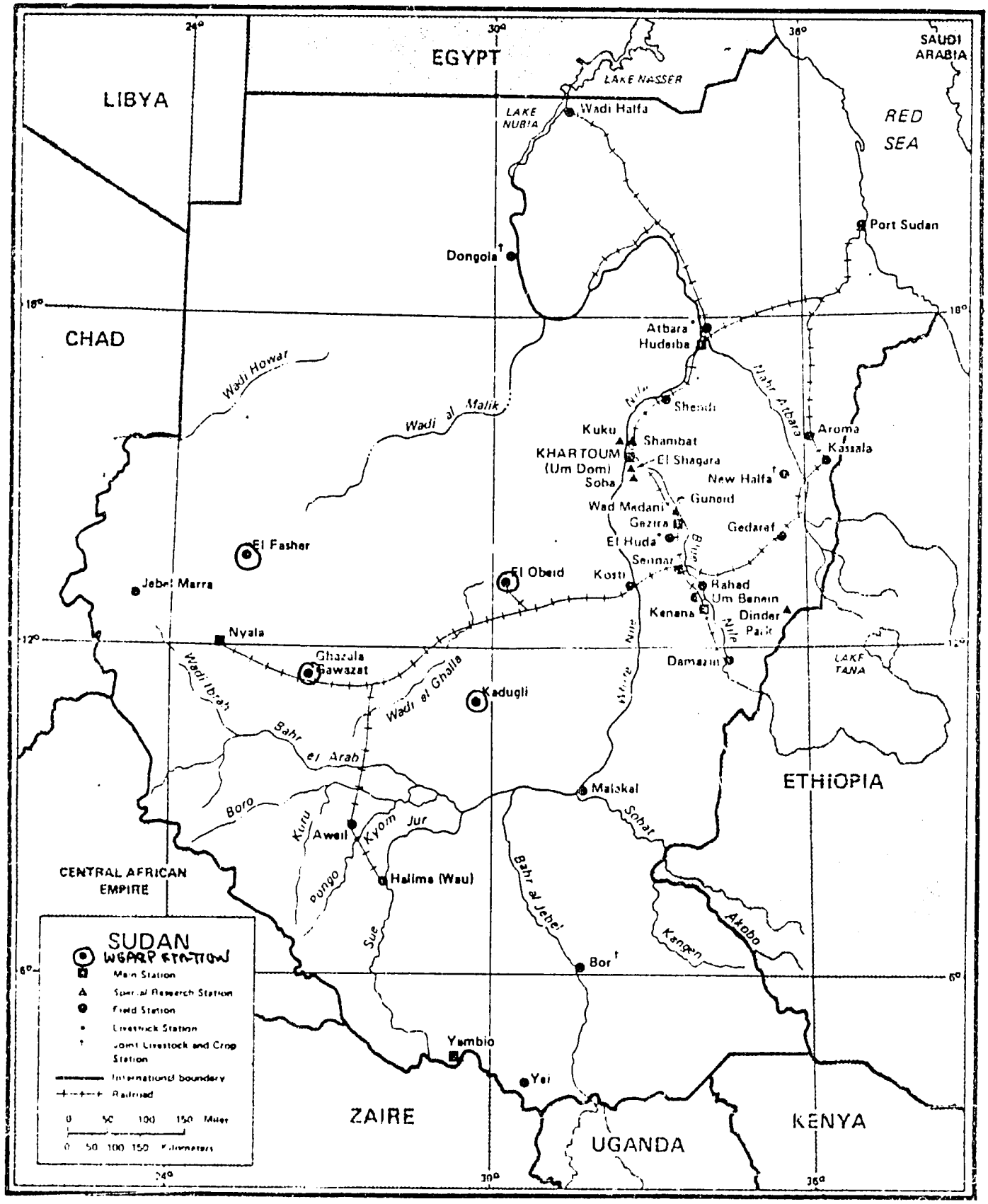
Western Sudan, which encompasses Darfur and Kordofan, covers an area of approximately 850,000 km^2, or 35% of Sudan's land area. The northern one-third of this area is virtually uninhabitable desert, with little or no agricultural potential. Project research is therefore centered in the southern two-thirds of the provinces (i.e. between latitudes $9^{o}30'N$ and $15^{o}N$, and longitudes $22^{o}E$ and $31^{o}30'E$), with research stations strategically located in each of the provinces to help reduce the logistical constraints associated with conducting research to serve such vast areas (see Figure 3).

Crop and livestock production in western Sudan contribute considerably to Sudan's agricultural productivity, accounting for about 90% of the total gum arabic and millet produced, 52% of the sesame, 46% of the groundnuts, 17% of the sorghum, 6% of the cotton, and an estimated 45% of the cattle, 37% of the sheep, 32% of the goats, and 65% of the camels. Traditional agriculture is the most important form of production, and consists of various types of sedentary cultivation and pastoralism.

General Distribution of Agricultural Activities

The type and nature of traditional agriculture in western Sudan are largely a reflection of the variations in the

Figure 3 LOCATION OF STATIONS IN THE NATIONAL RESEARCH STATION NETWORK



in the natural resource base. The major crop and livestock activities in western Sudan are described with respect to broad eco-climatic zones and various environmental factors which seriously limit the form of agriculture practiced in Table 2.

In general, nomadic grazing with camels, sheep, and goats is the only viable form of land-use in the desert and semi-desert areas in the north, although some cultivation is possible along streambeds subject to periodic flooding. As rainfall increases southward, the denser vegetation and more stable soils are capable of supporting greater numbers of livestock, and nomads with camels and small ruminants are replaced by transhumants tending cattle. Crops are grown at some point along the migration route. Sedentary cultivation, with the raising of some livestock, also becomes increasingly important particularly on stabilized sands in the central rainfall belt, and on the cracking and non-cracking clay soils of the Nuba Mountain region. Groundnuts, maize, and short-maturing varieties of millet, sorghum and sesame are planted on the more drought-prone sandy and coarse textured soils, while longer as well as short-maturing varieties of sorghum and sesame are grown on cracking clays. In areas with prolonged seasonal flooding, such as found in the Regeba Repeating Pattern, and especially toward the White Nile and Bahr El Ghazal river valleys where rainfall exceeds 800 mm, cultivation is precluded, and grazing is limited to the dry season.

TABLE 2 TYPES OF CROP AND LIVESTOCK ACTIVITIES IN RELATION TO ECO-CLIMATIC ZONES IN WESTERN SUDAN

Eco-climatic Zones	Agricultural Activity	Crops Raised	Livestock Raised *	Limiting Environmental Factors
Rainfall less than 200mm Desert scrub with scattered thorny shrubs and little or no grass on dune sands, clay pans, and stony soils	Occasional nomadism in wet season Very limited cultivation along alluvial drainages	No sustained rainfed crop production	Camels Desert long-tailed sheep Nubian and desert goats	Desert conditions: - extremely low and variable rainfall - lack of water and forage - eroded soils and blowing or moving sands
Rainfall 200-400mm Thornbush with sparse grass cover on qoz sands and non-cracking clays	Nomadism in the wet season Some sedentary cultivation and livestock raising on stabilized sands	Millet Sesame, Gum Arabic	Camels Desert long-tailed sheep Nubian and desert goats Western desert cattle	Low, unreliable rainfall Limited water distribution and availability Low seasonal forage production Fragile, infertile soils Desert encroachment
Rainfall 400-600mm Mixed deciduous Bushland Savanna on qoz sand and non-cracking clays	Dry & wet season camel nomadism Wet season cattle nomadism and transhumance Transhumant cropping on qoz sands Sedentary cultivation with some livestock, primarily on qoz soils	Millet Sesame Groundnuts Sorghum Gum Arabic Fruits and Vegetables Kerkadeh	Camels Baggara short-horned zebu cattle West African Umbororo cattle Kenana dairy cattle Long-tailed sheep Nubian & short-eared goats	Unreliable rainfall Seasonal availability of water and grazing Denuded/deteriorated soils and vegetation Non-cracking clays unsuited to cultivation Unsuited, infertile sands

* Excluding donkeys, pigs and chickens

TABLE 2 (CONTINUED)

Eco-climatic Zones	Agricultural Activity	Crops Raised	Livestock Raised	Limiting Environmental Factors
Rainfall 600-800mm Deciduous Broad-Leaf and Thorn Wooded Savanna on coarse textured hills and footslopes, cracking and non-cracking clays in the plains, and the repeating Baggara's Regeba soil patterns	Dry season transhumance with some cropping Limited dry season cattle and camel nomadism Extensive sedentary cultivation with considerable livestock raising	Sorghum* Sesame* Cotton* Groundnuts** Millet** Maize** Vegetables and fruits*** Gum from A. Seyal*	Baggara cattle Umbororo cattle Nuba or Koalib cattle Long-tailed sheep Short-eared goats Camels	Somewhat unreliable rainfall Limited water distribution which also affects access to grazing and cultivable land Erodible and infertile hill and footslopes soil Hard impermeable non-cracking clays Heavy, difficult to till or flooded cracking clays infested with biting flies in the wet season
Rainfall over 800m Deciduous Broad-Leaf and Thorn Wooded Savanna on cracking and non-cracking soils with seasonally flooded swamp grassland and semi-evergreen Riparian Woodland.	Transhumance and some nomadic dry season grazing	Nil	Baggara and Nilotic Sanga cattle Long-tailed and nilotic sheep Short-eared goats	Heavy, seasonally inundated cracking soils infested with tsetse and biting flies in the wet season Non-cracking soils unsuited to cultivation Limited distribution of water late in the dry season and hence restricts grazing at this time.

* Grown only on cracking clays

** Grown primarily on sandier soils and not on cracking clays

*** Horticultural crops are grown throughout Western Sudan where sufficient water for irrigation is available, usually in or near the normally dry sandy stream beds

Climate

The dominant climatic feature in Western Sudan is the rainfall pattern associated with the northward movement of the Inter-Tropical Convergence Zone in May to June. Moist tropical air from equatorial regions is brought into contact with the hot North winds from the Saharan desert. The converging air masses lead to the formation of convective storms which prevail over the area until the ITCZ retreats southward in September to October. Rainfall in the project area is highly variable and follows a general north-south gradient from 150-200mm in the north falling between July and September, to 900mm in the extreme south with a season from May to October. As rainfall decreases, its amount and distribution become more erratic and unreliable.

Evaporation follows a gradient opposite to rainfall with about 2500mm/annum in the north to 1500mm in the south. Temperatures are moderate to high throughout the year with greater daily and seasonal variation at more northern latitudes.

Geomorphology and Soils

The major landforms and soils found in the west can be briefly described as follows:

1) Nubian sandstone on the desert fringe overlies the Basement Complex in most locations, forming a flat to gently undulating surface with isolated flat-topped hills of low

relief. Soils are primarily of mixed composition and in advanced stages of erosion leaving loose sands and hard surfaces of non-cracking clays and sandy clays, or layers of gravel and stone.

2) Stabilized sandy or "qoz" soils form extensive, gently-rolling sheets and dunes from the Basement Complex zone to the White Nile, and between the desert, the Nuba Mountains, and the Baggara and Regeba repeating soil-patterns. The Qoz sands originate from a portion of the deep aeolian mantle, with quartz sands derived from the surrounding Basement Complex, Nubian Sandstone and Umm Ruwaba sediments. These soils are generally very low in fertility and organic matter, and highly susceptible to erosion. They are widely cultivated, which has accelerated water and wind erosion.

3) The Basement Complex formation in the Nuba Mountain region is characterized by steep, rocky hills or jebels with slightly inclined footslopes of coarse sandy loams and clays, merging into recurrent patterns on the plains of cracking and non-cracking clays. The hillside and footslope soils are inherently low in fertility, though commonly cultivated, and are undergoing moderate to rapid erosion. Cracking and non-cracking clays are products of in-situ weathering or erosion from the hill masses; the former soils being relatively fertile and widely cultivated, and the latter having a hard, impermeable surface resulting in high run-off

and low suitability for cultivation.

4) Non-cracking clay pediplain soils are derived from Basement Complex rock, and consist of flat to mildly wave-like plains of alternating deposits of red clays, brown sandy loams and sandy clays. These soils are scattered across parts of Kordofan and occur in the Regeba and Baggara repeating patterns in South Darfur. Their characteristics are similar to those described in (3) above.

5) Dark cracking clays occur in seasonally flooded plains and adjacent to the river networks of the Bahr el Arab, Bahr el-Ghazal and White Nile. These soils appear to be fairly fertile but prolonged water-logging precludes cultivation.

6) Baggara Catenary Soils occur in South Darfur and form a topographical sequence of undulating dune sand and various loamy soils, sloping onto non-cracking clay flats and terminating in depressions of dark cracking clays known as Butas which are seasonally waterlogged. Buta soils are fairly high in fertility, but because of their distribution as well as tillage problems due to flooding, they are rarely cultivated.

7) Regeba Catenary Soils are found adjacent to the Baggara soils and exist as a repeating pattern of non-cracking clays, alternating with black cracking clays and buta flooded clays. Cultivation problems are similar to those described previously.

Vegetation

Vegetation of western Sudan can be classified into broad ecological zones based on climate and soils. General physiognomic and botanical characteristics are presented here, but for details on specific vegetation types, see Bunderson, 1982, and Harrison & Jackson, 1958.

Semi-desert scrub is found in the extreme north with rainfall under 200mm/annum. Vegetation here is dominated by Acacia tortalis and A. mellifera on sandy and clay soils, respectively, with a sparse cover of grass composed mostly of Aristida spp., Cenchrus biflorus, Panicum turgidum, and Schoenefeldia gracilis. Farther south, in areas with a rainfall of 200-400mm/yr. on qoz sands and non-cracking clays, vegetation grades into a deciduous thornbush with many of the above named plants, but also including species such as Acacia senegal, A. nubica and the evergreen Boscia senegalensis among the shrubs, and Chloris virgata, Dactyloctenium aegyptium, and Stylosanthes fruiticosa in the grass and herb components.

In the 400-600mm/yr. rainfall belt, a deciduous bushland savanna develops which is dominated on qoz soils by Albizia amara, Dalbergia melanoxylon, Combretum cordofanum, and A. senegal, while non-cracking clays are populated by A. mellifera and A. nubica. Grasses, similar to those mentioned above occur, but form a more continuous cover and include

species such as Andropogon gayanus, mainly on clay soils, and Eragrostis tremula and Ctenium elegans on sands. As rainfall approaches 600mm/yr. Guieria senegalensis becomes a dominant shrub with occasional, emergent trees like Sclerocarya birrea, Terminalia brownii and Cadaba sp..

Within the rainfall zone of 600-800mm/yr. are found wooded savannas and woodlands. In the Nuba Mountain region, the structure and composition of vegetation shows considerable variability due to the complex heterogeneity of soil types. Basically, five broad categories of vegetation can be distinguished: (1) deciduous broad-leaf woodland and wooded grassland on jebel hillsides dominated by Boswellia papyrifera and Combretum hartmannianum, with Hyparrhenia confinis, Pennisetum pedicellatum and Panicum spp. in the herb component, (2) mixed deciduous and thorn wooded grassland on coarse textured footslopes with dominant trees including Albizia amara, Balanites aegyptiaca, Anogeissus leiocarpus and C. hartmannianum, and major grasses such as Setaria pallide-fusca, Hyparrhenia confinis, Loudetia togoensis and Schoenefeldia gracilis, (3) semi-deciduous thorn woodland and wooded grassland on cracking clay plains with Acacia seyal, B. aegyptiaca, and Dichrostachys cinerea dominant in the woody component, and Hyparrhenia pseudocymbaria, Sorghum purpureosericeum, Brachiaria obtusiflora and Cymbopogon nervatus as the principal grasses. (In areas of lower rainfall, Acacia

mellifera may replace A. seyal as the dominant species), (4) mixed deciduous wooded grassland on non-cracking clay plains with species similar to the footslopes but including trees like Lannea humilis, A. gerrardii, Terminalia laxiflora, and Diospyros mespiliformis, with grass covering being more patchy in distribution, (5) mixed deciduous and evergreen riparian woodland (dominated by Anogeissus leiocarpus, Tamarindus indica, and Acacia spp.) and wooded grassland on alluvial soils with trees such as Acacia albida, Ficus spp. and Piliostigma reticulata, and grasses like Pennisetum ramosum, Chloris spp. and Cynodon dactylon. In addition, swamp grasslands on seasonally flooded clay depressions are dominated by Echinochloa and Oryza spp..

Outside of the Nuba Mountain area, but still within the 600-800mm/Yr. rainfall zone, vegetation on cracking and non-cracking clays is similar to that described above. As rainfall exceeds 800mm/Yr. cracking clays are liable to periodic flooding and grasses such as Hyparrhenia rufa, Setaria incrassata and Andropogon gayanus become more common. Trees on the non-cracking clays are better developed and show greater diversity in composition. Cracking clays subject to pronounced seasonal flooding, such as along the Bahr el Arab drainage network, are characterized by tall grasses such as Echinochloa pyramidalis, E. stagnina, Oryza spp., Vetiveria nigritana, and Cyperus spp., with Setaria and

Hyparrhenia spp. along the swamp fringes. Mixed deciduous and evergreen riparian woodland is found locally outside the flooded regions and is similar in composition to that of the Nuba Mountain area.

The Baggara and Regeba Repeating Patterns contain aspects of many of the vegetation types described since their soils are similar to those found elsewhere. However, the vegetation on these repeating soil patterns should be considered distinct from other vegetation types because of their unique alternating pattern of soils and vegetation which are closely interrelated.

The nomadic herders of the northern desert and semi-desert regions make extensive use of a unique type of vegetation known as "gizzu" which is composed of several species including: Indigofera and Crotalaria spp. (legumes); Triaphus pumilio and Aristida ciliata (annual and perennial grasses respectively); and Newada procumbens, Tribulus and Fagonia spp. (annual herbs) as well as the surrounding Acacia scrub vegetation. The Gizzu plant community begins to flourish with the onset of cool weather (November) in years when there is above average rainfall. The green, lush vegetation, usually lasting until February, provides exceptional grazing and most of the water requirements for camels, sheep and goats.

Although gizzu vegetation is found principally in Chad, there are scattered pockets of gizzu, or some of the constituent species, across northern parts of Western Sudan, particularly in Northwest Darfur.

The Nuba Mountains area is a natural source of diversity of Sorghum species. The Project will attempt to preserve this valuable genetic resource and prevent further genetic erosion.

Livestock

Darfur and Kordofan provinces hold approximately 40% of Sudan's national domestic herd; 7.8 million cattle, 6.7 million sheep, 5.5 million goats and 1.5 million camels. The major type of cattle found in the area are East African short-horned Bos indicus, although cross-breeding with non-humped cattle have produced a large population of animals with little or no cervico-thoracic hump. In addition, Red Fulani cattle can be found, having been introduced by recent immigrants from West Africa. The predominate sheep of the region are a small version of the classic Sudan Desert type, and goats range from dwarf, Nilotic type, commonly found in Southern Kordofan to a much larger, long-eared type of Southern Darfur. Approximately 60% of Sudan's camels are found in the Northern Provinces. In general, the productivity of these herds is low, with the commercial off-take rate for cattle, sheep, goats, and camels being 7.5%, 25%, 18% and 4%, respectively.

Herd demographics play an important role in determining productivity, and for cattle male/female ratios vary

from 25/75 to 35/65 and for sheep from 25/75 to 30/70. Age at first conception and conception interval have been estimated at 3 years and 20-24 months respectively/for cattle and 0.9 years and 9 months respectively for sheep. Neonatal and adult mortalities range from 11 to 40% for cattle, the highest representing neonatal deaths in the sedentary sector. Sheep neonatal and adult mortalities range from 20% to 30%.

Infrastructure

The elements of infrastructure relevant to Western Sudan production systems include: communications, labor, markets, land tenure, commercial agricultural inputs (credit, fertilizer, insecticides, etc.), education (specifically agricultural education) and services (e.g. agricultural extension, veterinary services). Gaps in the infrastructure are substantial, though the basis for closing most of them has been established.

There are completed or under construction in Kordofan and Darfur Regions about 500 km of all-weather roads. The remainder of traffic is on underimproved roads that are little more than tracks. Roads on clay soils are passable, consistantly, only in the dry season or during long periods of drought in the rainy season. Roads over sandy soils are passable most of the year but are extremely rough in places. Few bridges exist resulting in frequent delays in the rainy season as vehicles wait for the passage of flash floods in

the ephemeral streams. Most goods, produce and people are transported by heavy duty trucks referred to as "suk lorries". Trips are time consuming and physically damaging to vehicles, cargo and passengers alike.

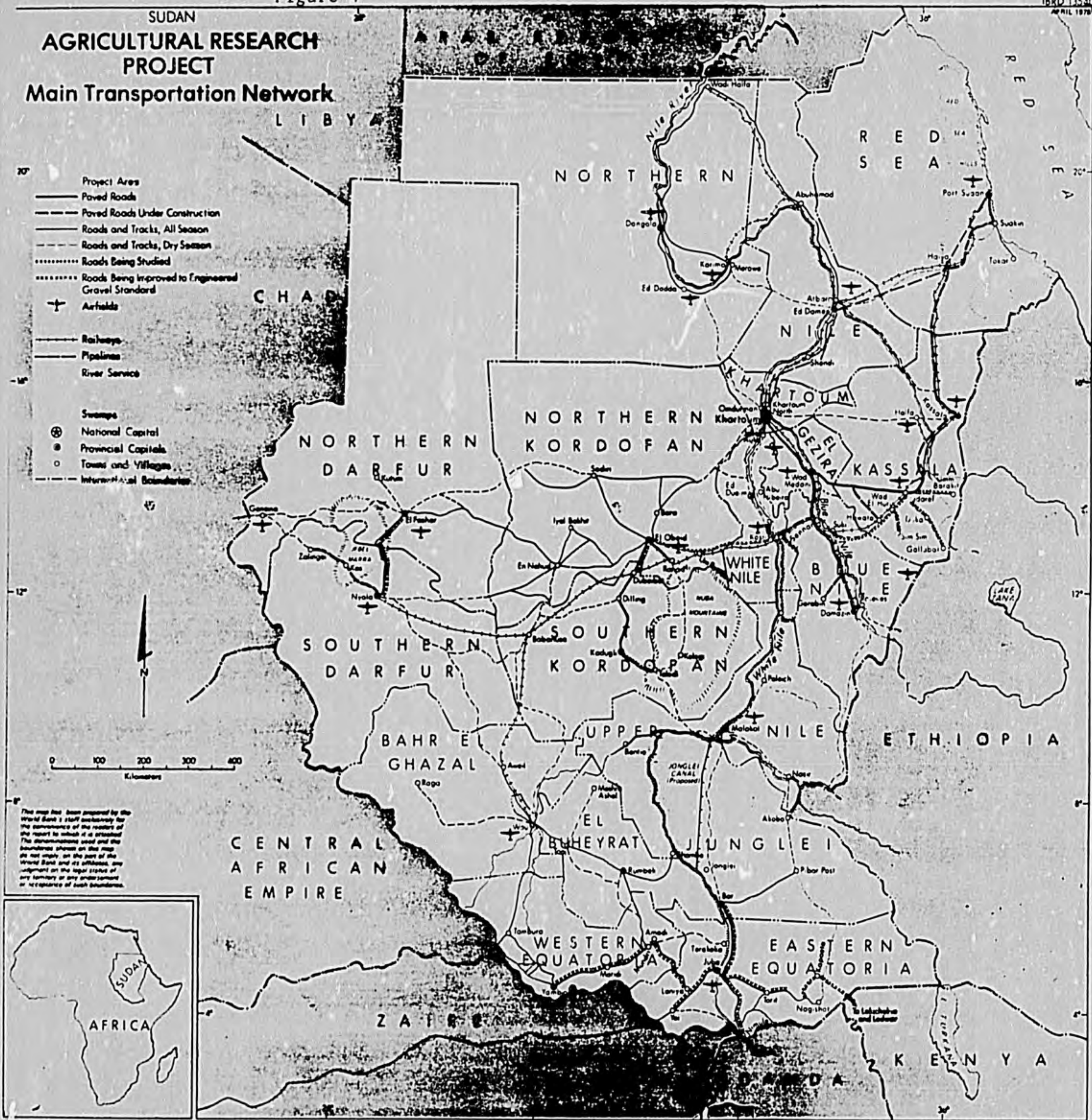
A narrow gauge railroad runs from Kosti (on the White Nile) to Nyala with spurs to El Obeid and Wau. (See Figure 4). Transport by rail is slow, unreliable and of inadequate capacity and likely to remain so for some time.

Radio Omdurman is intended to provide national radio coverage, but it can be received with regularity only near the capital. National television coverage is more comprehensive, with two country-wide transmitting stations and twelve receiving stations, four of which are located in Western Sudan in El Fasher, El Obeid, Nyala and Kadugli. (Transmitters in Wad Medani and Atbara provide a few hours of local programming daily to those communities). TV transmission is normally during the evening hours. It is estimated that there are fewer than 1000 TV sets in Western Sudan.

Most labor for agricultural production is provided by members of the producer's household. Seasonal labor is hired on a daily basis or obtained through informal cooperative labor organizations (nafirs) for weeding, harvesting, and occasionally for planting. Village labor shortages occur during periods of weeding and harvesting, and are exacerbated by labor-intensive methods and out-migration by adult males

27

Figure 4



IBRD 13540
APRIL 1978
SUDAN
AGRICULTURAL RESEARCH PROJECT
Main Transportation Network
Project Area
Paved Roads
Paved Roads Under Construction
Roads and Tracks, All Season
Roads and Tracks, Dry Season
Roads Being Studied
Roads Being Improved to Engineered Gravel Standard
Airfields
Railways
Pipelines
River Service
Swamps
National Capital
Provincial Capitals
Towns and Villages
Kilometers
LIBYA
CHAD
NORTHERN
RED SEA
NILE
KHARTOUM
Khartoum
EL GEZIRA
KASSALA
NORTHERN KORDOFAN
NORTHERN DARFUR
WHITE NILE
BLUE NILE
SOUTHERN KORDOFAN
SOUTHERN DARFUR
BAHR EL GHAZAL
UPPER NILE
ETHIOPIA
EL BUHEYRAT
JONGLEI
CENTRAL AFRICAN EMPIRE
WESTERN EQUATORIA
EASTERN EQUATORIA
ZAIRE
UGANDA
KENYA
AFRICA
SUDAN
Port Sudan
Suakin
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Zalingei
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Nasir
Akobo
Wau
Rumbek
Bor
Juba
Yei
Torit
Yambio
Maridi
Amadi
Tambura
Kapoeta
Raga
Bentiu
Awail
Sennar
Damazin
Kassala
Haiya
Tokar
Gedaref
Renk
Kosti
Sodiri
Bara
Babanusa
JONGLEI CANAL (Proposed)
LAKE TANA
Pibor Post
Nagishot
To Lokichoke and Lodwar

to the cities for higher paying jobs or military service.

Agricultural markets exist in most larger towns with separate facilities for livestock and crop products. In general the markets are large open areas where sellers can display their offerings. Potential buyers, many represented by professional commission buyers, circulate and attempt to make purchases by bargaining with the owners. Transactions are recorded by a government representative and a small transaction tax is paid. It is estimated that over half of the transactions are made outside the established market to avoid payment of the tax.

In most smaller towns and villages, agricultural products are sold to the local merchant who, after aggregating several purchases, transports the products to the larger markets for resale and/or holds the products for resale to the villagers at a later date. In instances where the merchant has provided credit, payment is often made in the form of agricultural products.

The Government of Sudan, by law, owns all unregistered land. However, usufruct rights over a parcel of land may be gained by clearing it and planting a crop. Usufructory rights are retained as long as use continues and may be inherited. Local magistrates make decisions regarding access to land use rights and settle disputes.

Sources of commercial agricultural inputs, including

credit, are almost non-existent. Fertilizers are not available and thus not used. Agricultural chemicals are available in very limited quantities and are used mostly to protect stored grain or control cotton pests on mechanized schemes. Farmers usually save seeds from the previous season's crops. Few new varieties are available from local merchants on a very limited scale. Credit is primarily obtained from local merchants at extremely high interest rates. The Sudan Agricultural Bank and other lending institutions have branches in the larger towns but most traditional producers lack the required collateral to borrow. Therefore, the use of credit to purchase agricultural inputs by the traditional sector is minimal.

There are a number of agricultural training institutions in the Sudan, although none are in Western Sudan. The Agricultural Extension Service has offices in major towns and is supposed to provide practical instruction to farmers but staff lack operational funds and proper training to provide the intended extension activities. Other Ministry of Agriculture departments represented in Western Sudan are: Crop Protection Service, Soil Survey Department, the Forestry Department, Range Department, Veterinary Service and several mechanized farming corporations. Most of these organizations face financial and staffing constraints rendering them inoperable or ineffective. In emergency situations, however, aid to producers is provided.

During serious insect or bird infestations sprays and equipment are made available, and vaccines and other medical supplies are provided for outbreaks of livestock diseases.

PRODUCTION SYSTEMS AND TARGET GROUPS

PRODUCTION SYSTEMS AND TARGET GROUPS

The four provinces of Western Sudan: North and South Kordofan and North and South Darfur, form one-third of Sudan's land area.* The area contains approximately one-fourth of the country's population. The region is characterized by rainfed cultivation and livestock raising among a rural population composed of traditional small farmers and pastoralists. The major crops are subsistence cereal grains; sorghum and millet, and some cash crops of grain, oil-seeds and fiber. The leading source of income for traditional producers is from sale of livestock destined for consumption in urban areas of Sudan and abroad.

Settled farmers are found wherever permanent sources of water are available, but vast areas of Western Sudan are exploited primarily by pastoralists who engage in systematic transhumance or nomadic treks dictated by the rainfall regime, available water and grazing resources. The rainfall gradient and soils differentiate the northern provinces from those in the south which have more cultivation potential.

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* Originally administered as two provinces, Darfur and Kordofan were merged as a single region after division into south and north provinces in the 1970's. In 1980 they were grouped as two separate regions each with a governorship. Current administrative boundaries between provinces and regions are arbitrary and do not reflect ecological limits. The main differences are between the semi-desertic northern areas with sandy soils and the wetter, forested southern areas with increasing amounts of clay and some rocky soils.

Although census data is not very accurate (the results of the last census taken in 1973 are still in dispute) various estimates of the population of Western Sudan suggest that the Kordofan region contained between 3.3 and 3.8 million people, the Darfur region between 3.0 and 3.5 million in 1980 for a total of 6.3 - 7.2 million persons.** Administrative and market towns in each province have grown rapidly over the past two generations, especially in the more densely populated areas of Kordofan. There has also been substantial out-migration to other parts of Sudan from the West.

The major division of the traditional target populations based on characteristic ways of life and systems of production are: sedentary farmers, transhumant agro-pastoralists, and nomadic pastoralists. The sedentary farmers constitute three-fifths of the rural population and are concentrated in the higher rainfall southern provinces and central areas of Western Sudan. They engage mainly in slash-and-burn rainfed hoe-cultivation using bush fallow. Approximately one-fourth to one-third of the population practices semi-nomadic livestock transhumance, and cultivates rainfed plots of land mainly in the southern provinces. A minority of about 10% of the population consists of nomadic pastoralists coming from the northern semi-desert fringe.

** PRC Engineering Report on Western Sudan.

Livestock raising is practiced by all segments of the traditional population, but the majority of large ruminants such as cattle and camels and small ruminants such as sheep and goats, are owned and tended by migratory pastoralists, i.e., transhumants and nomads. However, small ruminants are reared in sedentary communities throughout Western Sudan.

The Organization of Transhumance

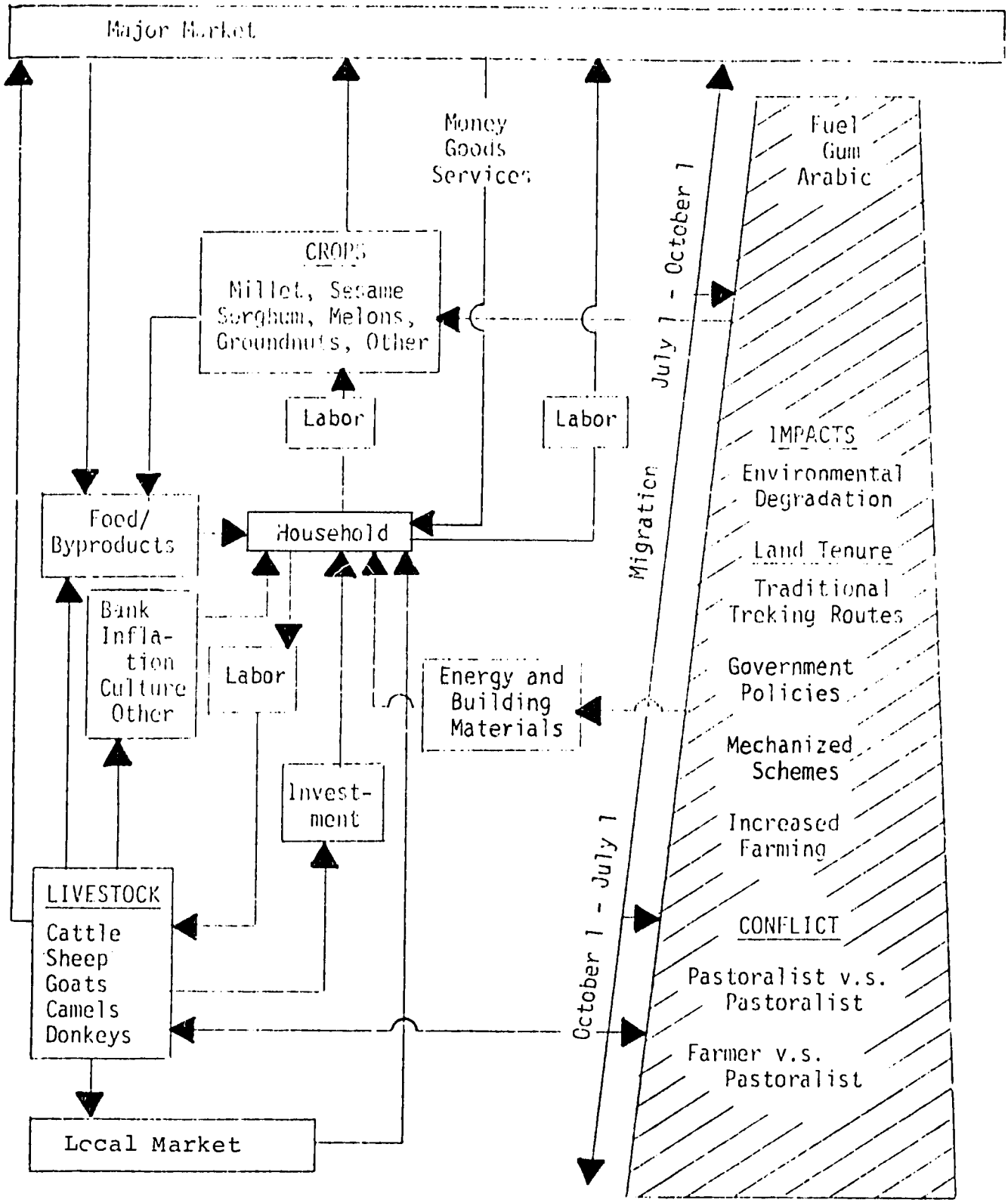
Transhumant agro-pastoralists keep livestock on the open rangelands of Western Sudan. They migrate along predictable annual routes according to seasonal availability of grazing and water resources, and cultivate foodgrains on established plots along these routes. Transhumant households are typically composed of a man and his wife or wives, children, and other dependents and are grouped into camps composed of several agnatically related households. Camping units (ferigs) migrate together and share some production and consumption activities on a cooperative basis. The major livestock species raised by transhumants are cattle, but small stock, especially goats and some sheep are also kept and camels and equidae are used as beasts of burden. Livestock are raised for sale, for use as beasts of burden, for their skins, milk products and meat, for economic security and for cultural reasons. A schematic representation

of a typical transhumant production system in Western Sudan is given in Figure 5.

In Western Sudan the main transhumant target groups are drawn from Arabic-speaking, Islamic tribes of the Baggara people (which means cattle keepers) located mainly in Southern Darfur and Southern Kordofan. During the rainy season these groups may migrate as far as the southern fringes of North Kordofan and North Darfur in search of traditional pastures. There are five major tribes among the Baggara (and some minor tribes) occupying adjacent, often overlapping corridors of north-south alignment from east to west. In Kordofan these tribes are the Awlad Himeid, the Hawazma, the Missiriya Zuruq and Missiriya Humr (who spill over into South Darfur). In South Darfur are the Rizeigat and smaller tribal fractions including the Ma'alia, Ta'aisha, Habaniya, Beni Hulba and Salamat. Although transhumance is traditional for these Baggara tribal groupings, today a minority of their households practice agro-pastoralism. The majority have settled as farmers throughout the southern provinces over the past few generations. Also, various traditional sedentary tribes (Nuba, Bediria, Fur, etc.) contain some transhumant households.

In the far south of Western Sudan along the Bahr el-Arab river basin Nilotic tribes, especially Dinka and Nuer, carry out transhumance. They move north during the wet

Figure 5. Schematic Representation of a Typical Transhumant Production System in Western Sudan



season into lands vacated by the Baggara, and south, across or along the rivers and lakes during the dry season. The Ngok Dinka of South Kordofan engage in this limited form of transhumance.

Transhumant households are grouped into tribal sections which maintain local tribal homelands (called dars); they cultivate land in the higher rainfall areas. During the dry season covering over half the year (from December through June) transhumants maintain relatively fixed encampments near permanent sources of water. They are often associated with sedentary communities. Their livestock graze on dry rangelands and crop residues, with each household unit operating its herd independently and drawing its water from shallow wells and pools. Men, assisted by boys, manage the herds including the milking of cows and goats. Women remain at the camps, performing household chores and caring for young animals. The invasion of biting flies and other insects harmful to animal health from the south serves as a stimulus to northward movement. Animal and human health suffers the most just at the start of the rains.

Beginning in July after the seasonal rains have begun whole groups of associated camps begin the northward migration along the lagging fringes of the rainfall front as pools of water are formed and new grasses sprout.

Households and livestock follow specific migratory routes with known areas for camping along the way. By August, transhumant camps have reached the limit of northerly grazing on sandy qoz soils. The limit is determined by the amount of rainfall and is between 12° and 14° latitude. (See Figure 6.)

Households, which normally live in groups of 3-4 in the South, band together in larger groups on the northward trek. Although the main objective of the trek is adequate grazing and water for the animals, during the trek most men will sell livestock in nearby market towns and women sell cow milk to local cheese factories.

Frequently, transhumant households are entrusted with livestock, especially cattle, of sedentary farmers and others in the southern provinces during their northerly transhumance which is thought to benefit animal growth and health. After a period of one to three months in the northern pastures (depending on the rainfall and abundance of grass and water) transhumant herders begin southward migration in October.

During the migratory period members of each household travel to their cultivation plots along the route, planting crops of sorghum and millet at the beginning of the rains, and returning later to harvest their crops. One member of a household may stay with the fields to manage cultivation,

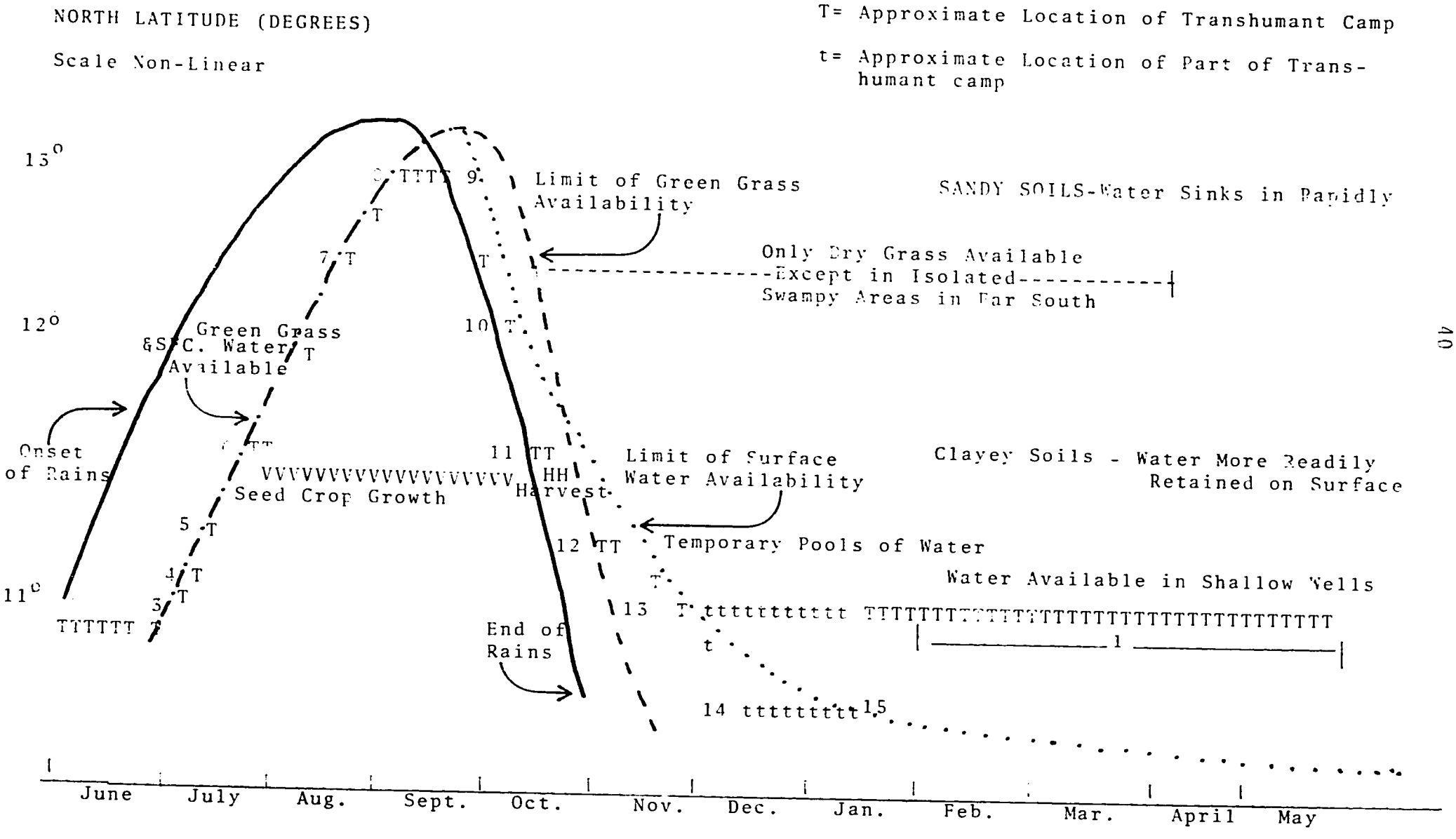
FIGURE 6 LEGEND

1. DRY SEASON WATERING & GRAZING CAMP
2. RAINS BEGIN
3. GRASS SPROUTS, RAINWATER POOLS FORM
4. MOVEMENT NORTH BEGINS
   MIXED GRAZING OLD & NEW GRASS
5. GRAZING ON NEW GRASS
6. CROPS PLANTED
7. GRAZING ON SANDY SOIL PASTURES WITH WATER IN POOLS
8. FURTHEST NORTHWARD MIGRATION DEPENDING UPON AVAILABILITY OF WATER AND GRAZING
9. DEPARTURE FROM NORTHERN MOST CAMPS AS WATER POOLS VANISH AND GRAZING BECOMES SPARCE
10. SOUTHWARD MOVEMENT CONTINUES ALONG LINE OF AVAILABLE WATER
11. CAMP STOPS TO ASSIST IN CROP HARVEST. HERDS GRAZE ON CROP RESIDUES AND REMAINING GRASS
12. EXTENDED STOP AROUND SEASONAL SPRINGS, RETURN TO PERMANENT WATERING AND GRAZING SITE DELAYED AS LONG AS POSSIBLE TO RESERVE FORAGE FOR USE LATER ON
13. RETURN TO DRY SEASON SETTLEMENT SITE
14. PART OF CAMP MOVES FARTHER SOUTH TO TAKE ADVANTAGE OF WATER AND GREEN GRASS IN PREVIOUSLY FLOODED AREAS
15. SPLINTER GROUP REJOINS MAIN CAMP WHEN DEPLETION OF WATER LIMITS AVAILABLE FORAGE

Figure 6

ORBIT OF SHORT DISTANCE MIGRATION OF TRANSHUMANT CAMPS IN RESPONSE TO ENVIRONMENTAL/RANGE CONDITIONS

KORDOFAN, SUDAN



often with the use of paid labor. Alternatively, sedentary relatives supervise their croplands while they are on transhumance. Grains are then transported to the dry season dwelling areas to feed their families during the lengthy period of residence from December to June. The northward transhumant migration resumes after the rains return, and the orbit continues.

Among transhumants, tribal solidarity and segmentary lineages are the traditional modes of social control with self-help groups composed of tribal sections paying blood-debts and preventing vengeance by making peace settlements between themselves and with other tribes in adjacent territories. Tribal councils also attempt to regulate relations with settled farmers with whom the transhumants experience many conflicts due to livestock depradations of planted fields. Provincial and rural governments often intervene in these and other legal matters to control violence and impose justice. Within herder groupings, each transhumant camp has its titular leader. He is usually a senior male; father, active elder brother or paternal uncle of the household heads, who represents the agnatic group to other such units. Each household is led by a male head who manages the entire herd. Preferred close-cousin marriage and Islamic inheritance and values help maintain the solidarity of these herding groups.

Nomadic Pastoralism

Nomadic pastoralists form the smallest segment of the target groups in the Western Sudan. Most have their homeland areas in the semi-desert regions of the northern provinces. They raise mostly camels and sheep, engaging in long-distance treks through low rainfall districts during the short rainy season (July to September). They move into the southern provinces during the long dry season (October through June) in search of water and pasture. Camel owners often provide beasts of burden for s:ttled populations, and sell gum collected from Acacia seyal trees. The length of their migratory treks has increased in recent decades due to poor rains, overgrazing and desertification in the north. In the wet season, nomads move away from permanent water sources; some households sow subsistence crops of millet in the north, but do not maintain regular cultivation. Hence, their harvests are inconsistent due to the lack of rains and management.

The main camel and sheep nomadic tribes are the Kababish Kawahla, Hawaweer, Maganeen, Dar Hamid, Hamar and Shanabla of North Kordofan and Darfur; and the Zayadia, Berti, and Mahrya subtribe of the Rizaigat Baggara in North Darfur. In addition, some nomadic groups keep cattle but do little or no cultivation. The Umbororo (Fulani) have spread across Western Sudan from West Africa,

and the Zaghawa are camel raisers and wild-grain gatherers whose homeland lies astride the Chadian-Northern Darfur border area. Several tribes graze their animals on gizzu vegetation. Some, such as the Kabbabish, reportedly travel up to 600 km to reach it. In regions where gizzu is extensive, tribes have traditional grazing rights to certain areas some of which span international borders.

Nomadic households are organized around livestock raising activities and are dominated by male heads. Within tribes, many related households gather in encampments around specific water points but operate independently in grazing activities and as providers of beasts of burden. Formerly dominated by elite tribal chiefs in the northern zones, their solidarity is decreasing with dispersion southward and increased provincial government authority.

The Sedentary System of Farming

Traditional sedentary farmer households live mainly in the southern and central zones of Western Sudan. They make up about three-fifths of the rural population, but are often among the poorest and least productive. There are two main types of farming communities: the dispersed type, and the clustered type.

Dispersed Communities

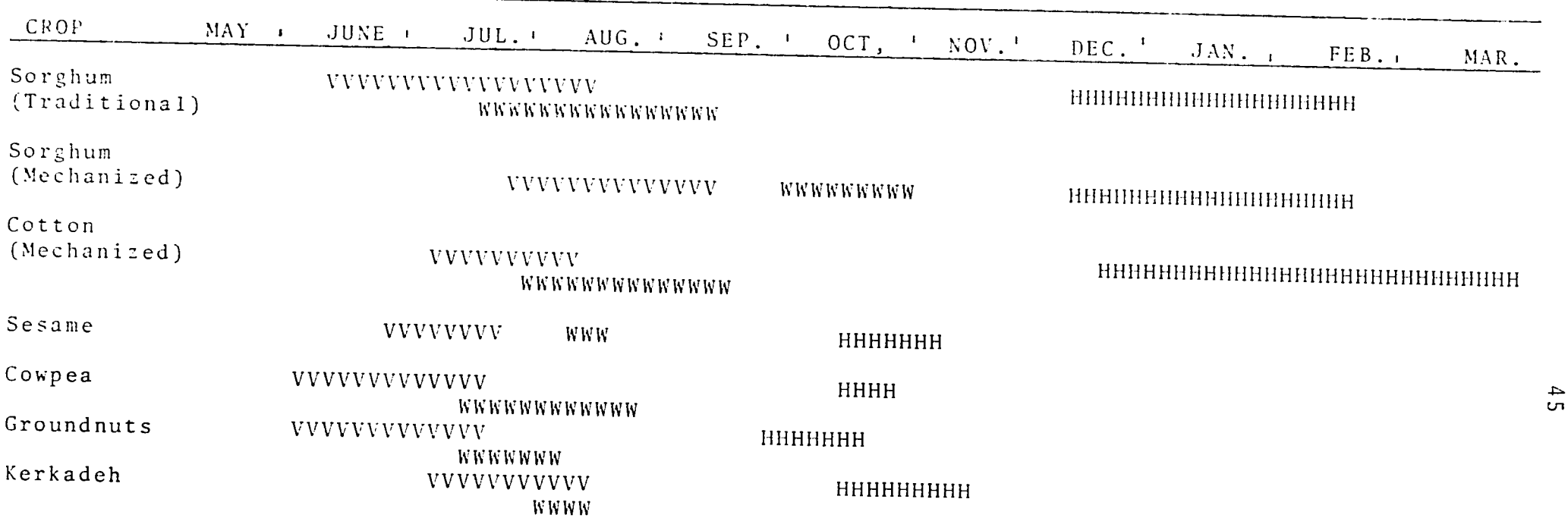
The dispersed type is found in the wetter southern latitudes, especially on cracking clay soils and in the Nuba Mountains area. Here sedentary communities consist of dispersed neighborhoods; households live in hamlets made of mud or stone huts formed into small compounds. These households reside on plateaus or hillslopes above the clay plains. They cultivate by using slash-and-burn techniques of hoe-cultivation and bush fallow. Each ethnic or tribal group forms its own communities and farming territory in this environment. Colonies move into unclaimed areas of the plains as population pressures, sedentarization, and downhill migration draw tribal groups into the cash-cropping infrastructure.

Typically, the major crops of the higher rainfall areas consist of sorghum, late maturing sesame, and cowpeas interplanted on cracking clays, as well as pure stands of cotton as a cash-crop. A typical crop calendar of activities for field crops in South Kordofan is given in Figure 7. Another type of farm-plot, the "housegarden (jubraka)" surrounds the living compound. It consists of garden vegetables and fruits as well as early maturing grains or sorghum, millet and maize grown on coarse soils. Manures and housesweepings are used as fertilizers under a continuous cropping cycle. Also, on sandy soils, peanuts are grown as a food an cash crop. The dispersion of

Figure 7

TYPICAL CROPPING ACTIVITIES CALENDAR FOR FIELD CROPS

S. KORDOFAN, SUDAN



V= Planting Period
W= Weeding Period
H= Harvest Period

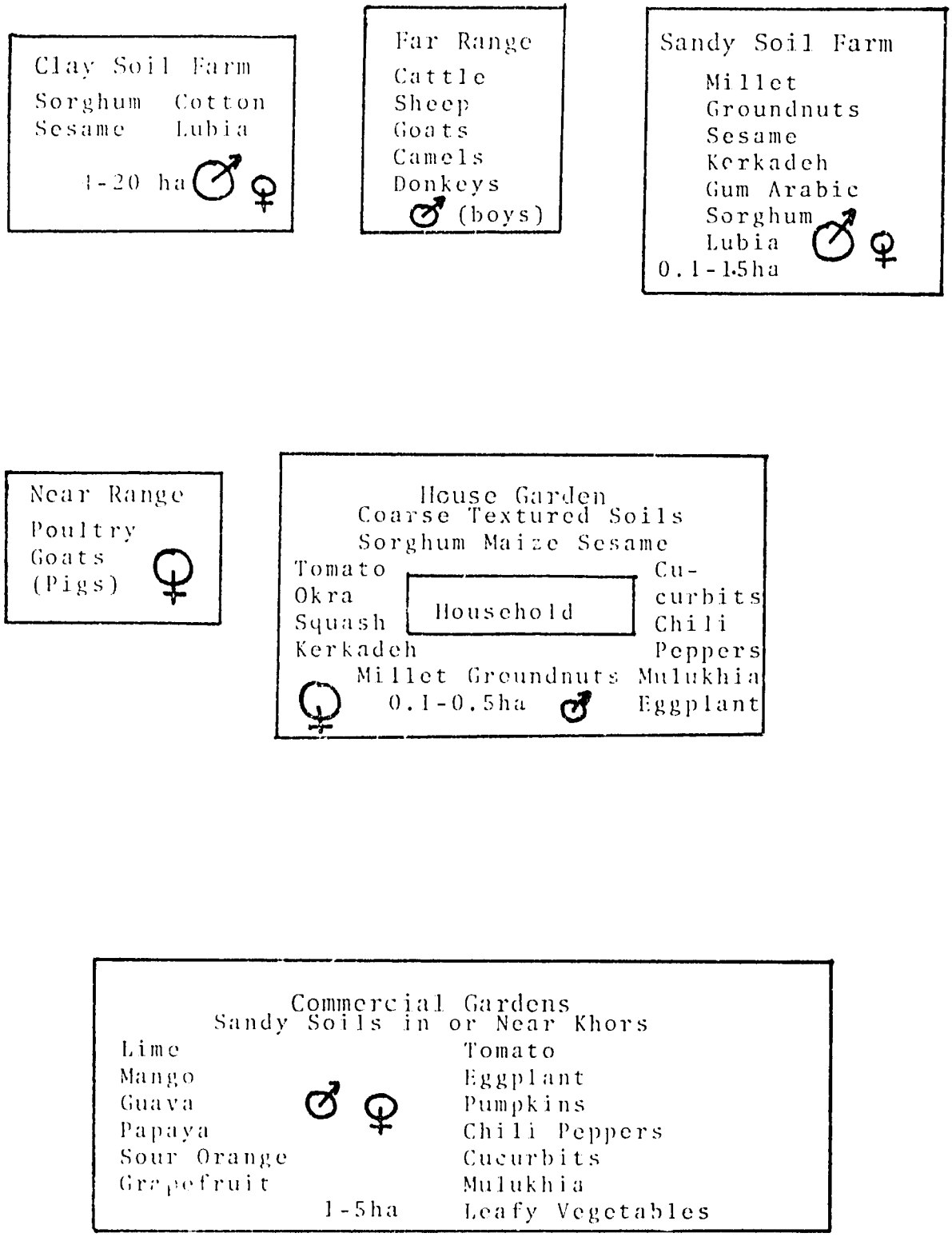
hamlets permits this extensive form of cultivation near the house and in more distant fields (see Figure 8 for a schematic rendering of production areas for typical groups in Western Sudan).

Livestock are raised on crop residues and bush areas of the range. Herds consists mainly of small stock such as goats and a few sheep, and a few head of cattle per household. Domestic fowl are kept, and, among non-Muslims, pigs are raised as scavengers.

The major large groups on southern lands consist of: (1) the more than 50 tribes of Nuba peoples in South Kordofan, each with a distinct language and set of customary practices that distinguish it from neighboring tribal groups; (2) the settled majority of the Baggara tribes, who live in Southern Kordofan and Darfur; and (3) other smaller tribal groupings such as the Daju, the Fellata, the Umborgo, etc., who are scattered across the higher rainfall zones of Western Sudan, and often practice small-scale irrigated gardening where permanent water sources are found.

Figure 8

STYLIZED INDICATION OF AGRICULTURAL PRODUCTION AREAS AND ACTIVITIES BY MEMBERS OF SEDENTARY HOUSEHOLDS IN WESTERN SUDAN



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.

Clustered Communities

In the central areas of Western Sudan, mainly in North Kordofan and across Darfur, are farmers who cultivate the stabilized sands, knows as qoz soils as well as clays. These groups exhibit a distinct settlement and cultivation pattern. They tend to live in clustered villages of straw huts accessible to water points. Villages are surrounded by cultivated areas in which millet, early maturing sesame, and peanuts dominate as intermixed or pure stands. Watermelons are also grown as a source of fruit, water and oil seed. After several seasons of cropping, farms are put into fallow.

Many of the sedentary farmers on the sandy soils in the Northern Provinces incorporate production of Acacia senegal, Gum Arabic, into their long term crop rotations. A typical planting sequence on a given plot found in N. Kordofan is as follows:

Years	
1-4	Field Crop Production (Millet, Groundnuts, Sesame)
5	Acacia senegal seedlings sown
8-10	Gum Arabic harvest begun

Years	
11-13	Level of Gum production drops. A. senegal trees cut and used for building poles or making charcoal.
12-14	Field crops planted. Tree coppice cut annually for fencing.
16-18	A. senegal coppice allowed to grow
19-23	Gum harvest begins again

The gum from Acacia senegal does not flow naturally. The bark of the limbs must be sliced (tapped) once or twice a year to elicit gum production. Gum globules forming along the wounds are collected when their surface hardens. Annual gum yield increases with tapping intensity, but excessive cutting may shorten tree life. Thus, gum garden owners aim for moderate annual production over a number of years. Consequently, they prefer to tap the trees themselves. The male members of the owners household usually tap the trees and the women collect the gum. However, men may be hired to help harvest larger plantings.

Another gum generating tree of lesser importance to national gum production, Acacia seyal, grows most profusely on cracking clay soils found primarily in southern Kordofan. Gum that oozes out of natural wounds caused by browsing animals or grass range fires is collected by migrating pastoralists, or consumed by their goats and camels. Tree life is shortened by infestation of cracks by termites and bark beetles as well as the damage caused by foraging camels.

Livestock are raised on a small scale by sedentary farmers.

Herds consist mainly of goats, sheep and a few cattle, with donkeys as the main beast of burden. Horses are also raised and domestic fowl are kept in the villages.

The target groups of clustered village farmers include a wide range of ethnic types and tribal factions spread across the southern tier of the northern provinces, including the Bediriya Messibat, Fur, various Arabs and others. In addition there is localized oasis farming of irrigated vegetable crops in specific zones of the northern provinces and southern provinces where sub-surface water is easily available, such as the Bara region.

Traditional farmer households may be differentiated regardless of tribal affiliation by access to infrastructural resources, such as market towns, roads, and mechanized farming operations. Where these resources are available (in less isolated areas) traditional farmers are more deeply involved in the cash-crop economy of Western Sudan. They plant additional acreage of specific cash-crops such as cotton and sesame as well as increased amount of land in surplus food grains to be sold at market. Farm size varies from 1-4 hectares among the majority of small farmer households (mainly subsistence hoe-cultivators) to 10-20 or more hectares among market oriented farmers. In some areas, larger farmers benefit from participating in tractor cultivation on mechanized farming areas for part of their crop income.

The typical settled farm household consists of an elementary

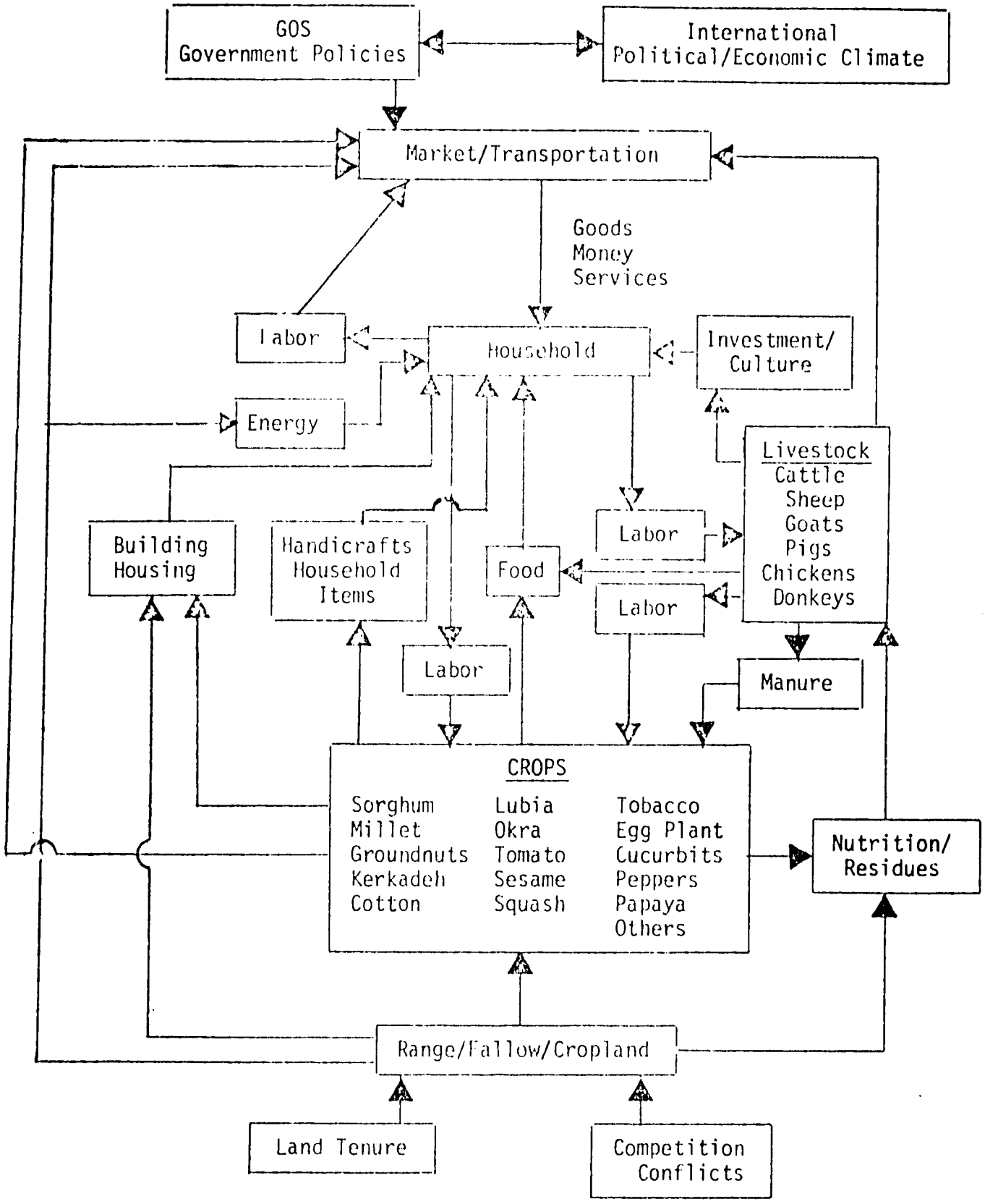
family unit, or a compound family with more than one wife, under management of a male household head. Farm labor is derived mainly from adult members of the household, while adolescent boys perform most of the livestock herding. Girls carry domestic water, collect firewood, and gather wild vegetables and fruits. Men and women perform the bulk of the farm tasks. Men market the major crops, while women sell minor crops. (see Figure 9 for schematic of sedentary production system).

The developmental cycle of the domestic group varies according to customary tribal and religious rules. Among Islamic groups, which cover the northern provinces, land use and animal holdings are concentrated under male management. Land is primarily passed from father to sons in equal shares. Society is highly stratified and land tenure is well defined in northern provinces. Hence, entrepreneurship and wealth make important differences within village society and between villagers and urban traders. Arable land is bought, sold and rented as it is relatively scarce.

In the southern provinces where farm groups are more isolated and land is relatively abundant, there are wider variations in customary forms of inheritance. Land is held mainly through usufructory rights and is not usually purchased or rented. Patrilineal groups are in the majority in the southern provinces with land-use rights passing from father to son.

Figure 9.

SCHEMATIC REPRESENTATION OF SEDENTARY PRODUCTION SYSTEMS IN WESTERN SUDAN



However, several Nuba tribes in South Kordofan have primarily matrilineal or double-descent systems of inheritance such that a man inherits land from his mother's brother. Their households are often organized to include a man, his wives and his sister's sons rather than his own children.

Among the settled farmers of Western Sudan, there is a strong tendency for male wage-labor migration to the Nile region during the dry season. Some men return to their homes to cultivate during the rainy season. Others send home money to their families.

Wage labor on traditional small farms has also increased, but remains limited due to labor shortages and lack of operating capital. Larger farmers, especially in the northern provinces regularly hire seasonal laborers. The practice of communal work parties within communities (nafirs) represents the main form of supplementary labor during peak cropping activities such as land clearing, weeding and harvesting. This labor exchange tends to even out the level of production among neighbors. Work is performed in return for food and drink supplied by the sponsoring household. Communal work parties are more frequent in the southern provinces.

Certain persons are customarily exempted from farmwork depending on the ethnic group. Among Nuba communities young men herd cattle and engage in physical culture training and wrestling matches. Among some Arab groups younger women and

and girls are often limited to house chores as it is considered shameful for them to work in the fields. Today many youths attend school or join the military and are excused from farmwork most of the year. Human health problems reach a seasonal peak during the rainy season "hunger months" due to combination of insect and water-borne infectious diseases and malnutrition. As this is the critical period of farm labor demand, sickness and hunger limit labor productivity in traditional farming.

PRODUCTION CONSTRAINTS

PRODUCTION CONSTRAINTS

The ten most important constraints to agricultural production in Western Sudan are briefly described in this section. Studies by WSARP and others have led us to conclude that these constraints are generally applicable throughout Western Sudan in varying degrees and emphasis as they originate from basically the same eco-system. By taking the holistic approach we seek to identify the principles governing the improvement of agricultural productivity in the region in order that results from one part of the system can more readily adapted to another. It should be noted that despite these imposing constraints, the farmers and pastoralists of Western Sudan have achieved remarkable levels of productivity. It is our intent to help them contribute even more to the agricultural wealth of Sudan and improve their own quality of life.

The relative importance of constraints and associated research priorities varies from one location to another. Therefore, the constraints, as listed here, are not given in order of priority. Specific production constraints and research priorities are addressed in the accompanying volumes in conjunction with the detailed presentation of each station's research plans.

Inadequate Water Availability, Conservation and Management

Water is the single most important resource limiting agricultural productivity and human settlements in Western Sudan, but little has been done to conserve it or to increase the efficiency with which it is used. Transhumant movement and crop production are governed by the time of advance and retreat of the rainfront and the length of the rainy season. The hand tools employed do not sufficienty open the soil for adequate water penetration. The shallowly planted seeds may be caused to germinate prematurely by isolated early showers prior to the true onset of the rainy season. Seedlings may die or have stunted growth resulting in crop failure or poor stand if not replanted.

Erratic, intense rainfall causes a disparity in planting dates and highly variable plant growth over short distances. Low areas on clay soils are often flooded for long periods during the rainy season which either delays land preparation or waterlogs existing crops.

Frequent periods or years of drought lead to overcrowding of watering points by migratory and sedentary herds thus exacerbating inter-group conflicts and facilitating the multiplication of pest populations and the spread of diseases.

Environmental Degradation Due to Poor Land-Use Practices

Poor range management and agronomic practices in Western Sudan deteriorate the environment and seriously undermine the agricultural potential and economic stability of the region. Soil erosion is hastened by removal of natural vegetation, frequent cultivation and later abandonment of large tracts of land for mechanized farming. Widespread overgrazing in the arid rangelands of the north; expansion of cultivation into marginal lands; range burning, and tree cutting for construction and fuel accelerate the degradation of this fragile environment.

The productivity of the wetter southern ranges suffers primarily from extensive burning and underutilization rather than overgrazing. Herds migrate away from wetter regions in the rainy season leaving highly nutritious grasses ungrazed. When livestock return at the start of the dry season, the grasses already have lost much of their nutritive value. The frequent range burning adversely affects the structure and composition of the vegetation by replacing desirable species with coarse, unpalatable ones and leaves the soil highly susceptible to erosion and dessication. Another factor contributing to environmental degradation is the poor integration of crop and livestock production.

Low Soil Fertility

Continuous cropping over the years without additions of fertilizer or manure or the inclusion of legumes in any systematic crop rotation has depleted the soils of nitrogen and other essential nutrients. Traditionally, land is cropped for several years until yields become so low that cropping is no longer profitable. The land is then left fallow for a number of years to restore its fertility.

The magnitude of the problem posed by low soil fertility on clay and sandy soils remains to be defined in detail. Hunting Technical Services has suggested the low soil fertility is a more important problem on sandy than clay soils.

Most of the soils in the WSARP area are subject to moderate to severe erosion during the rainy season. Some soils, particularly in the north, are subject to wind erosion. In general, no conservation practices are followed to reduce loss of top soil or to increase water penetration into the root zone.

Inadequate Infrastructure

The rural infrastructure of Western Sudan is not adequately established to encourage or maintain increased agricultural development. Agricultural research has been minimal and agricultural extension of limited effectiveness. Problems exist with roads and transport, communications, markets, supplies of agricultural inputs including credit and land tenure systems. There are less than 200 kms. of all weather roads between urban centers in Western Sudan. Clay soils in the rainy season are impassable barriers to vehicular movement, isolating many areas from markets and services for five to six months a year. The inheritance of usufructory rights to farming plots awards rights to use rather than full ownership. The "user" faces uncertainties with regard to continued control of the users land, hence is less willing to invest labor or capital in improving the land or in conserving its resources.

Poor Agronomic Practices

The farmers of Western Sudan have learned to survive in an adverse environment with little or no infrastructure. Crops produced year after year on fields with limited rainfall are given almost no inputs except the farmers' labor. The simple tools available to traditional farmers for land preparation do little more than scratch the soil surface, leading to poor plant stand establishment. Wide plant spacing favors weed growth, the control of which is the most labor intensive agronomic activity on the rainfed lands of Western Sudan. Labor constraints can lead to improper timing of planting, cultivation and harvesting which keep yield levels low. Continuous cropping of fields with the same crops lowers soil fertility and leads to a buildup of crop specific insect pests, diseases and parasitic weeds. Long fallowing periods to "rest" the land enable weed species to regain or surpass their former prominence. Continuous crop rotations to maintain soil fertility and reduce weed infestation are not practiced. Many grasses which grow wild in South Kordofan are related to sorghum and can act as hosts for striga, thus maintaining the population of this harmful parasitic weed during the periods of fallow.

Poor Genetic Stock - Crops and Livestock

The plant cultivars and livestock breeds in Western Sudan are of local origin or lines introduced several decades ago. They generally are well suited to the local environmental conditions and possess some valuable characteristics, but are low in productivity. Although the area is rich in genetic resources, seed production and distribution facilities are absent to multiply promising selections or introduced improved lines. Seeds for the next season, collected by farmers from the previous seasons' crops and stored in their homes until planting time, are subject to damage by storage pests and reduced viability resulting in low germination rates and stands. For livestock, poor culling and selective breeding programs and the unavailability of improved sires have limited potential livestock productivity.

Conflicts Among Target Groups

Disputes occur in Western Sudan between transhumant camps and sedentary communities over crop destruction by livestock or competition for permanent water sources. Members of sedentary communities burn range and crop residues in the early part of the dry season to ward off transhumant and nomadic herds. Recurrent range wars over land tenure occur, resulting in loss of human life, crops and livestock. Voluntary formation of associations that might raise crop, range, and livestock productivity is often precluded by differing tribal and religious customs. Mechanized farming schemes displace traditional farmers (using hand tools) to less desirable agronomic land. The large land tracts of the production schemes often cut across traditional migratory routes of transhumants creating additional conflicts between sedentary farmers and pastoralists.

Crop Pests and Diseases

Striga (Striga hermanthica) is the single most serious pest limiting crop production in Western Sudan. It parasitizes the roots of sorghum and millet, lowering yields. It becomes worse with each year of continuous cropping until yield levels are so low that the land must be abandoned. Resistant varieties, systematic crop rotations and other appropriate cultural management practices which might help control striga are presently absent on traditional farms. Covered smut, stem borers and several leaf diseases also cause a reduction in sorghum yields. Millet is attacked by the insect pests Cyrtocamenta beetle and Eublemma brachygonia during the reproductive stage. Long Smut and Downy Mildew form on millet heads and cause yield loss. Flea beetles, bollworms, bacterial blight and black arm disease are the most serious pests of cotton production.

Large flocks of Quelea (Quelea quelea), weaver birds, often numbering in the hundreds and occasionally reaching several thousand can devastate a sorghum or millet crop in the grain filling stage in a few hours. Traditional varieties resistant to bird damage have low yield potentials. Stored-grain pests, especially weevils, take their toll of stocks of sorghum or cowpeas stored in households or market warehouses. Termites and ants often remove seeds before they germinate and attack senescing roots or stems, but the magnitude of the crop loss they cause has not been assessed.

Labor Constraints

In the hoe-cultivation and herding societies of Western Sudan there are several basic labor constraints limiting productivity. The number of able-bodied household members is often insufficient to manage and perform the physical labor needed for peak-season demands, i.e., clearing, weeding, harvesting, herding livestock away from planted fields, etc. In the dry season there is a dearth of household labor to water cattle. Opportunities for wage-labor on mechanized farms and urban areas attracts workers away from traditional farming during the cropping season and makes it difficult for small farmers to recruit and pay hired farm laborers and for transhumants to find and retain herd boys. Certain age/sex groups (adult women among transhumants and adolescents among some sedentary farmers) are excluded from most farming or herding activities. Disease, hunger, and other factors such as pregnancy and lactation also limit the productivity of transhumants and sedentary people at critical moments in the production cycle in a variety of ways.

RESEARCH PROGRAM

A large amount of planning has been carried out by WSARP prior to the preparation of this document. These planning efforts have addressed a number of subjects including organization structure, construction program, staffing, budget, research and others. Participating in these planning activities have been staff from WSARP, Consultants, ARC, USAID, World Bank, various GOS Ministries, and other projects. For a description of the previous research planning activities, the reader is referred to the following documents:

a. Initial Survey Report
b. Initial Scope of Work
c. Work Plan 1982-1985
d. Consultant Reports
e. Annual Reports
f. Horticulture Report
g. Range Report by T. Bunderson
h. Anthropology Report by F. Araujo

The Research Program at each station is summarized briefly in this section. An indication of the relative research emphasis at the WSARP stations in relation to the 10 major production constraints in Western Sudan is given in Table 3.

TABLE 3 RELATIVE RESEARCH EMPHASIS AT WSARP RESEARCH STATIONS IN RELATION TO MAJOR PRODUCTION CONSTRAINTS IN WESTERN SUDAN

CONSTRAINTS	WSARP RESEARCH STATION PROGRAM EMPHASIS			
	KORDOFAN REGION		DARFUR REGION	
	KADUGLI	EL OBEID	GHAZALA GAWAZET	EL FASHER
Environmental Degradation	x	x	x	x
Low Soil Fertility	x	x	x	x
Inadequate Infrastructure	x	x	x	
Poor Agronomic Practices	x	x	x	
Poor Livestock Health and Nutrition	x		x	x
Poor Genetic Stock Crops and Livestock	x		x	
Inadequate Water Availability and Management		x		x
Conflicts In and Between Target Groups	x		x	
Crop Pests and Diseases	x	x		
Labor Constraints		x		

Sources : Kadugli Work Plan
Reeves & Frankenberger Report No. 2
El Obeid Work Plan

KADUGLI

Poor Livestock Health and Nutrition

Poor livestock health and nutrition are interrelated factors limiting livestock productivity in Western Sudan. The seasonal incidence of livestock pests and disease likely limit the utilization of southern grazing areas by the migratory herds, and present the sedentary animals with decreased productivity resulting from high neonatal losses, decreased milk production, poor weight gains, low fecundity, and extended conception intervals. Little definitive information exists concerning specific etiologies; however, rinderpest, anthrax, haemorrhagic septicemia, black quarter, and contageous bovine pleuropneumonia are endemic in the region. In addition, tick and fly infestations are a considerable problem during the rainy season, with trypanosomiasis, babesiosis, anaplasmosis, theileriosis, heartwater and Rift Valley Fever potential problematic diseases. Most insidious are the sub-clinical disease problems, which, contracted during the rainy season, become manifest during the latter stages of the dry season due to the concomitant stress of poor nutrition resulting from the unavailability of good quality forage. The rapid depletion of nutrients in uncut forage during the dry season is not appreciated by local animal producers with the result that no effort is made to preserve natural range grasses for later consumption as hay. The limited availability of soil phosphorus leads to low concentrations of phosphorus in forage and phosphorus deficiency in grazing animals. Other mineral deficiencies, of a more subtle clinical nature, likely occur due to either their low availability or low concentration in the soil and forage.

KADUGLI

Previous Research and Studies

Agricultural research was initiated in the Nuba Mountains in 1935 when the Agricultural Research Corporation opened the Kadugli Research Station. Research was focussed primarily on cotton varietal improvement, but, numerous cultivars of sorghum, sesame, maize, sunflowers, guar, soybean and groundnuts have been evaluated over the years. Several collections of indigenous Sorghum spp. have been made by the ARC, ICRISAT and others.

The Nuba Mountains Cotton Corporation established in the early 50's and reorganized in 1967 to the Nuba Mountains Agricultural Production Corporation, NMAPC, has gathered considerable experience and information on mechanized production of cotton, sorghum and sesame on the cracking clay soils.

The Federal Republic of Germany, via the GTZ, is currently assisting the NMAPC to develop improved cultural practices. The French technical assistance agency, SATEC, is evaluating the feasibility of introducing animal traction into the area. Hunting Technical Services, HTS, has written and compiled the most extensive collection of technical information in the area as well as preparing a detailed Rural Development Plan. UNICEF is drilling wells and reclaiming hafirs to increase the availability of domestic water. Various national and regional surveys such as that made by Resource Management and Research Ltd., have included the South Kordofan and Nuba Mountains region.

KADUGLI

WSARP Studies and Reports

Initial studies by WSARP staff and consultants in S. Kordofan have focused on indigenous farming systems, range evaluation, horticultural crop potential and varietal trials of sorghum, millet, soybean in collaboration with ICRISAT, INTSORMIL, INTSOY, IITA and AVRDC. The results of these studies are contained in the following reports:

Henson, J.B. and J. Noel 1981 WSARP Annual Report (1979-1980).

Henson, J.B. and J. Noel 1982 WSARP Annual Report (Aug. 1980-Aug. 1981) WSARP Publication No. 1.

Araujo, F.P. 1982 Social Perspectives on Agricultural Research and Development in S. Kordofan, Sudan: Systems of Agricultural Production among the Nuba. WSARP Publ. No. 2.

Bunderson, W.T. 1982 Annual Report of Range Research Activities WSARP Publ. No. 3.

Riley, J.J. et al 1982 Horticultural Resources of the Kordofan Region of Sudan. WSARP Publ. No. 4 (in press).

Dwyer, D.D. 1980 Range Management in Sudan. Report of Visit to Sudan Oct. 20-Nov. 10, 1979. Utah St. Univ. Logan, Utah USA.

El Amin, El Tighani Mirghani 1981 A Background Report on South Kordofan, WSARP, Khartoum, Sudan.

Kenani, Mukhtar et al 1980-82 Kadugli Station Crop Research Reports.

Saad, Zakaria Abdalla 1980 Forest Resources of South Kordofan Province. IN: The use of Homegrown Timber in Buildings Symposium 6-8 Feb. 1979, Khartoum, Sudan.

Wilson, R.T. 1981 Consultants Report on a visit to WSARP, Southern Kordofan, 25 Feb. - 3 March, 1981, ILCA, Bamako, Mali.

Dwyer, D.D. 1982. Range Research at the Kadugli Station, Review and Recommendations WSARP Consultants Report based on visit 26 Oct.-16 Nov. 1981.

KADUGLI

Kadugli Station Research Program

The Kadugli Research Station staff has prepared a detailed work plan for the period of October 1, 1982 through February 29, 1984. This work plan, which contains all current research proposals, has been prepared as a separate document. It is anticipated that following this initial effort work plans will be developed on an annual basis.

A production systems approach will be utilized to address the production constraints and problems of the sedentary, transhumant and nomadic people of South Kordofan. Initial emphasis will focus on the central districts during the first year or two. Preliminary investigations of the western and eastern districts will begin in 1983. The narrower focus, during early years, is made necessary by limitations of staff, vehicles and research supplies and equipment, as well as the remoteness of the western and eastern areas of South Kordofan.

The research program at Kadugli will be consistent with the 10 production constraints given in the previous section. However, due to the uniqueness of the resource base, agricultural production systems and people in South Kordofan, these constraints have been listed slightly differently, as follows:

1. Low soil fertility
2. Poor animal health and nutrition
3. Inefficient land and water use management and cultural practices
4. Poor genetic stock
5. Inadequate infrastructure
6. Conflicts among target groups
7. Labor constraints
8. Crop pests and diseases

A major effort will be made to identify grain and forage legumes which can be utilized in rotation, to maintain or to increase the nitrogen fertility of soils in the Nuba Mountain region. The goal of this effort is to reduce or to eliminate bush fallow, maintain crop productivity levels, allow more land to be cultivated, and provide a leguminous forage for livestock during the dry season. The effect of nitrogen and phosphorus deficiencies on the productivity of other crops will be examined in collaboration with GTZ.

Crop screening trials will continue in association with IITA INTSOY, AVRDC, INTSORMIL and other international research groups. The purpose of these trials is to identify varieties that produce satisfactory yields under present cultural practices and to identify varieties that are economically responsive to increased fertility levels and improved management practices. Studies will be conducted to determine economic losses associated with weed competition, and optimum crop population studies will be undertaken in collaboration with the SATEC animal traction project.

Continual observations both formal and informal will keep the research staff apprised of the constraints, problems and progress of the sedentary, transhumant and nomadic agriculturalists in South Kordofan.

In 1982 sedentary production system survey will be conducted to assess existing cultural practices. On-farm trials will be conducted as soon as techniques have been sufficiently evaluated to indicate there is a relatively high probability of success. It is believed that several of the above mentioned interventions, i.e., timing and frequency of weeding; higher yielding varieties of sorghum, sesame and soybeans; and forage legume species, may be ready for on-farm testing in 1983.

A study of the actual conditions of transhumant herding will address the human factors involved in improving range and livestock management. A range resource evaluation study is nearing completion. Information derived from these studies will facilitate on-range/in-herd trials concerned with improved grazing practices and supplemental livestock feeding. This study should demonstrate the feasibility of feeding properly harvested and preserved forage to improve livestock nutrition and to reduce grazing pressures. The burning of crop and range land is considered a serious constraint to both crop and livestock production. A study will be conducted to determine the reasons for and the effects of burning, and to identify measures which could mitigate the problem. A one-year diagnostic study will be made to identify the seasonality of pest and disease problems in livestock in South Kordofan. Two sentinel herds of

cattle have been purchased for intensive study; one confined year-round to the Kadugli Research Farm, and the other migrating with a transhumant camp. In subsequent years disease and insect control measures will be evaluated.

WSARP will initiate an agricultural market study in collaboration with USAID in late 1982. Both quantitative and qualitative data will be collected, aimed at improving information provided to farmers and herders and to improve the utilization of markets and agricultural incomes. Other studies of the transport, credit and input marketing systems are planned. A Pilot village study is planned for 1984 in which all known improved interventions can be tested in a village environment. This will be a coordinated effort between the WSARP scientists and the Agricultural Extension Service, with assistance from the Soil Survey Department, Range Department, Crop Protection Service, and Veterinary Service. It is anticipated that significant increases in productivity will accrue, but that the most important output will be a demonstration of the positive effects to be generated when the various departments and services of the Ministry of Agriculture work together toward a common goal.

EL OBEID

Gum Research in Sudan

Organization History

Gum Arabic was the principal export from Sudan from the turn of the century until 1920 when cotton took over the lead. It reached the peak of its importance in 1912 when it constituted 43% of total export value. In 1924 the government official gum markets were organized where gum was sold by auction under government supervision. 1932 witnessed the passing of Forest ordinance in which the responsibility of gum production was assigned to the provincial governors. Between 1911 and 1926 Forestry staff was seconded to Kordofan province to induce gum producers to improve stocking of gum gardens by sowing of seed. District commissioners assisted by tribal chiefs were responsible for fire protection of the gum area.

In 1957 the post of Gum Research Officer was created to look into problems of production and utilization of Gum Arabic. Research was divided into two main areas:

1. The chemistry of gum with view of finding further uses for the product and thus increasing demand.
2. All aspects of gum production in the field.

It was decided that the first topic would be best carried out at some European or American University, while the second subject was to be achieved by conducting experiments on gum trees established in foresty reserves.

An extension component was added to the research program

whereby improved seed planting techniques and tapping hand tools were disseminated free of charge to the farmers.

Accomplishments

Silvicultural and ecological investigations were carried out in a number of places within the gum belt of Sudan. Seed collection and handling techniques were developed for Acacia senegal trees. Nursery techniques, including containerized planting and soil block seedling production were developed. Major emphasis was given to improving gum yield per tree by identifying high producing trees. Open pollinated seed from reputedly high yielding maternal trees were collected and propagated in Demokeya Forest Reserve in order to find out whether their progeny were appreciably higher yielding than normal. Because of the length of time required for the completion of the Acacia senegal reproductory cycle, 20 years, results are slow in coming. The use of hormones to stimulate the gum exudation rate was attempted but without much success. Gum samples were sent to European universities for chemical analysis. A good working relationship has been maintained with Edinburgh University and some French institutes engaged in gum research.

Current Research Program

Currently gum research is being conducted in a number of areas which can be summarized as follows:

1. Biotic, climatic and edaphic factors affecting gum production;

2. Genetic research with cutting and grafting techniques;
3. Selection for high yielding ability;
4. Correlation between seed yield and gum yield;
5. Effect of age and tapping intensity on gum exudation;
6. Regional differences in A. senegal growth and yield;
7. Nursery trials to improve seedling production;
8. Behavior of gum arabic in storage;

1981-1982 Results

Initial efforts to vegetatively propagate A. senegal via root cuttings were not successful. Studies will be continued as seed propagation is sometimes thwarted by weevil damage or environmental factors.

Annual gum production of A. senegal was found to be directly proportional to tapping intensity and inversely proportional to seed yield.

A nursery for propagating seedlings of Acacia senegal and other species was re-established and staffed under the WSARP. Over 18,000 A. senegal seedlings were produced and distributed to farmers as a part of a project to restock Sudan's gumbelt. Another 10,000 seedlings of 17 other tree species of import to the region were distributed to schools, research stations, farmers and other government sections (i.e., Forestry, Soil Conservation, etc.).

A national seed collection was made. The collected seeds will be planted and evaluated at several locations in Sudan.

A study on post harvest losses of Gum Arabic was initiated. Early observations indicate losses on the order of 1-2 grams/kilo/day are common.

Planting of Prosopis sp. to stem the southward sweeping tide of desertification in Sudan has been advocated. In some locations in other countries, Mesquite, a Prosopis sp., has become a noxious weed. Therefore, a trial was planted to evaluate the ability of A. senegal to compete with Prosopis spp. In another experiment, the natural regeneration ability of Prosopis chilensis is being evaluated on the desert fringe north of El Obeid.

Studies exploring the potential for economic production of frankincense (Boswellien papyrifera) in South Kordofan were begun. It was first introduced into the area in 1978 and seems to do well.

Windbreaks composed of several combinations of trees and tree spacing were planted. Once well established their affect on soil erosion, crop productivity and amelioration of the general environmental conditions will be measured. Additionally, the best combination of trees for forage, shelter, shade, fuelwood and building materials will be evaluated.

Silvicultural observations on exotic species with commercial timber potential planted in the Nuba Mountains and on Jebel Marra were continued. Entries include species of: Tectina grandis, Pinus, Eucalyptis, Khaya senegalinsis and Cupressus lusitanica.

Summary of INTSORMIL Program in N. Kordofan, Sudan

SOCIO-ECONOMIC CONSTRAINTS TO THE PRODUCTION, DISTRIBUTION AND CONSUMPTION OF MILLET, SORGHUM AND CASH CROPS IN NORTH KORDOFAN, SUDAN - REPORT NO. 1

E.B. REEVES AND T. FRANKENBERGER

EXECUTIVE SUMMARY

This preliminary report issued in November 1981 from the University of Kentucky International Sorghum and Millet (INTSORMIL) socioeconomic project in the el-Obeid region of Northern Kordofan, Sudan is a report of work in progress. The major findings of the project to date include the following:

- The farmers of this region are involved in a complex mixed subsistence/cash economy. They are producing primarily millet and sorghum for home consumption and sesame and groundnuts for sale. In addition, a variety of other wild and cultivated crops are also being consumed and/or sold by households.
- There is an integration of crop and livestock production among these farmers. Livestock such as camels, cattle, donkeys, goats, and sheep are an important aspect of household economy.
- Wage labor is also quite important with many families hiring workers for their own fields as well as selling their own labor to others. Seasonal migration to work in cities and on mechanized farming schemes is becoming increasingly prominent.
- Farmers have been quite innovative in searching for new economic opportunities and technological assistance. Sesame and groundnuts are increasingly being grown as cash crops, insecticides are widely used to control pests, and extraordinarily

diversified strategies are used to survive in an extremely harsh and risky environmental setting. Farmers recognize and attempt to manipulate the extraordinary diversity of the principal crops in order to maximize production and to reduce risk.

- Village merchants are an important link between farmers and the larger market system. Merchants provide credit and consumption goods, purchase agricultural products, and arrange transportation of goods to and from larger market centers.
- Water is the principal constraint. People often have to travel long distances and/or spend scarce cash resources to get access to water for their needs and the needs of livestock. Crop production depends on the vicissitudes of the rains.
- Given the harsh and risky environment, farmers frequently find it necessary to plant and re-plant their crops several times in order to ensure that their land resources are fully utilized. Early-maturing varieties of millet, sorghum and sesame are recognized and appreciated in situations when re-planting is necessary, but often farmers cannot secure sufficient quantities of seed of these varieties.
- The most important pests affecting millet and sorghum production are a beetle called santa (Cyrtocamenta spp.), the quelea birds, the larva of naffasha (Eublemma brachygonia), buda (striga), ants and termites, long smut, and downy mildew.

SOCIO-ECONOMIC CONSTRAINTS TO THE PRODUCTION, DISTRIBUTION AND CONSUMPTION OF SORGHUM, MILLET AND CASH CROPS IN NORTH KORDOFAN, SUDAN: A FARMING SYSTEMS APPROACH

REPORT NO. 2

E.B. REEVES AND T. FRANKENBERGER

EXECUTIVE SUMMARY

This research report of the University of Kentucky INTSORMIL (International Sorghum and Millet) Project issued November, 1982 is the second of two reports written during the course of field investigations carried out in the el-Obeid area of Sudan. Like its predesessor this is a report of work in progress. Succeeding reports will analyze larger data bases which may call for the modification of a few of the conclusions found in this manuscript.

The two principal soil types are associated with some differences in cropping patterns and livestock rearing. Both types of soil are characterized by low fertility. Fallowing is the principal means for restoring soil fertility. The natural propagation of Acacia senegal, allows farmers to gain an income from their fallow land through the collection of Gum Arabic.

The rural population is dispersed in villages that vary in size from five to six households to 1,000 or more. The population is greatest during the rainy, cropping season and

lowest during the dry season. The average household numbers between seven and eight members.

Agricultural production is typically in the hands of more than one decision-maker in a household. A common pattern is for husband and wife to manage separate farms. Unmarried sons and daughters who are old enough may also be given land to manage.

The average cultivated landholding of a household head is 18 makhammas (13 ha). Most farmers cultivate more than one-half of their total land holdings, indicating that there is insufficient fallowing. One-third of all cultivated lands are rented by better-off farmers from farmers who are poorer.

Thirty-eight per cent of the cultivated lands were found to be cultivated in millet, while 95 per cent of the households grew it. About three-quarters of the farmers grow some sorghum. Local varieties are frequently planted in the same hole with sesame. Forty-eight per cent of the cultivated land is planted in sesame, while 93% of the farmers grew sesame in their fields. Sesame is often intercropped with sorghum, cowpeas, watermelon or karkadee. Some farmers sow varieties of sesame which mature at different rates in order to avoid the labor bottlenecks. Since sesame is threshed by hand, it must have the characteristic of shattering easily. Ten per cent of the cultivated land was planted in groundnuts during the 1980-1981 season. Barbiton variety is grown exclusively and seed quality is said to be very poor. Price instability makes this a high-risk crop for farmers.

Besides these four major crops, a variety of lesser-important crops are grown. Roselle is usually sold for cash or traded in kind. Cowpeas and okra are intended for domestic consumption but may also be sold or traded. Watermelon is grown as a water source and fodder for livestock during the dry season. It is also consumed domestically and sold in local markets. These minor crops are frequently interplanted with sesame and sorghum.

The cropping cycle begins in the period of January to Arpil with land clearing. Millet is planted earliest because the locally preferred variety is long-maturing. If the early plantings succeed, owing to an early arrival of the rains, the crop will mature before the season in which insects and birds usually attack the immature candles otherwise. Regular plantings of sesame, groundnuts and sorghum generally occur in June and early July. These crops, too, may have to be replanted if rains are insufficient for germination or if sandstorms kill the seedlings.

Poor farmers are forced by their need for cash, to hire their labor to other farmers and thereby neglect adequate weeding of their own fields. Harvesting operations are spread out over the period of late August to January, with most activity occurring in October and November. Returns to labor by crop was highest for millet, followed by groundnuts, sesame, and sorghum.

Animals play an important role in this farming system. The availability of drinking water, first, and pasture during the dry season, second, are the central-most constraints on livestock raising. Crop residues as well as commercial sorghum are an important source of fodder for working animals but herd animals subsist largely on the pasture that lies beyond the village's zone of cultivated lands. Most farm families own a donkey and several goats.

Nearly every farm household supplements its income through off-farm activities. The latter include dry-season migration for a wage, charcoal manufacture, water-hauling, tailoring, carpentry, metalworking, itinerant marketing, and the operation of such capital-intensive enterprises as village shops, bakeries, flour mills, oil presses, cisterns, and trucks. Monetary gifts from relatives living elsewhere is another important source of income for about one-fourth of the farm households.

Farming in this region is not subsistence-oriented. Farm households purchase foodstuffs at village shops each day, or several times per week at least. In the most prevalent marketing system a crop's price is determined in auction, after which the farmer's produce is weighed. The government prefers this procedure because the tax rate is precisely assessed. The other system relies on an estimation of the weight and price

of the crop according to a formula set by the district council. This procedure results in a lower tax estimation than the weighing and auction system, but it appears to be well suited to small, isolated markets where the extra incentive of reduced taxes encourages crop buyers to visit the market. The illegal conveyance of certain crops, particularly sesame, from the farm gate to crop buying agencies in el-Obeid without the full assessment of taxes - is believed to be a widespread practice.

Millet consumption is supplemented by the importation to the region of sorghum (feterita) grown principally on the mechanized farming schemes at Habila, South Kordofan. A typical farm family supports itself on its own millet for only about four months in the year. The rest of the time it buys Feterita sorghum.

The relation between nomad and farmer, who are frequently in conflict over access to forage and water, is complementary when it comes to livestock marketing.

SUMMARY OF WORK CONDUCTED
BY DR. TARKE BERHE, INTSORMIL AGRONOMIST

1982 CROPPING SEASON, EL OBEID, KORDOFAN REGION, SUDAN

OBJECTIVES:

1. Strengthen agronomic component of farming systems studies initiated by INTSORMIL anthropologists.
2. Evaluate potentially promising cultivars and cultural practices in trials on farmers' fields.
3. Compose local millet nursery by collecting land races of millet from farmers' fields from which entries can be selected for inclusion in rotation and inter-cropping trials.

ON-FARM TRIALS:

Trial I observation of performance of ARC released millet variety (UGANDI) on farmers' fields near El Obeid, North Kordofan, Sudan, 1982.

Entries:

1. UGANDI (Abu sul)- locally selected very early maturing variety from Uganda, which was released for use in Sudan by ARC in 1981.

2. BALADI (Kordofani) LOCAL CHECK late maturing variety.

3. HIREHREE early maturing introduction

Area: 1 fd/entry

Location: 3 villages near El Obeid

Inputs: Local cultural practices for rainfed millet production (i.e. no fertilizer or other inputs except labor and occasionally seed treatment)

Planting Date: on or around June 26, 1982 (before rains)

Result: No tabulated data available yet.

Observations:

1. Rainfall was exceptionally low. Many crops suffered from drought.
2. UGANDI matured 10-15 days earlier than HIREHREE, but, did not produce as many tillers.
3. Yield for all entries will be low due to the severe drought.
4. Farmers expressed preference for UGANDI for the following reasons:
    a. produces edible food grain sooner than other entries.
    b. less affected by insect pests like sinta.
    c. avoids late season drought by maturing early.
    d. resistant to long smut.
    e. less preferred by birds.
5. BALADI had better seedling establishment and plant vigor and a more rapid recovery following periods of drought than UGANDI.

Trial II observation of performance of promising ICRISAT millet variety (ICMS 7817) and ARC released millet variety (UGANDI) on farmers' fields near El Obeid, North Kordofan, Sudan, 1982

Entries:

1. ICMS 7817 - millet variety developed in India by ICRISAT found to be well adapted to conditions in Wad Medani.

2. UGANDI (Abu Sul) locally selected very early maturing variety originating in Uganda and released for use in Sudan by ARC in 1981.

3. BALADI (Kordofani) LOCAL CHECK late maturing variety.

Area: 500m^2/entry

Location: 4 villages near El Obeid

Planting date: About July 6, 1982 (after start of rains)

Results: No yield data due to drought.

Observations:

1. BALADI plant growth was superior to other entries.

2. Failure of late season rains to materialize prevented proper crop growth and development.

Trial III adaptability of Market Chickpeas to El Obeid production conditions.

Entry: Unknown chickpea variety from Northern Sudan brought to El Obeid for local consumption.

Area:

Location:

Inputs: local cultural practices

Treatments: 1. Date of Planting - early August and early September.
2. Seeding method.

Results: None to date.

WORK PLAN FOR INTSORMIL

AGRONOMIST - EL OBEID, SUDAN

1983-1984

GENERAL: INTSORMIL plans to station a highly - qualified millet/sorghum agronomist at El Obeid, Sudan beginning in the first quarter of 1983 to provide direct technical support to the WSARP/ARC and ICRISAT programs.

FINANCIAL SUPPORT: Direct expenses for salary, benefits, travel. housing and some local transportation will be provided by INTSORMIL from its dollar funds. Limited funds also will be available to support local research costs.

LOGISTICAL ASSISTANCE: WSARP/ARC will provide general program support, facilities for some in-region travel and transport to trials away from El Obeid to enhance the effectiveness of the project within the limit of their available physical and administrative resources.

PLAN OF WORK:

1. Continue in field seasons of 1983 and 1984 the millet evaluation and demonstration trials begun in 1982. Objective is to learn and demonstrate in farmer's fields which varieties of millet give best all-around agonomic performance.

2. Learn as much as possible about villagers' reaction to performance, storage quality and food uses of improved millet types.

3. Continue trials of chickpea cropping association in millet-sorghum system.

4. Initiate intercropping and sequential planting studies with legumes (peanuts and cowpeas) and cereals (millet and sorghum). Sesame will be included in some rotations.

5. Develop basis for integrated pest control studies on millet and sorghum.

6. Investigate practical cultural practices farmers might use to increase available soil moisture for crop production to lessen crop failure especially in years of low rainfall.

7. Collect, describe, evaluate and turn over to ARC, ICRISAT and INTSORMIL researchers farmers' varieties and wild types of pearl millet and sorghum.

8. In tiate fertilizer and sowing methods trials with pearl millet.

9. Identify topics requiring further research.

COORDINATION: In all activities, the agronomist will maintain close coordination with WSARP, ARC, ICRISAT and USAID/Khartoum.

REPORTING: Reports will be filed at least once every six months with INTSORMIL headquarters; copies will be provided to WSARP, ARC, ICRISAT/Sudan, and USAID/Khartoum.

SOCIOECONOMIC CONSTRAINTS TO THE PRODUCTION AND UTILIZATION OF SORGHUM AND MILLET WITH A FOCUS ON NORTHERN KORDOFAN

Phase 3: Reducing Constraints to the Adoption of Improved Technologies by Small Farmers and Herders

Introduction:

A baseline analysis of farming and marketing systems in North Kordofan which helped identify constraints and points of leverage for improving production and marketing was conducted in Phase I (Reeves and Frankenberger). The organization and conduct of agricultural research in the Sudan with a focus on research decisions processes was conducted in Phase II (Lacy and Busch). Phase III will be concerned with the development and improvement of linkages between the research, agricultural extension, and input marketing sub-systems and small farmers. The guiding assumption is that with the development of research programs and improved infrastructures in North Kordofan more effective communications with farmers and more efficient distribution of inputs and products also will be required. These developments will require studies of existing institutions as well as the development and evaluation of programs and policies of new agricultural research and development organizations.

Purposes:

1. To study the Kordofan Extension Service with a view to improving its effectiveness both with respect to farmer training and information dissemination and the effective linkage with experiment station and on-farm researchers.

2. To monitor change in farming and marketing systems and advise in the establishment of on-farm demonstration experiments.

3. To study the effectiveness of various public and private organizations, agencies, and businesses that distribute farm inputs with the respect to standards of quality and efficiency and recommend improvements.

Methodology:

The Department of Sociology, University of Kentucky, with the approval of the USAID/INTSORMIL project, proposes to place two social science researchers in the field for 4-6 months in 1983 to address issues outlined in the statement of purposes. Data will be collected primarily at El Obeid and Kadugli but it is expected that activities pursuant to the first purpose above would be carried out in various locations.

A detailed research design will be developed via visits with appropriate persons in AID, ARC, WSARP, and the Kordofan Regional Ministry of Agriculture.

STATION RESEARCH PROGRAM

EL OBEID

STATION RESEARCH PROGRAM

Current Research Projects

1. Identification and control of the most harmful biotic factors affecting growth and yield of Acacia senegal.

Nearly a dozen biotic factors are known to damage A. senegal. A survey will be conducted to determine their relative importance in decreasing the stand of Gum Arabic trees in N. Kordofan. Means of controlling the most serious factors limiting growth and gum production will be studied.

2. Propagation and production of useful trees in Western Sudan.

Previous studies have indicated that there are 6 gum producing tree species; 8 trees suitable for lumber production; 4 species of trees of agro-pastoral importance and 7 trees which produce fruits that are of nutritional or medicinal value. Methods for propagating these species will be developed and evaluated at several sites throughout the Kordofan. Emphasis will be given to species which can help slow desertification, provide feed for animals, protect crops from wind damage, or enrich soil fertility.

3. Environmental and agricultural influence of mixed species of forests.

Five species of trees (A. senegal, A. albida, A. mellifera, Prosopis chilensis and Maerua crassifolia) have been planted perpendicular to the prevailing wind direction in differing proportions on seven plots of 2fd each. When the trees have grown

sufficiently, the growth/yield of sesame, millet, groundnuts, sorghum and other crops will be measured in comparision to unprotected plots. The utilization of the trees as forage will also be evaluated.

4. Physiological studies on gum production and yield in A. senegal.

Data will be collected on Gum Arabic trees of various ages growing in the Demokeya Forestry Reserve, near El Obeid. Attempts will be made to relate gum production and flow to environmental factors and physiological processes. An understanding of these, will be of use in identifying high yielding genotypes.

5. Genetic improvement of Acacia senegal.

Conventional and unconventional means of breeding and/or propagating superior trees will be explored. Development of appropriate tissue culture methods should greatly accelerate widespread planting of high yielding trees.

6. Reduction of storage losses of Gum Arabic.

Studies will be conducted in cooperation with the Food Research Centre to identify storage conditions and /or containers that reduce gum weight loss during storage.

Future Research Plans

A more comprehensive research plan will be set forth when the new station is completed and staffed. It is anticipated that WSARP programs on preservation of the environment and conservation of water resources will emminate from El Obeid with some field activities in El Fasher and perhaps at other stations. The predominance of El Obeid as a marketing center for all Western Sudan and the importance of market transactions to all

agricultural production activities dictates that WSARP marketing studies will be centered in El Obeid. The exact nature of the economics studies will depend on the results of surveys conducted by Reeves and Frankenberger in 1981-1982 and USAID in 1982-1983.

The El Obeid station will become the major ARC station for millet breeding. It is anticipated that the millet improvement program along with the technical assistance from ICRISAT will be shifted to El Obeid at the earliest possible date. The efforts by INTSORMIL agronomist to improve on-farm crop and water management practices will be continued and expanded upon as the WSARP program develops.

It is expected that WSARP training activities will be based in El Obeid. Concomitantly it is anticipated that collaboration with the Extension Service will be the most extensive in El Obeid since it is the site of the Kordofan Regional Agricultural Ministry.

EL FASHER

EL FASHER

RESEARCH PROGRAM EMPHASIS

El Fasher will serve as a field station for research programs on water conservation and prevention of desert creep, based in El Obeid. Promising means of improving range and forestry conditions will be evaluated on the desert fringe. Collaboration with the Camel Research Institute, being established by the University of Khartoum, is envisioned. Improvement of husbandry practices and health status of camels, sheep and goats will be a major program objective. Cooperation with and strengthening of Regional Veterinary Services will be fostered as the Darfur Ministry of Agriculture has its headquarters in El Fasher.

GHAZALA GAWAZET

GHAZALA GAWAZET

Earlier Studies

Animal production and range research has been carried out in Ghazala Gawazet since the station's establishment in 1957. In addition various surveys and studies have been carried out by the GOS and their consultants. The results can be found in the offices of the Animal Production Division of the Ministry of Agriculture and Irrigation, the Western Savannah Development Corporation, Hunting Technical Services and Sir M. McDonald and Partners.

Agronomic studies were initiated in 1976 at the Umm Rakuba Development Farm, a year after its establishment by the Western Savannah Development Corporation. The farm is 60 km East of Ed Da'ein and approximately 75 km ESE of Ghazala Gawazet at a latitude of 11^0 19'N and longitude of 26^0 35'E. Over 50 trials have been conducted with major emphasis on groundnuts and millet, but, including also sesame, sorghum, cowpea and pigeon pea. Trials from 1976 through 1981 consisted primarily of identification of suitable varieties and cultural practices. Millet cropping systems were the subject of several 1982 trials which included: response to organic fertilization, intercropping with groundnuts or cowpea and an evaluation of several long term rotation schemes. Intercropping trials of other crops,(i.e. sorghum, groundnuts and sesame) and varietal trials of guar and forage legumes, also were scheduled at Umm Rakuba in 1982.

Ghazala Gawazet

Research Program Emphasis

The WSARP research program at Ghazala Gawazet will emphasize improvement of genetic stock by instituting breeding programs for cattle and groundnuts. Range evaluation studies will be conducted in cooperation with the Western Savannah Development Corporation. Observation of range regeneration and composition in response to several levels of controlled stocking rates by WSDC complement WSARP data collected in range exclosures established in S. Kordofan. Animal (primarily cattle) nutrition and husbandry will be studied with the aim of improving herd health and productivity. Conflicts between target groups are a major constraint to continuity of development programs. Consequently, social scientists will be directing their efforts toward identifying means of alleviating tensions through the introduction of potentially synergetic activities. WSARP agronomic studies will supplement those being conducted by WSDC at Umm Rakuba in developing crop cultural management practices that utilize water more efficiently and maintain soil fertility. Especial emphasis will be given to studying the role of Acacia albida and Acacia senegal in the agro-pastoral production systems.

RESEARCH SUPPORT

Central Research Support

In addition to the administration and the scientific research activities for Northern Kordofan, the following central research support facilities will be located at El Obeid: Analytical Laboratory, Training Program, Library and Information Services, Data Processing and Statistical Services and the Environmental Resources Evaluation Unit. The function of these are describe briefly in the succeeding paragraphs.

- Analytical Laboratory

The Analytical Laboratory will support the entire project in analyzing the composition of range plants, crops, soils and feed stuffs. In addition, the laboratory will establish and maintain a close liaison with the laboratories of the ARC, University of Khartoum, Ministry of Agriculture and other organizations and draw on their capabilities as needed. Initially, the lab will give more attention to soil and forage analyses. However, the scope of activities will be widened to meet the needs of the project. The fundamental facilities for broader activities will have to be installed at El Obeid initially, so that laboratory services may be expanded as required.

- Training Program

Facilities are being constructed at El Obeid to carry out in-service training by the project. In addition, the project will provide as appropriate, workshops, short-courses and other training endeavors to meet the needs of various disciplines and organizations within the project area. In

this regard, discussions have been held with the regional government in Kordofan concerning potential training of extension staff, management staff and others. The details of the training program will be developed by the training officer in conjunction with consulting experts. Training activities will call upon the scientific and support staff of the project and ARC to carry out in-service and external training.

- Library and Information Services

A library and basic facilities to reproduce reports and extension materials will be established at El Obeid to serve the entire project. Relevant journals have already been ordered and are arriving in Khartoum. Books have been and will continue to be ordered to build up the needed library resources for the project staff. In addition, during the life of the project, staff will have access to the world literature held by the international section of the Washington State University Library, which was specifically established to provide services to overseas projects.

The mechanisms for providing adequate information services to the WSARP stations remains to be defined. It is envisioned that publications will be circulated to the researchers at the stations for defined time periods via the project aircraft. In addition to serving the project per se the library and information services will also provide a regional resource

for other organizations and the regional governments.

- Data Processing and Statistical Services

Data storage and evaluation capabilities will be established as a project-wide service at headquarters. A biometrician will assist scientists in experimental design and data analyses. Appropriate computer and/or other capabilities will be provided for data storage and evaluation.

- Environmental Resources Evaluation Unit

The World Bank Staff Appraisal Report (June 6, 1978) indicates that a "Water and Land Use Management Program" will be established at project headquarters to address resource potentials and analysis, water management technology, socio-economics of water management, land use planning and solar energy.

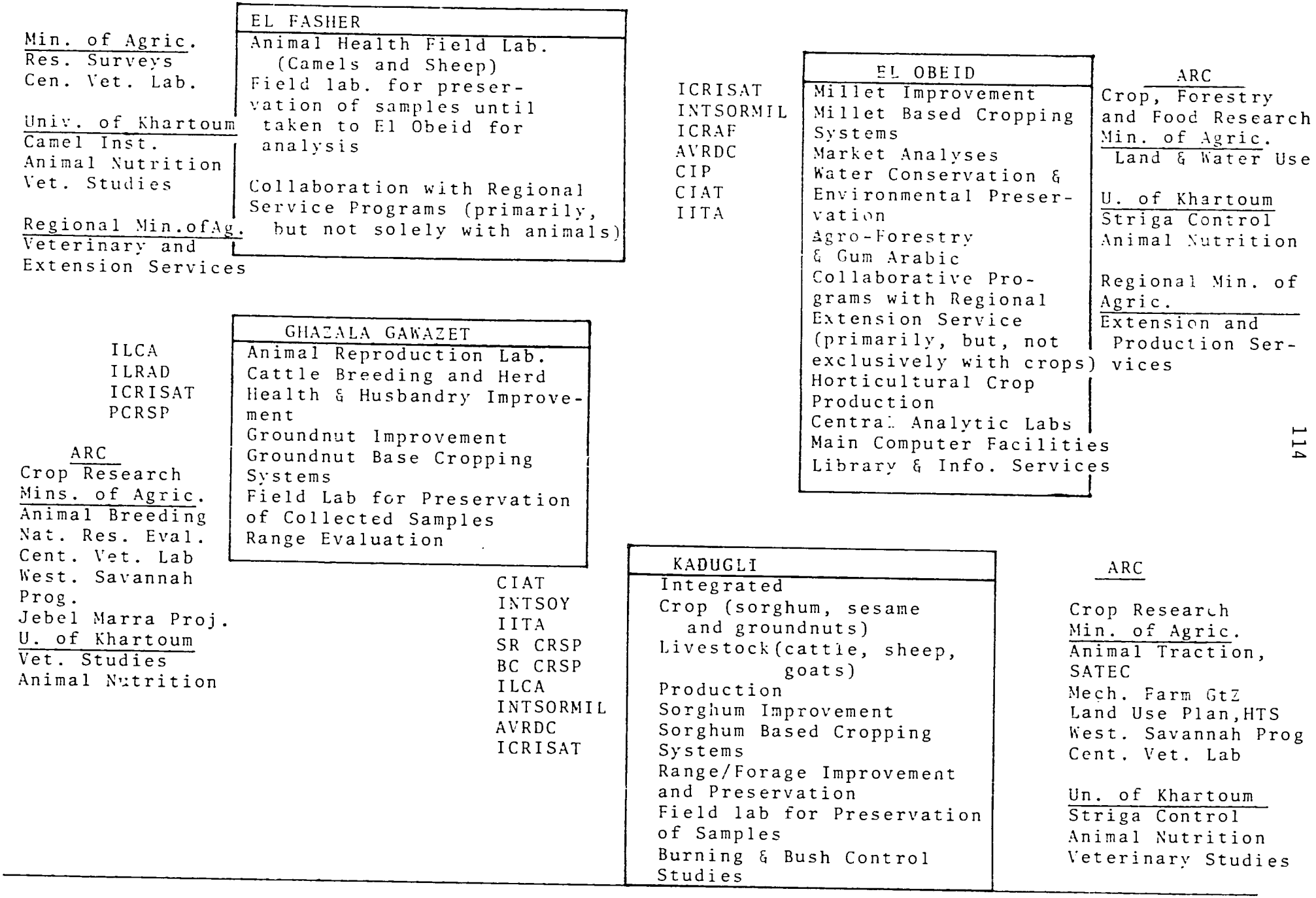
The project recognizes the importance of improved management of renewable resources, however, a question has arisen as to whether such activities are best centralized or carried out in association with the project activities at one or more stations. The matter is unresolved at present and needs to be discussed more fully before finalizing staffing plans.

General Research Support

In addition to the research support provided by El Obeid, each station must have adequate facilities and staff to support the planned research programs. Each station has certain elements of its program that are unique which require specialized facilities not duplicated at other stations within the project area. Some of the specific station related programs and facilities identified to date are given in Figure 10 along with an indication of potential local and international collaborators.

Figure 10

RELATIVE RESEARCH PROGRAM EMPHASIS AND FACILITIES WITH INDICATION OF MAJOR PRINICIPAL LOCAL AND INTERNATIONAL COLLABORATORS



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GLOSSARY OF ACRONYMS

ACRONYM	ORGANIZATION	HOME OFFICE LOCATION
ACSAD	ARAB CENTER FOR STUDIES IN ARID ZONES AND DRYLANDS	SYRIA
ARC	AGRICULTURAL RESEARCH CORPORATION	SUDAN
AVRDC	ASIAN VEGETABLE RESEARCH AND DEVELOPMENT CENTER	TAIWAN
B/C CRSP	BEAN/COWPEA COLLABORATIVE RESEARCH SUPPORT PROGRAM	USA
CIAT	CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL	COLOMBIA
CID	CONSORTIUM FOR INTERNATIONAL DEVELOPMENT	USA
CIMMYT	CENTRO INTERNACIONAL DE MEJORMIENTO DE MAIZ Y TRIGO	MEXICO
CIP	CENTRO INTERNACIONAL DE LA PAPA	PERU
GOS	GOVERNMENT OF SUDAN	SUDAN
GtZ	DEVELOPMENT ASSISTANCE AGENCY	W. GERMAN
HTS	HUNTING TECHNICAL SERVICES	UK
IBRD	INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT	USA
ICARDA	INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN DRY AREAS	SYRIA
ICRAF	INTERNATIONAL COUNCIL FOR RESEARCH ON AGRO-FORESTRY	KENYA
ICRISAT	INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS	INDIA
IITA	INTERNATIONAL INSTITUTE FOR TROPICAL AGRICULTURE	NIGERIA
ILCA	INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA	KENYA
ILRAD	INTERNATIONAL LABORATORY FOR RESEARCH ON ANIMAL DISEASES	KENYA
INTSORMIL	INTERNATIONAL SORGHUM AND MILLET PROGRAM(CRSP)	USA
MAFNR	MINISTRY OF AGRICULTURE, FOOD AND NATURAL RESOURCES	SUDAN
MOAI	MINISTRY OF AGRICULTURE AND IRRIGATION	SUDAN

ACRONYM	ORGANIZATION	HOME OFFICE LOCATION
NMAPC	NUBA MOUNTAINS AGRICULTURAL PRODUCTION CORPORATION	SUDAN
NMCC	NUBA MOUNTAIN COTTON CORPORATION	SUDAN
P CRSP	PEANUT COLLABORATIVE RESEARCH SUPPORT PROGRAM	USA
SATEC	SOCIETE D'AIDE TECHNIQUE ET DE COOPERATION	FRANCE
SM CRSP	SOIL MANAGEMENT COLLABORATIVE RESEARCH SUPPORT PROGRAM	USA
SR CRSP	SMALL RUMINANT COLLABORATIVE RESEARCH SUPPORT PROGRAM	USA
UNICEF	UNITED NATIONS INTERNATIONAL CHILDRENS EMERGENCY FUND	USA
USAID	UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT	USA
WSARP	WESTERN SUDAN AGRICULTURAL RESEARCH PROGRAM	SUDAN
WSDC	WESTERN SAVANNAH DEVELOPMENT CORPORATION	SUDAN