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AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

WORK PLAN

VOLUME IV

INITIAL RESEARCH PROPOSALS

KADUGLI RESEARCH STATION

WSARP PUBLICATION No. 18 1983

THE WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

is supported by

The Government of Sudan

The Agricultural Research Corporation

US Agency for International Development

The World Bank

The USAID portion of the project is being implemented by

The Consortium for International Development
Tucson, Arizona, USA

with

Washington State University, Pullman, Washington, USA

as the Lead University

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Khartoum, Sudan and Pullman, Washington, USA.

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KADUGLI RESEARCH STATION

WSARP/ARC

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FOREWARD

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.

Previous documentation was 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 a general description of research plans for the Kadugli station.

Volume IV contains initial research proposals prepared by the scientific and technical staff of the Kadugli Research Station. Detailed plans and proposals of other WSARP stations will be prepared as the stations come on line and scientists have an opportunity to examine constraints, priorities, etc., develop strategies, and draft research proposals. Not included is a work subplan for marketing research currently under preparation.

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 PROPOSAL

Identification:

Station: Kadugli

Expt. No. 1

Date of Proposal: June 20, 1983

Beginning Season for Research : Summer 1983

Subject of Research: Sedentary Farmers of Nuba Mtns. Area

Principal Researchers: Neil Patrick - Abu Sabah
Cooperating Entities: Agron., Soil and Water Section, Extension Department

Proposal:

Title: Adoption and Utilization of New Sorghum Production Technology by Farmers of the Nuba Mountains

Duration: 1 Year

Overall Objectives: To determine adoption rate and methods of utilizing a new technology in the production of sorghum. To provide a significant on-farm trial of this new technology. To test a method of extending a new technology.

Background and Brief Literature Review:

Informal reconnaissance surveys over the past two years have pointed out the widespread incidence of smut and soil insects among both sedentary and transhumant producers of sorghum. The more formal survey just completed of sedentary farmers in 14 villages in the Nuba Mountains area indicates a strong verification of these problems. Although just in the first stages of analysis, the collected data has been summarized to show that 71% of farmers interviewed indicate a significant problem with insects and 42% of these specifically indicate these problems consist of insects attacking the seed or newly germinated seedings. Similarly 74% indicate problems with disease and of

these, 88% indicate smut on dura. Low rainfall quantity or periods of drought were indicated as the major problem in the production of crops by 4[illegible]% of the respondents. It should be noted that the data summarized here were provided as answers to open-ended questions that were designed to solicit answers without suggesting answers. In group discussions with farmers in the 14 villages, farmers in 10 villages indicated a need for a short-season variety (farmers in one additional village (Faid El Garad) were already raising Gadem El Hamam and indicated that it was the only variety that gave a yield in 1982). It should be further noted that the 1982 cropping season was characterized by low and poorly distributed rainfall. The above answers were probably biased somewhat by this most recent experience.

Farming Systems literature indicates that one of the guiding principles involves activation of interventions as rapidly as possible in accordance with proper scientific investigative procedures. The on-station research; on-farm, researcher managed trials; on-farm, farmer managed trials; and extension phase continuum should be entered according to the probability of success and degree of confidence in a given intervention.

The dura variety, Gadem El Hamam is recommended by the author for use in this experiment. It was developed for use on mechanized schemes and has found high levels of utilization there. It is white grained, medium grain size, 90-95 day maturity and the plant is uniformly about 1½ meters in height. Yield

data at the Kadugli Research Station is summarized as follows:

1979-1980 Ranked second of 7 varieties tested. Yield was not significantly different from first ranked variety which was a medium maturity variety.

1980-1981 Data not located.

1981-1982 Ranked 15th of 17 varieties, (mostly traditional varieties), of those with higher yield only one was a short season variety.

1982-1983 Ranked 13th of 19 varieties, (mostly traditional varieties), again only one with higher yield was a short season variety.

The National Yield Trials of 1982 indicate that Gadem El Hamam ranked 3rd. The only varieties with better yield were experimental varieties not yet released.

A GTZ report written by Dr. Westphal in 1982 states that no other short season variety has shown a better yield potential than Gadem El Hamam.

At present, the Extension Department at Kadugli recommends Gadem El Hamam to farmers who request information concerning a short season dura variety.

Chemicals such as Aldrex T are widely used to control smuts and soil borne insects. It is understood that there is another formulation of the same chemical which is as effective but is safer to the user since it colors the seed blue and therefore is easily identifiable. No data on the effectiveness of these seed dressings can be found at the Kadugli Research Station.

Methodology:

Although the above information is mixed in terms of

yield potential of Gadem El Hamam, the fact remains that no other improved short-season dura variety shows a better potential for the Nuba Mountains area. Gadem El Hamam is a tested and recommended short-season dura variety for the Nuba Mountains area. Likewise, chemicals applied to seed prior to planting are used throughout the world to control certain types of smut infestations and soil borne insects. This proposal suggests a Farming Systems approach to these three problems common to the farmers of the Nuba Mountains.

It is proposed to prepare 20 bags each containing 1 kg of Gadem El Hamam seed, properly treated with chemicals to combat the smut and soil insect problems; to distribute these bags to farmers in the village of Keiga Timmero. The distribution would be made to the eight farmers interviewed during the Sedentary Production Systems Survey plus 12 others chosen at random. The distribution would be accompanied by a short public presentation by WSARP Agronomists and Extension Department personnel regarding methodology to best take advantage of this new technology; ie; land preparation, planting methods, plarting rates, weeding and thinning, etc. A printed (in Arabic) paper would accompany each bag to reiterate these suggestions and to inform the farmer concerning the source of the seed and the purposes and objectives of WSARP. The 20 farmers would be closely monitored during the growing, harvest and consumption seasons to determine several aspects of technology acceptance. Included would be the following:

(1) What did the farmer do with seed? Did he plant or sell or give it away? Did he plant it on his land or on land of mechanized scheme?

(2) Did the farmer follow the recommendations as explained in the public presentation and on the printed matter or did he use other methods? why?

(3) How did the farmer use the grain produced? Did he save most for the next year's seed, sell it or consume it in the household? If consumed what was the acceptability? What is the storability?

(4) What is the actual production potential of this variety under various production regimes? What can we learn regarding extension recommendations from this trial?

Monitoring will require periodic visits by WSARP staff (Social Economics and Agronomy Sections) throughout the growing, harvest and consumption season of 1983-1984. Perhaps 8 visits will be made to each of the farmers chosen for seed distribution. See Figure 1. Extension personnel will be an integral part of these visits.

The village of Faid El Garad will also be visited several times during the duration of the experiment to monitor the production of Gadem El Hamam. As mentioned above, farmers in Faid El Garad have been planting this variety for several years. This provides an opportunity to study adoption and consumption of the variety under conditions of technological change resulting from farmers incentive. Questions pursued and timing of visits will be similar to those outlined above.

It is to be made clear that what is being suggested in this proposal is not a production trial (however some production data can, and should be collected, as above). The primary purpose

Figure 1: Tentative Schedule of Farmer Visits - Keiga Timmero

Visit	Timing	Purpose
1	July 15 - 20	Observe Planting
2	10 - 15 days after planting	Check germination and weed conditions
3	20 - 25 days after planting	Weeding and thinning
4	45 - 50 days after planting	Check plant population, weed conditions and plant condition
5	95 - 100 days after planting	Check maturity, pest damage and harvest plans
6	mid-November	Observe harvest and yields
7	mid-January	Check on threshing and consumption plans
8	mid-March	Collect consumption data

of this proposal is to observe and qualify how a new technology is accepted and used by farmers in a traditional agricultural society.

Resources Required:

Personnel	Level of Effort
Dr. Neil Patrick, Ag. Economist	10%
Mr. Abu Sabah, Social Scientist	5%
Senior Scientist, Agronomy	5%
Senior Technician/Trainee, Socio/Econ.	15%
Junior or Senior Technician, Agronomy	15%
Junior Technician, Socio/Econ.	30%

Equipment and Support	Level of Use
Vehicle (1)	10%
Typewriter and typist	10%
Electronic Mini-Computer	10%
Copy Machine	5%
Audio/Visual Equipment	10%
Gadem El Hamam Seed	20 kg.
Seed Treatment Chemicals	Sufficient for Treating 20 kg. of seed
Cloth Bags (1 kg. size)	20

Justification:

During the Sedentary Production Systems Survey, three problems consistently were mentioned by producers of dura in the 14 villages. These problems are (1) the need for a good short-season dura variety, (2) significant problems with soil borne insects eating the seed and newly germinated plants, and (3) problems with smut. A short season dura variety, Gadem El Hamam, is recommended for this area but farmers in the villages have great difficulties in obtaining the seed. Chemicals are known that can provide production from smuts and soil borne insects but can only be obtained through government agencies which are generally inaccessable to farmers in the villages.

Thus an intervention is known that can address three very significant problems associated with dura production. The probability of success (ie: increasing per area dura production) appears to be quite high.

An important purpose of this proposal is to develop confidence in the farmers of the Nuba Mountains in the work and recommendations of WSARP Scientists and the Extension Department.

Using known technology with a high probability of success will also have a high probability of increasing confidence. High confidence levels will facilitate the introduction of more far-reaching technological interventions in the future.

Little is known concerning attitudes toward new technology, adoption and utilization of new technology by farmers of the Nuba Mountains. This proposal will monitor these factors using an intervention that addresses three important production constraints.

Outputs:

The most important output of this proposed research will be an increased level of confidence in agricultural research and extension efforts by farmers of Nuba Mountains. A second important output will be understanding of the acceptability, adoption and utilization of new technology by farmers. A third output will be an improved capacity to increase production of dura in south Kordofan. The second and third outputs will be published in the form of research reports in early 1984.

WSARP RESEARCH PROPOSAL

Experiment No. 2

Title of Experiment: Varietal Screening Trials for South Kordofan*

Varieties and/or cultivars that already grow in Southern Kordofan or which have the potential of becoming an integral part of the Total Production System will be selected for evaluation. The screening trials will be divided into individual experiments designated as 3a, 3b, etc. More trials may be added and some may be deleted depending on timely acquisition of essential resources.

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* See Rationale for Agronomic Studies in Kadugli in Appendix.

WSARP RESEARCH PROPOSAL

Experiment No. 2a

Title of Experiment: Varietal Screening Trial for South Kordofan - Sorghum.

Beginning Date and Duration: A continuing trial that will be planted on the WSARP Research Station beginning 1983.

Immediate Objectives: To evaluate the effect of moderate applications of N and P on the most promising five to ten lines of sorghum in relation to yield, maturity, pest and disease resistance, and marketability.

Justification: Sorghum is not only the major food crop of South Kordofan, but it is grown on more hectares than any other crop. In fact, approximately 53% of the cropped area in the Nuba Mountain Region is devoted to this vital staple. As plant breeders are continually releasing new varieties which outperform older ones, it is essential that they be evaluated under South Kordofan conditions. Several years of screening are required to subject each variety to different climatic conditions, different pest attacks, etc. before recommending it for general use. Evolvement and distribution of improved, high yielding varieties are serious constraints to increased sorghum production.

The proposed trial is a modified continuation of the National Sorghum trials conducted at the Kadugli Research Station for a number of years. For the proposed trial, 5 to 10 of the best varieties will be evaluated under moderate applications of nitrogen and phosphorus.

Methodology: Five to 10 of the more promising sorghum varieties or selections will be evaluated with and without fertilizer in a RCBD with 4 replications. Individual plot size will be 4-60cm rows wide (2.4m) x 7m long. The fertilizer treatment will consist of banding 40kg P_2O_5/ha at planting and sidedressing 40kg N/ha at first weeding. The seed will be sown in rows and thinned to 10cm between plants to give a plant population of about 167,000/ha. Yields will be taken from 5m of two center rows.

Data to be recorded are yields, days to flowering, days to maturity, resistance to diseases and pests, including *Striga*, and stalk counts at harvest.

Resources Required:

Approximately 1600 m^2 cracking clay soil

Sufficient seed of each variety for 112 m of row

Nitrogen fertilizer

Sufficient superphosphate or TSP for 0.08 ha

Measuring tapes, plot stakes, etc.

Sudanese agronomist - Mukhtar M. Kenani

US agronomist - Joe R. Gingrich

Senior technician - Ahmed K. Elseed

Junior technician

Laborers

Vehicle (s)

WSARP RESEARCH PROPOSAL

Experiment No: 2b

Title of Experiment: Varietal Screening Trial for South Kordofan - Sesame.

Beginning Date and Duration: A continuing trial that will be planted on the WSARP Research Station beginning 1983.

Immediate Objective: To evaluate the more promising lines of sesame in relation to yield; maturity; pest, disease, and shatter resistance; and quality.

Justification: Sesame is the most important cash crop of the Nuba Mountain Region of Southern Kordofan. Hunting Technical Services estimated that it was grown on approximately 48,000 ha in 1980, second only to sorghum in number of hectares planted. It is well adapted to the cracking clay soils. With the assignment of a sesame breeder within the ARC more and improved varieties are in the future. It is essential that new high yielding varieties continue to be screened so that the better ones can be increased and made available to the grower.

The proposed trial is a continuation of the trial started at Tilo in 1982, and is in cooperation with the sesame breeding unit, Kenana Research Station at Abu Naama.

Methodology: Approximately 20 varieties or selections will be planted on the WSARP Research Station in a RCBD with 4 replications. Individual plot size will be 4-60cm rows wide (2.4m) x 7m long. The seed will be sown in rows and thinned to 5cm between plants to give a population of about 333,000/ha. Weeding

will be sufficient to eliminate any effects of weed competition. Yields will be taken from 5m of two center rows.

Data to be taken include yields; days to flowering and maturity; resistance to disease, pests, and shattering; and number of plants at harvest.

Resources Required:

Approximately 1600m^2 land

Sufficient seed of each variety to plant 112m of row

Measuring tapes, plot stakes, etc.

Sudanese agronomist - Mukhtar M. Kenani

US agronomist - Joe R. Gingrich

Senior technician - Ahmed K. Elseed

Junior technician

Laborers

Vehicle (s)

WSARP RESEARCH PROPOSAL

Experiment No.: 2c

Title of Experiment: Varietal Screening Trial for South Kordofan - Soybean.

Beginning Date and Duration: 1983, to continue for 1 year subject to renewal.

Immediate Objectives: To evaluate the effect of a low application of phosphorus on the more promising lines of soybeans in relation to yield, maturity, disease and pest resistance, nodulation, and keeping quality of the seed.
To evaluate adaptability of other soybean cultivars to South Kordofan.

Justification: Although soybeans are not grown by South Kordofan farmers to any great extent, they have been grown experimentally at the ARC Research Station at Kadugli for a number of years. Some varieties have performed quite well. For the past three years, the WSARP Research Station at Kadugli has cooperated with INTSOY, IITA, and AVRDC on international trials. Soybeans are one of the best sources of vegetable protein for humans, and many varieties provide very good and abundant forage for livestock. They also have the ability to fix atmospheric nitrogen and should fit into a good soil building cropping system. Presently they are being grown in the Blue Nile province in sufficient quantity to be exported abroad. Thus they have the potential for being an important cash crop and a foreign exchange earner as well. The fact that they are not used as a human food or as a livestock feed at the present time should not stand in the way of further screening.

$3c_1$ Evaluation of 5 Best Cultivars

Methodology: The most promising varieties of previous screening trials (ICAL 125, Jupiter, Caribe, IGH 23, IGH 24, Davis and Ecuador M) will be evaluated on the WSARP Research Station in a RCBD with 4 replications. Each individual plot will be 4 - 60cm rows x 7m long. Each variety will be planted with and without an inoculum treatment in combination with two phosphorus levels: 0 and 40kg P_2O_5/ha. Each block would thus contain 28 treatments. Seeding will be in rows and thinned to about 5cm between plants to give a population of approximately 333,000/ha. Weeding will be sufficient to eliminate effects of weed competition. Insects will be controlled by appropriate means. Yields will be taken from 5m of two center rows.

Data to be taken include yields, days to flowering and maturity, resistance to diseases and pests, number of plants at harvest, nodulation, and keeping quality of seeds.

Resources Required:

Approximately 2300m^2 of land ($3c_1$)

Sufficient seed of each variety to plant 112m of row

Inoculum

Measuring tapes, plot stakes, etc.

Sudanese agronomist - Mukhtar M. Kenani

US agronomist - Joe R. Gingrich

Senior technician - Ahmed K. Elseed

Junior technician

Laborers

Vehicles(s)

3c$_2$ Varietal Screening Trials

The following trials will be conducted contingent on the availability of land and labor. They are listed in their approximate priority rank.

(a) Freely Nodulating Soybeam

A trial from INTSOY in cooperation with ITTA containing lines capable of forming nitrogen fixing nodules on soybean roots by utilizing native soil *Rhizobia*. These lines do not require inoculation. Consequently, should any of them perform well, it would be easier for farmers to incorporate them into their cropping system(s) since they don't have to use imported inoculum.

(b) Vegetable-Type Soybeans

A trial provided by AVRDC. One of the major problems limiting introduction of soybean into a new area is finding a suitable means of utilizing the beans. Soybeans are not eaten in Sudan, at present. Dried beans require lengthy cooking, or processing into soy milk or bean curd for direct consumption. Neither of these products are currently popular and it may take considerable time for them to be eaten in sufficient quantity to justify their production. Extraction of oil from soybean requires large processing plants with considerable capital investment. Simultaneous introduction of a new crop for farmers, such as soybean, and a processing industry to go with it is difficult to achieve under the best of circumstances.

Vegetable-type soybean is intended to be picked and consumed as a green bean. It should be comparatively easier to introduce soybean as a vegetable crop to farmers and consumers,

than as a dried bean crop.

(c) ISVEX 83 Soybean Trial (Two Sets)

This trial is distributed by INTSOY worldwide. Entries are selected for their performance in the sub-tropics. Similar, earlier trials have been planted for a number of years at Kadugli. Some entries are added each year, so there are some lines that have not been grown in Kadugli before, which may show promise.

(d) ASET 83 Trial

The entries in this trial have been selected by AVRDC for suitability to the tropics and sub-tropics. Entries are chosen for their performance in the more humid regions of the tropics and sub-tropics so they may not be as well suited to Kadugli conditions. Last year all the ASET entries had low yields. If it can be worked into the testing program, the trial may produce some high yielding lines.

Resources Required: (for $3c_2$ (a)(b)(c) and (d))

Land - Approx. ½fd.
Seed
Inoculum (Except for $3c_2a$)

Agronomists: Mukhtar M Kenani
J.R. Gingrich
Senior Technician: A.R. Elseed
Junior Technician
Laborers
Vehicles

WSARP RESEARCH PROPOSAL

Experiment No. 2d

Title of Experiment: Varietal Screening Trial for South Kordofan - Cowpea/Mungbean

Beginning Date and Duration: A continuing trial that will be initiated on the WSARP Research Station beginning 1983.

Immediate Objective: To evaluate several varieties of cowpeas, *Vigna unguiculata* and mungbeans (*V. radiata*) collected from various places throughout the world as to their adaptability to South Kordofan conditions.

Justification: Cowpeas are important components of the diets of the people of South Kordofan and the Sudan in general. Next to sorghum, they are the most important food crops grown in the Nuba Mountain Region. Farmers are accustomed to growing them usually intercropped with sorghum. Usually local strains are grown which are late maturing, have spreading growth habits, and are low yielding.

Although mungbeans presently are not grown in South Kordofan, they have been grown at Tozi and other areas of the Sudan as a green manure and forage crop. They form a vital part of the diet of many people of the world, especially in the developing countries, and could give greater variety to the diets of the people of South Kordofan.

Cowpeas and mungbeans fix nitrogen which will help maintain soil fertility. They provide excellent forage for livestock, and any excess can be sold at the local market.

By screening varieties and plant types from various places throughout the world, more suitable, higher yielding varieties of these crops can be selected for the cropping systems of South Kordofan.

The International Cowpea Center is located at the University of California - Riverside. At the present time, Ibrahim Medani, WSARP, Kadugli, is connected with the project there. Cowpea cultivars have been received from UC-R and from UC-R cooperator at the National Agronomy Research Center, Bambey, Senegal. Mungbean cultivars have been received from the International Mungbean Center now associated with the AVADC, Taiwan.

Methodology: All introduced selections, along with local cultivars, will be sown as an alternate row intercrop with an improved selection of dura in a RCBD with four replications. Each individual plot will be 8-50 cm rows wide x 4 m long. Spacings within the row for Vigna will be 25 cm for erect types and 50 cm for prostrate types. Within row plant spacing for dura will be approximately 15 cm. Harvested area will be from four center rows of each plot.

Data to be taken include date of sowing and emergence, yield of each crop, and for the food legumes forage yields, days to 50% flowerin and maturity, harvest index, and several yield components.

Resources Required:

Approximately 0.25 ha of cracking clay soil

Sufficient seed of all cultivars

Measuring tapes, plot stakes, etc.

Sudanese agronomist - Mukhtar M. Kenani

U.S. agronomist - Joe R. Gingrich

Senior technician - Ahmed K. El-Sed Ahmed

Junior technician

Laborers

Vehicle(s)

WSARP RESEARCH PROPOSAL

Experiment No. 2c

Title of Experiment: Varietal Screening Trials for South Kordofan - Forage Legumes

Beginning Date and Duration: 1983. To continue for three years.

Immediate Objective: To evaluate various legumes, introduced as well as indiginous, in terms of nitrogen fixation, yields, food value or feeding quality, and persistence (in the case of perennials).

Justification: Soils of South Kordofan are deficient in nitrogen and phosphorus. Commercial fertilizers are not available and if they were, the cost and difficulties in transportation and distribution to farmers would make them uneconomical.

Before the chemical era, farmers throughout the world learned to maintain relatively high yields by including legumes in their cropping systems. Usually the legume was an annual clover and often furnished several cuttings of excellent forage before being plowed under as a green manure. Most legumes have the capacity to fix atmospheric nitrogen if inoculated. They are also effective "feeders" being able to absorb phosphorus more effectively than grasses. Thus they not only add N to the soil but may absorb soil phosphorus and return it to the soil as organic phosphoru which in turn is mineralized to become available to succeeding plants. The amount of N actually added to the soil by legumes depends on the amount left in the residue which remain on the land. Legumes may also supply nitrogen to non-legumes by growing the two crops together.

It is difficult to say with any degree of accuracy just how much N/ha is fixed annualy by legumes. Estimates for soybean range from 40 to 140kg, cowpeas 95kg, groundnut 40kg, clovers from 50 to 600kg, Stylosanthes guyanensis 100kg, and Desmodium intortum 380 kg.

Animal production systems in developing countries are usually based on low quality, low yielding forage grasses. Very little use is made of leguminous pasture of forage. During the long dry season in South Kordofan, cattle suffer severely from inadequate nutrition even though uncropped land was available during the rainy season that could have been producing high quality legume hay.

In additional to enriching the soil and providing high quality forage, some legumes as cowpeas, soybeans, chickpeas, several bean, etc. furnish high quality human food. Several of these already make up part of the local diet.

Legumes as cowpeas, pigeonpeas, and even forage can be sold as a cash crop if the grower ends up with a surplus.

If the cropping systems of South Kordofan are to bu built primarily on restoring soil nitrogen by growing forage and food legumes then it is essential to evaluate those thought to be adapted to the area.

Methodology: Various legumes including Vigna unguiculata, Glycine max, Clitoria terneata, Phaseoulus trilobus, Dolichos spp., Stylosanthes spp., and others thought to be adapted to South Kordofan conditions and for which seed can be obtained will be included in a trial on cracking clay soil on the WSARP Research Station.

Each individual plot will be 5m x 8m in a split block design with artificial inoculation vs. natural inoculation as the main blocks and the legumes as subplots provided that inoculum can be obtained for all legumes used. If inoculum cannot be obtained for all, the design will be a randomized complete block under natural inoculation with three replications in either case.

A seedbed will be prepared and seeding will be broadcast or in rows whichever is recommended for that particular legume. Forage samples for nutritive analyses will be taken at appropriate times during the year. Yields will be taken from a 3m x 6m area in the center of each plot.

Data to be taken include annual forage and bean yields, nodulation, TDN, % protein, resistance to pests and diseases, competition with weeds, and persistence.

Resources Required:

Approximately 0.50ha of land

Sufficient seed and inoculum

Measuring tapes and plot stakes

Sudanese agronomist - Mukhtar M. Kenani

US agronomist - Joe R. Gingrich

US range scientist - Trent Bunderson

Sudanese animal nutritionist - Babo Fadlalla

Senior technician - Ahmed K. Elseed

Junior technician

Laborers

Vehicle (s)

WSARP RESEARCH PROPOSAL

Station: Kadugli
Experiment No. 2f

Title of Experiment: Varietal Screening Trial for South Kordofan - Pigeonpea

Beginning Date and Duration: 1983/One-Year Subject to Renewal

Immediate Objective: To evaluate suitability of pigeonpea cultivars to growing conditions in the Nuba Mountains.

Justification: Pigeonpea is a late maturing legume well suited to the semi-arid tropics with a multitude of uses. Its beans are nutritious and tasty. Its leaves and branches are excellent forage for livestock. Its woody stem can be used as firewood. In addition, nitrogen fixing nodules form readily on its roots without application of inoculum, thus, increasing soil nitrogen content.

Pigeonpea currently is grown in Sudan as a border crop on irrigated schemes, but, it should grow well under rainfed conditions in South Kordofan. Consumers in Sudan are already familiar with pigeonpea, so there should be no problem in marketing the beans. It would be, in our opinion, a valuable addition to cropping systems and households in Western Sudan.

Methodology: Depending upon the availability of seed, pigeonpea cultivars will be evaluated solely and intercropped with sorghum or millet. Seed has been requested locally and from ICRISAT. The exact design of the trials will be determined by the number of lines and the amount of seed received.

Resources Required:

Approximately ½ fd. of land

Seed

Measuring tape, stakes, etc.

Agronomists: Mukhtar M. Kenani
Joe R. Gingrich
Senior Technician - Ahmed K. Elseed

Junior Technican

Laborers

Vehicle(s)

WSARP RESEARCH PROPOSAL

Experiment No.: 3

Title of Experiment: Maintenance of Soil Fertility through Legumes

Beginning Date and Duration: 1983. To continue at least six years.

Immediate Objective: To introduce more food, forage, or cash crop legumes into the Nuba Mountain cropping system to maintain or improve soil fertility, and add variety to the local diets, provide supplemental forage for livestock, and increase overall production.

Justification: Commercial fertilizers are not available for purchase by farmers of South Kordofan and would probably be too expensive if they were available. Little use is made of animal manures and as far as can be ascertained, very little use is made of soil improving crops such as legumes in any type of rotation. As a result, farmers must clear and burn land which has been idle for 8 to 15 years, farm it for 8 to 15 years, then abandon it again. During this idle period, soil fertility tends to be built up.

The proposed experiment will test the feasibility of using more legumes in the traditional sorghum - sesame cropping system to maintain or increase soil fertility, thus eliminating or decreasing the idle period. Some legumes have promise of being a dual or triple purpose crop. Although the primary purpose of the experiment is to increase or maintain soil fertility, the legume can provide an additional food crop (pigeon pea), the stems and leaves can provide a forage crop for use as a supplemental feed for ruminant livestock, or any excess can be sold as a cash crop.

Methodology:

The experiment will be conducted initially at the Agronomy Research Station in a RCBD with four replications. Each individual plot will be 8-60 cm rows wide x 10 m long. Food legumes used will be intercropped with dura in alternate rows and will be a local cultivar of cowpea (*Vigna unguiculata*) and a Sudanese cultivar of pigeon pea (*Cajanus cajan*). Initially the forage legume will be *Clitoria terneata*. Yield data will be taken from the four center rows of each plot.

Data to be recorded include grain yields of each crop, forage yields of legumes, nodulation, weeding times, intensity of Striga, and net return per rotation.

Cropping systems to be evaluated are:

1. Continuous sorghum
2. Continuous sesame
3. Sorghum - sesame rotation
4. Sorghum+cowpea intercropped - sesame
5. Sorghum+pigeon pea intercropped - sesame+cowpea intercropped
6. Sorghum+cowpea intercropped - sesame+pigeon pea intercropped
7. Same as T-5 but replace sorghum with millet when Striga reaches the threshold level.
8. Clitoria - sesame+cowpea intercropped = sorghum+pigeon pea intercropped.

Resources Required:

Approximately 0.30 ha of cracking clay soil

Sufficient sorghum and sesame seed to sow approx. 1400 m^2 each, cowpea seed for approx. 1000 m^2. pigeon pea seed for approx. 800 m^2, and Clitoria seed for approx. 200 m^2.

Measuring tapes, plot stakes, etc.

Sudanese Agronomist - Mukhtar M. Kenani

U.S. Agronomist - Joe R. Gingrich

U.S. Social Scientist - Joel Teitelbaum

U.S. Economist - Neil Patrick

Senior technician - Ahmed K. Elseed Ahmed

Junior technician

Laborers

Vehicle(s)

WSARP RESEARCH PROPOSAL

Identification

Station: Kadugli

Experiment No.: 4

Title of Experiment: Critical Periods of Weed Competition in Sorghum

Beginning Date and Duration: 1983, to continue for 3 years on 3 sites each year, if possible.

Immediate Objectives: (1) To define the time or period at which sorghum yields are most affected by weed competition, and (2) to ascertain the critical duration of weed competition after the crop emerges.

Justification: Control of weeds by farmers probably accounts for the highest percentage of the total costs of production. In developed countries large sums are spent each year on herbicides. In developing countries, weeding various times throughout the cropping season produces the greatest demand on the farmer's labor force, a force that is often inadequate during certain critical periods. Yet every farmer knows that weeds if not controlled will reduce yields, even to zero if competition is severe.

Weeds will never be completely eliminated. It is usually not economically feasible for a farmer to maintain an absolutely weed free field. Are there periods during the crop cycle that are more critical than others with regards to weed competition? Are there stages during crop development where the crop competes more effectively with the prevailing weeds than at other stages? If these periods can be defined, weeding costs should be minimized without reducing crop yields.

This experiment should help define those periods during the growth of sorghum when weed control is critical and when weeding is no longer economically advantageous.

Methodology: Sites selected should be based on some knowledge of weedy types of the area. Each plot will be 4-60cm rows wide x 7m long. Treatments selected are:

1. Weed free
2. Weedy check
3. Weed free first 10* days after crop emergence
4. " " " 20 " " " "
5. " " " 30 " " " "
6. " " " 40 " " " "
7. " " " 50 " " " "
8. " " " 60 " " " "
9. Weedy first 10 days after crop emergence
10. " " 20 " " " "
11. " " 30 " " " "
12. " " 40 " " " "
13. " " 50 " " " "
14. " " 60 " " " "

* Times are tentative and subject to change.

Data to be recorded include predominant weeds, number, and weight; yield of sorghum; and times required for weeding.

Resources Resuired:

Approximately 0.13 ha for each experiment

Sorghum Seed

Measuring stakes, plot stakes, etc.

Sudanese Agronomist - Mukhtar M. Kenani

U.S. Agronomist - Joe R. Gingrich

U.S. Economist - Neil Patrick

Senior Technician - Ahmed K. Elseed

Junior Technician

Laborers

Vehicle(s)

WSARP RESEARCH PROPOSAL

Identification

Station: Kadugli

Experiment No.: 5

Title: On-Farm Evaluation of Package of Improved Practices for Increasing Sorghum Production

Implementation Period: 1983 Cropping Season

Principal Investigators: J.R. Gingrich, Agronomist; M.M. Kenani, Agronomist; M.A. Abu Sabah, Social Scientist

Collaborators: W.T. Bunderson, Range Management Specialist, N.A. Patrick, Agricultural Economist

Rationale: Sorghum is grown in Sudan primarily on the cracking clay plains, without irrigation, in regions that receive 500+mm of rainfall annually. The clay plains extend from Eastern Sudan through the Nile Valley into Southern Kordofan. The Agricultural Research Corporation has conducted research on rainfed sorghum production on the Central and Eastern portions of the clay plains in Tozi, Abu Naama and Sim Sim near Gedarif.

This experiment is predicated upon the premise that the research results obtained at one location on the clay plains are applicable at other sites on the plains with similar rainfall. It will attempt to apply the following findings from the Eastern and Central rainlands research stations on the clay plains to traditional farmers fields near Kadugli. Previous research found that higher sorghum yields were obtained when the following

were used:

(1) Improved earlier maturing cultivars

with rapid establishment and growth as well as a higher harvest index that make better use of limited rainfall and avoid certain major diseases and pests (birds) by maturing prior to the primary time of their occurrence.

(2) Early planting

soon after the beginning of the rainy season to achieve good stand establishment, as early as possible, in order to take advantage of the sparse rainfall.

(3) Early weeding

to promote good crop establishment by limiting competition with weeds within the first 4 to 6 weeks. (weeding after that period was found to decrease yield).

(4) Seed treatment with a combined insecticide and fungicide

to control the major fungal disease (head smut) and damage by soil insect pests.

Although these research results were obtained in studies conducted in support of rainfed mechanization schemes, we think they may be equally applicable on the traditional farms on the cracking clay in Western Sudan.

In Southern Kordofan, sorghum is the major cereal crop grown on the vertisols. Farmers generally use a mixture of late maturing varieties which they plant slightly prior to the middle of the rainy season. Weeding, the most labor demanding cultural

practice, is done by hand with small hand tools, once or twice after the crop has become established. Yields are generally low, due to poor stand establishment, competition with weeds and damage by insect pests, birds and diseases.

The 1983 on-farm agronomic trials will be conducted on several farms on each of three villages within a 20-mile radius of Kadugli. Social scientists working with agronomists will attempt to determine factors governing the rate of adoption of the selected interventions being evaluated in this study, plus gain a better understanding of the farmer's decision-making process. Farmers representative of major groups of farmers have been selected to enable extension of positive results to similar farms in the same recommendation domains.

Methodology

Three general areas have been selected for on-farm sorghum trials during the 1983/84 cropping season. Three locations are with Baggara transhumants in Hamra, one site in Bilinga and two sites in adjacent Hajar Ranaba with Nuba sedentary farmers. The two other sites are located in Shaer and in Saraf El Daie with sedentary farmers.

Because of its high yield on some mechanized schemes and its short growth duration, Gadam El Hamam has been selected for inclusion in the on-farm trials. This improved cultivar will be introduced with a simple package of practices and compared with the farmer's local varieties and his traditional practices.

All trials will be researcher managed with the farmers doing all planting, weeding, etc., on their own land.

Treatments included in each trial are:

(1) Gadam El Hamam, seed treatment for head smut and soil borne insects, high plant population (approx. 10,000 /fd) and timely weeding.

(2) Same as No. 1 except using farmer's own varieties and seed.(Introduction of improved cultural practices only).

(3) Farmer's practices - farmer's own varieties and seed. Farmer's traditional planting methods, spacing and weeding practices.

All trials will be on land that has been farmed continuously for several years. Pre-planting land preparations will be according to individual farmers' practices, which usually consists of clearing residue of previous crop and removal of excessive weeds.

Individual plot size will be 0.25 feddan when adequate land area is available. The farmer will be given sufficient seed dressing for Treatment No. 2 and some marked twine to use as a guide for the recommended plant spacings. He will also be given sufficient Gadam El Hamam seed for Treatment No. 1.

Initial weedings for Treatments 1 and 2 will be sufficiently early to avoid competition with sorghum seedlings. Additional weedings will be made when necessary. All trials will be monitored for disease, insect, and bird damage. At harvest, grain and forage yields will be taken from random areas within each

plot. Stand counts after thinning and at harvest will also be taken.

Technical Staff

Junior Technicians	30%
Senior Technicians	15%

Equipment

Vehicle

Fertilizer

Seed Dressing

Tapes

Stakes

Drying Oven

Twine

WSARP RESEARCH PROPOSAL

Experiment No.: 6

Title of Experiment: Crop Responses to Applications of N and P on Nuba Mountain Soils.

Beginning Date and Duration: 1983, to continue at least three years.

Immediate Objectives:

1. To determine to what extent crop production in the Nuba Mountain region is limited by inadequate levels of N, P, and K.

2. To determine if low to moderate amounts of N and P can be economically applied to crops grown on Nuba Mountain soils.

Justification: There is a consensus among agricultural scientists in Western Sudan that low soil fertility is one of the major constraints to increasing crop yields. However, crop responses to fertilizer applications under rainfed conditions in Western Sudan have not been very conclusive. Experiments conducted have been limited in number and those that have been reported often do not show large differences among treatment yields. When statistical analyses are given, coefficients of variation are usually high.

In general, past fertilizer trials have been concentrated on nitrogen applications in the form of urea, usually to dura or cotton. If all or part of the urea is surface applied without soil incorporation, significant losses of nitrogen may occur from alkaline soils.

Soil analyses data show that available phosphorus is low in the cracking clay soils of the region and also may be a factor limiting yields. However, there is very little information available correlating soil test data with crop response.

Even though one of WSARP's aims is to maintain or increase

production by including legumes in simple crop rotations, it may be that small to moderate applications of commercial fertilizer could economically increase yields. Legumes may fix appreciable nitrogen, but the amount returned to the soil depends on use made of the crop.

An anhydrous ammonia plant is under construction in Sudan at the present time. Some of the largest phosphate deposits in the world are located on the African continent. Researchers almost 30 years ago at the Tozi Research Center reported an increase in yield of dura from 2344 rpf to 2780 rpf by the application of only "0.2 cwt of N/f". With the WSARP Research Station, Kadugli located in a slightly higher rainfall area and the supposition that present varieties would give a greater response to nitrogen, it seems logical that significant yield increases could be obtained at Kadugli.

Therefore, as an attempt to more clearly define the constraint of low fertility on crop production in the Nuba Mountain region, it is essential to begin various fertilizer trials on soils which differ in inherent fertility. The initial thrust will be with dura on cracking clay soils and, if time permits and an off-station site can be found, with groundnuts on coarse textured footslope soils.

Methodology:

An attempt will be made by soil sampling and soil analyses to select soils showing wide differences in available phosphorus. Sites selected for dura will be on typical cracking clay soils, while those selected for groundnuts will be on footslope soils. Each experiment will be a factorial in a RCBD with four replications.

Fertilizer levels for dura will be:

N-0, 20, 40, and 60 kg/ha

P-0, 20, 40 and 60 Kg P_2O_5/ha

K-0 and 60 kg K_xO/ha

Each individual dura plot will be 2.4m (4-60cm rows) wide x 7m long. Phosphorus and potassium will be banded below the seed in each row for those treatments including phosphorus. The sorghum will be thined at time of first weeding to yield approximately 167,000 plants/ha. Nitrogen will be side-dressed as soon as possible after the first weeding. Additional weedings will be as necessary to eliminate severe weed competition. Yield data will be taken from 5m of two center rows of each plot. Data to be taken include yields of grain and stover, N and P content of plant, number of plants at harvest, visual fertilizer response, maturity date, and cost of all inputs.

Fertilizer levels for groundnuts will be:

N-0 and 20kg N/ha

P-0, 20, and 40kg P_2O_5/ha

Each individual groundnut plot will be approximately 3m x 7m. Seeding will be in hilss. Phosphorus will be localized below the seeds. Nitrogen will be side-dressed at time of first weeding. Data to be taken include yields of nuts and tops, nodulation, plants harvested, visual fertilizer response, and plant analyses.

Resources Required:

Approximately 0.25 ha of cracking clay soil and 0.12 ha of footslope soil
Dura and goundnut seed
N and P fertilizers
Measuring tapes, plot stakes, etc.
Sudanese agronomist - Mukhtar M. Kenani
US agronomist - Joe R. Gingrich
US economist - Neil Patrick
Senior technician - Ahmed K. Elseed
Junior technician -
Laborers
Vehicle(s)

October 1982

WSARP RESEARCH PROPOSAL

Identification:

Experiment No.: 7

Title of Experiment: Range Resource Classification and Evaluation in South Kordofan

Principal Investigator: Dr. Trent Bunderson, Range Ecologist

Cooperators: Dr. Babo Fadlalla, Animal Nutritionist; Dr. Joe Gingrich, Agronomist/Soil Scientist

Time Frame: Broad preliminary surveys: March - May 1981
Detailed quantitative surveys: June - October 1981 - 1982
Monitoring Activities: Every two to five years.

Objective: The overall aim of this study is to provide a better understanding of the range resources of South Kordofan particularly in the Nuba Mountain Region. Specific activities are described below:

1. To collect and identify plant species in the area with annotated notes on physical features, abundance and distribution, and ecological characteristics including economics and important uses. Plant collections will also be used to establish a basic herbarium facility for South Kordofan.
2. To classify and map the rangeland communities of the region in terms of major vegetation types and their associated soils.
3. To determine primary production of herbage in the various range communities, and to assess changes in the nutritional quality of forage through the year.
4. To evaluate current range condition in the different plant-soil associations in relation to its ecological potential, and to assess this condition as a function of past and present land-use.
5. To estimate the livestock carrying capacities of the major range communities under current conditions, and its potential for increase with range improvement.

Rationale:

Baseline information on the structure and composition of rangelands and their current condition and productivity, is fundamental not only to the understanding of livestock production systems dependent on this resource, but also to any program of research and rangeland development aimed at improving such systems on a sustained level of productivity (see also Pratt& Gwynne 1977 pp. 3 and 40-99; Hodgson, 1975; Risopoulos, 1975; Heady, 1960; Shute & West, 1982).

The classification and evaluation of range communities provide the very basis of land-use decisions for they describe the nature and current condition of the range as influenced by past and present land-use, and determine its productive potential under optimum management. Continued long-term monitoring of range condition is vital to research and development planning because it assesses the environmental impact of various land-use practices, as well as the success of attempted improvements, in terms of whether the range is improving, stable, or deteriorating.

It is clear from the foregoing that attempts to change animal husbandry or land-use practices for the purpose of increasing agricultural productivity should not proceed without adequate information on the relationship between the ecological status of rangeland and its current forms of utilization. This necessitates the inclusion of socio-economic factors which represent the cultural framework of grazing systems. Lack of such knowledge has led to frequent failures,often with disastrous consequences,

of many agricultural projects in Africa.
(Glover & Gwynne 1961; Brown 1963, 1971; Darling & Farvar 1972; Russell 1972; Talbot 1972; Baker 1975; Hemming 1975; Jacobs 1975).

Information gathered on range resources should not be so detailed and extensive that much of the generated data has little practical application; nor should it be so generalized that one cannot identify important features which determine the grazing value of various ranges at different seasons, and the constraints which prevent their productive potential from being realized.

These points should help elucidate the need for baseline range research prior to the implementation of range and livestock improvement programs. Non-range scientists often have difficulty appreciating this need due to a poor understanding of the complexities of range-pastoral systems. For example, a commonly proposed solution for range improvement is reseeding with perennial grasses, a highly expensive undertaking at the very least. Without sufficient knowledge of the range base, this presupposes that (1) the abundance of native perennials is low, or that the existing perennials and annuals are less desirable than the introduced onces, (2) the introduced species are adapted to the local environment and will readily survive, even though the factors causing the scarcity of perennials or the lack of desirable ones, are still in operation, and (3) the economic benefits will override the costs. Unless the causal factors responsible for converting

a perennial range to an annual one are controlled, a reseeding program with perennial grasses is doomed to failure.

Other reasons for conducting range research in South Kordofan are as follows:

(a) Only 10-15% of the land surface in the Nuba Mountain region is currently under cultivation (HTS, 1980, 1981) and despite the potential for increase, crop production is never likely to exceed 40% of the area due to topo-edaphic and climatic limitations. In addition, the large amount of land that is necessarily under fallow during any given year (as high as twice the amount currently cultivated) will probably not be reduced significantly for considerable time due to the already limited supply of labor for cultivating increased areas of land. Thus, at least 60% of the region can be classified as rangeland for which the only practical form of use is livestock production.

(b) South Kordofan has potentially some of the most productive rangeland for livestock in Sudan, but under present practices, they are inefficiently used. Management should be optimized to achieve the area's potential for a stable and productive livestock system.

(c) Worldwide in this ecoclimatic zone, productive agricultural systems invariably integrate the livestock component Presently this is poorly developed in South Kordofan. It

must be recognized that the agricultural and economic benefits derived from an integrated crop-livestock system are greater than the sum of the two separately, particularly where conflicts between range-use and cultivation are seriously undermining the economic potential and environmental stability of the region as a whole.

(d) With the growth of human populations and the spread and intensification of agriculture, conflicts between nomadic and sedentary people will continue to increase. Results of range research will help the Government of Sudan in land-use development strategies designed to cope with the gradual but ultimate shift from nomadic to less mobile systems of livestock production.

Literature Review:

Information on the range resources of South Kordofan is limited to a few old surveys in the 1940s and 1950s, notably Andrews, 1948, Smith, 1949, and Harrison & Jackson, 1958. These surveys were broad in scope for they attempted to describe on a subjective basis, the general botanical composition of major land forms across the whole of Sudan. It is largely from these works, particularly the latter, that descriptions of range resources by HTS, 1981, GtZ, 1977 and RMR, 1976 & 1977, were obtained. Consequently, the definition of range communities is not only sketchy, but it is sometimes inaccurate.[1] More important is the total absence of information on the past and present condition and productivity of the various range communities.

1. For example, RMR 1977 states that all the vegetation types in the Nuba Mountain area are dominated by medium or tall perennial grasses, and mentions only one species, Hyparrhenia rufa. The fact is that these rangelands are dominated by annuals, and Hyparrhenia rufa is limited in distribution to the fringe of seasonal swamps. Similarly, HTS, 1981, notes that the weeds of cultivated land are composed of perennial tussocky grasses when all but one of the species named are annuals.

Data of this kind are essential to understanding the environmental and socio-economic constraints affecting range and livestock productivity, and to evaluating appropriate programs of range improvement designed to support and maintain a more stable and productive livestock system.

Methodology:

Collection and Identification of Plants

Investigations of rangelands necessitates a proficient familiarity with the flora of an area and the environmental conditions under which each species is found. A first step in achieving this objective is to make extensive plant collections with the ultimate aim of establishing a basic herbarium facility for the region. Such a plant library will not only provide information on the ecology of South Kordofan but will serve as an essential aid to all range and agricultural scientists working in the area.

During the rainy and early dry seasons of 1981 and 1982, plants will be collected in the field. Whenever possible, identifications will be made by the range ecologist using taxonomic keys of Andrews (1952), Bogdan (1958), Dale and Greenway (1961) and the Flora of Tropical East Africa (1952-). A minimum of two specimens will be taken of each species with notes on vernacular names, physiognomy, distribution and abundance, general habitat

characteristics, and uses. At least one specimen will be sent to the East African Herbarium in Nairobi for verification of plant names, and for identifying unknown species. Other specimens will remain at the Kadugli Research Stations as a reference herbarium for South Kordofan.

Classification of Rangeland

Major vegetation types of the area will be classified according to physiognomy, floristic composition and topo-edaphic characteristics. Delineation of vegetation types for mapping purposes will be aided with the use of aerial photographs at a scale of 1:50,000, and land-sat imagery in color composites on a scale of 1:100,000-1:250,000. Specific characteristics of each range community will be described using appropriate sampling techniques as described below.

Initially, extensive reconnaissance surveys will be conducted through the region to gain an appreciation for the types and distribution of plant communities present in the area. Once major vegetation types have been distinguished in broad terms, quantitative assessments of structure and composition will follow.

Within each vegetation type, two sites will be randomly selected for sampling a number of plant and soil parameters. Sites will be located in different areas to help account for any variability in vegetation types which exhibit a discontinuous though repeatable pattern of distribtution. Parameters to be recorded, and the sampling procedures used at each site are presented below.

1. Woody vegetation: The point- centered quarter method of Cotton and Curtis (1956) will be employed for determining the relative density and frequency of woody species, where mature trees are distinguished from shrubs and regenerating plants. These measures of species abundance will be used with estimates of plant heights to assess dominance.

Sampling will be carried out at 50-200m intervals along two transect lines to give a total of 20 sample plots per site (i.e. 80 records of mature trees, and 80 records of shrubs and regenerating trees by species and height.)The exact spacing between sample plots will depend on the distribution pattern of the vegetation.

Physiognomic features will be described according to the overall canopy cover and height of the woody component and the relative proportion of deciduous, evergreen and thorny species in the vegetation.

2. Herbaceous vegetation: A two-point frame designed by the principal investigator, and consisting of sight lines rather than steel pins because of greater accuracy and objectivity (Greig-Smith, 1964), will be used for measuring the percentage cover and species composition of herbaceous vegetation. Sample plots will be taken at 10-50m intervals along the transect lines described above, with two frames of two poirts each at every plot. The heights of species will also be recorded by taking the average of the culm and leaf heights above the ground. Height measurements, when used with data on herbaceous cover, can provide precise estimates of standing crop biomass.

3. Topography and soils: A soil sample will be taken from selected sites within each vegetation type. This will entail drilling a hole to 1.0m with a soil auger and extracting about 400g of soil from each of 3 depths, i.e. 0-30cm, 30-60cm and 60-100cm. Soil samples will be analyzed for physical characteristics, (e.g. color, texture, and moisture retention capacity) and chemical composition. Topography will be described based on qualitative estimates of slope, potential runoff, pattern of drainage, and susceptibility to inundation.

Range Condition and Forage Productivity

Evaluations of range condition and forage production will involve the use of exclosures as well as permanent transect lines through open rangeland. A total of 10 exclosures, each measuring 50mx50m with fire guards around the perimeter, will be established within easy access of Kadugli in major vegetation types.

Exclosures are designed to (1) measure primary production of herbage on different range types and to relate this to rainfall and soil moisture, (2) to assess the nutrient value of pasture at different seasons and stages of growth, (3) to evaluate the range condition of each community with respect to its potential by monitoring changes in composition and productivity following the exclusion of fire and grazing, and (4) to estimate current and potential carrying capacities for livestock in each major type of rangeland.

Permanent transect lines outside each exclosure, and in other representative, open-range situations, will aid in assessing the productivity, and condition of these various rangelands.

Herbage production measurements: Herbage production inside and outside the exclosures will be determined at the end of the growing season from randomly selected plots along transect lines varying in length from 40m inside the exclosures to 100m outside. Herbage will be clipped to 3cm above ground level, weighed green, and air dried to constant weight (if drying ovens are available, these will be used). Primary production will then be related to rainfall.[2] In addition, one season's data will be collected on the pattern of growth exhibited by major species as a function of soil type and soil moisture content.

Moisture content analysis: During the first year, randomly clipped samples of herbage will be collected from each exclosure for nutrient analysis at different stages of growth. This will provide an appreciation of the nutritional value and deficiency of different pastures through the year. The results should

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2. Rainfall stations are available at Kadugli town, Kadugli Research Station, and new ones have been established at some of the exclosure sites.

closely approximate natural conditions since grazing pressures are low during the growing season, and exclosure vegetation will have had little time to change in response to the absence of fire and grazing.

In subsequent seasons, samples will be collected of common grasses, legumes, shrubs and trees found on different soils in open-range situations. This will be done at three times of the year i.e., mid-wet season before flowering; late wet season after seed maturity; and mid-dry season when most plants have completed their life cycle, or have entered dormancy. Nutrient analyses of these samples will help identify important key species towards which management should be directed in each range community. They will also identify species of low grazing value and there-by help to initiate improvements to reduce their abundance.

Determination of range condition: Measurements of herbage production and forage quality will form part of the basis for assessing range condition in different communities. In addition, transect lines inside and outside the exclosures will be used for recording various plant and soil parameters, monitoring changes in these over time, and comparing results between the open-range with areas excluded from fire and grazing. Parameters[3] recorded will include:

a) Woody cover: species composition and density of trees and

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3. Methods used for recording these are presented in Bunderson, 1981.

shrubs; height class distribution by species; and canopy cover.

b) Herbaceous cover: species composition; overall ground cover; litter accumulation; and ability to burn.

c) Forage value: herbage production, and forage quality at different seasons, with a breakdown of herbaceous and woody components into desirable and undesirable species based on nutritive value, palatability, and persistence. (See earlier descriptions of herbage production and nutrient analysis).

d) Soil stability and fertility: structure and chemical composition; susceptibility to erosion based on soil depth, ground cover, slope, and pattern of drainage.

The frequency of recording these parameters is variable. Production of herbage in different plant-soil associations should be measured annually in order to determine the relationship with rainfall amount and distribution. Soil erosion, and the cover and species composition of herbaceous and woody vegetation need only be monitored every three to five years unless there is reason to believe that rapid changes are taking place. Trends in range condition can then be related to the pattern of fire and grazing, or the absence thereof. Additional assessments of pasture quality at different seasons are also unnecessary if no significant changes in vegetation structure and composition have occured.

Determination of livestock carrying capacities: Preliminary estimates of livestock carrying capacities for each rangeland will be determined using the results of the studies described above.

Attempts will then be made to determine current levels of use and compare these with estimated carrying capacities. This will entail defining the pattern of range-use in terms of the season, distribution, and intensity of grazing, and the types of livestock used. The results will determine whether current grazing practices are efficient and whether principles of proper range-use have been applied.

Ranges considered to be in less than optimum condition will be evaluated to assess the potential for increasing their carrying capacity through improved use and management.

REFERENCES

Andrews, F.W. 1948. The vegetation of the Sudan. In T.D. Tothill, e.d. Agriculture in the Sudan, London.

Andrews, F.W. 1952. The Flowering Plants of Anglo-Egyptian Sudan. Vols. I, II, III. T. Buncle and Co. Litd., Arbroath, Scotland.

Baker, R. 1975, 'Development' and the pastoral peoples of Karamoja, Northeastern Uganda. An example of the treatment to symptoms. In T. Monod, ed. Pastoralism in Tropical Africa. Oxford Univ. Press, London 520pp.

Bogdan, A.V. 1958. A revised list of Kenya grasses with keys for identification. Govt. Printer Nairobi.

Brown, L.H. 1963. An assessment of some development schemes in Africa in the light of human needs and the environment. Proceed. of the 9th Technical Meeting, IUCN, Nairobi.

Brown, L.H. 1971. The biology of pastoral man as a factor in conservation. Bio. Conserv. 3(2): 93-100.

Bunderson, W.T. 1981. Range Research Activities, Western Sudan Agricultural Research Pro ect Annual Report, Washington State Univ. Pullman, pp.65.

Cottam, G & J.T. Curtis, 1956. The use of distance measures in phyto-sociological sampling. Ecology 51: 949-958.

Dale, I.R. & P.J. Greenway. 1961. Kenya trees and shrubs. Buchanan's Kenya Estates Ltd. Nairobi, in association iwth Hatchards, London. 654 pp.

Darling, F.F. & M.A. Farvar. 1972, Ecological consequences of sedentarization of nomads. In: M.T. Farvar & J.P. Milton, eds. The Careless Technology. Nat. Hist. Press, Garden City, N.Y. 1030pp.

Flora of Tropical East Africa. 1952. Govt. Printer, Nairobi.

German Agency of Technical Cooperation Ltd. 1977. Nuba Mountain Region Development Potential Survey. Vols. 1-4. Agrar Und Hydrotechnik, GMBH, Essen, for the Democratic Republic of Sudan.

Glover, P.J. & M.D. Gwynne. 1961. The destruction of Kenya Masailand. New Scient. 11: 450-453.

Grieg-Smith, P. 1964. Quantitative plant ecology. Butterworths, London.

Harrison, M.N. & J.K. Jackson. 1958. Ecological classification of the vegetation of the Sudan. For Bulletin No. 2, Min. of agric. Khartoum.

Heady, H.F. 1960. Range Management in East Africa. Govt. Printer Nairobi, 125pp.

Hemming, C.F. 1975. The need for a wide ecological approach in the planning of future rangeland surveys. In: Evaluation and Mapping of Tropical African Rangelands, ILCA, Bamako pp. 229-231.

Hodgson, H.J. 1975. Needs for evaluation and mapping of African rangeland. In: Evaluation and Mapping of Tropical African Rangelands, ILCA Bamako, pp. 371-372.

Hunting Technical Services, Ltd. 1980. South Kordofan Central Districts Development Plan. HTS Ltd. Borehamwood, England.

Hunting Technical Services, Ltd. 1981. South Kordofan Rural Planning Unit. Annexes 1-5, HTS Ltd. Borehamwood, London.

Jacobs, A.L. 1975. Maasai pastoralism in historical perspective. In T. Monod, ed. Pastoralism in Tropical Africa. Oxford Univ. Press, London. 502pp.

Pratt, D.J. & M.D. Gwynne. 1977. Rangeland Management and Ecology in East Africa. Hodder and Stroughton, London 310pp.

Resource Management and Research Ltd. 1976-1977. Sudan National Livestock Census and Resource Iventory. Vols. 18-23. Min. of Agric. Khartoum.

Resource Management and Research Ltd. 1977.

Risopoulos, S. 1975. Rangeland Survey in the framework of range development. In Evaluation and Mapping of Tropical African Rangelands, ILCA, Bamako, pp. 21-23.

Shute, D.A. & N.E. West. 1982. Two basic methodological choices in wildland vegetations. J. appl. Ecol. Vol 19: 249-262.

Smith, J. 1949. Distribution of tree species in the Sudan in relation to rainfall and soil texture. Bulletin No. 4, Min. of Agric. Khartoum.

Talbot, L.M. 1972. Ecological consequences of rangeland development in Masailand, East Afric a. In M.T. Farvar & J.P. Milton, eds. The Careless Technology. Nat. Hist. Press, Garden City, N.Y. 1030pp.

RESOURCES REQUIRED OVER A 2-YEAR PERIOD

Staff	Allocation of time
Dr. Bunderson, Range Ecologist	40%
Dr. Fadlalla, Animal Nutritionist	10%
Dr. Gingrich, Agronomist/Soils Scientist	5%
Senior Technician	50%
Junior Technician	50%
Driver	30%
Assistant Driver	30%
Permanent Field Laborers(3)	30%
Temporary Field Laborers (10)	5%
Equipment	
One-4-wheel drive vehicle	30%
Fencing materials for exclosures	-
Transport for above by truck	5%
Weighing Scales	20%
Measuring Tapes	50%
Hand Calculators	60%
Laboratory Facilities	10%
Camping Equipment	10%

WSARP RESEARCH PROPOSAL

Identification:

Station: Kadugli

Experiment Number: 8a

Date of Proposal: Sept. 1982.

Beginning Season for Research: March - June 1983

Subject of Research: Supplementary Feeding of Livestock During the Dry Season.

Principal Researcher (s):

Dr. Babo Fadlalla
Dr. R. Cook
Dr. T.W. Bunderson

Cooperating Entities: Dr. N. Patrick and other WSARP Staff in Soc./Eco. Unit.

Proposal:

Title: Supplementary Feeding of Cattle During the Dry Season.

Duration: 2-3 years.

Overall Objective: To increase efficiency of livestock production and farm income through adoption of an integrated farming approach whereby agricultural by-products and cut hay are fed to cattle during the dry season.

Intermediate Objectives:

1. To investigate the effect of dry season supplementary feeding on the following production and fertility parameters.

   a. Changes in liveweight.
   b. Age at first service.
   c. Age at first calving.

2. Compare the nutritive value of the following agricultural by-products as supplements.

   a. Dura straw.
   b. Groundnuts haulms.

3. Study the technical feasibility and economics of hay making.

4. Evaluate the economics of supplementary feeding.

Rationale:

Dramatic weight losses occur in cattle during the dry season. This is believed to be the cause of delayed maturity and long calving intervals. This study aims at increasing productivity through dry season supplementary feeding. Agricultural by-products will be fed during the time of acute shortage of energy and protein. Hay making will be considered because it could supply the animals with nutritious food particularly when hay is cut at flowering or early fruit set stage. Being cut during the period early September hay does not compete for labour with other crops. This supplementary feeding program will be extended as from next season (1983-84) to include the evaluation of forage legumes that will be grown by the agonomy unit to improve soil fertility through rotations.

Summary of State of Knowledge:

A wide variety of crops are grown under rain in South Kordofan. These include food crops such as sorghum and cash crops and oil crops such as cotton, sesame and groundnuts. After harvest huge amounts of crop residues are left in the field to be grazed. Cakes of sesame and groundnuts may also be available.

Dura stubbles, cotton stalks and leaves, and groundnut tops were evaluated as sole feeds for cattle at the Gezira Research Station (Fadlalla, 1974/75). Daily intakes of dry matter (DM) were 4.1, 2.5 and 4.8 Kg respectively. Intakes of DM/Kg 0.75 were 59.7, 39.3 and 76.4 g respectively. The animals consumed about 1.5, 1.0 and 1.9% of their body weight. Metabolizable energy/Kg DM was 1.96, 2.23 and 2.1 Mcal/Kg respectively whereas digestible

crude protein (DCP) was 1.0, 7.2 and 1.7%. It will be of interest to investigate the effects of such feeds on liveweight gain and puberty when fed to cattle during the dry season.

Hay making is not practiced in S. Kordofan despite the huge amounts available. Methods of hay making need to be developed and the economics of such an operation need to be investigated.

Methods:

Forty growing animals will be required for this experiment (age 1 year). The animals will be assigned to 4 treatments in groups of 10 according to weight, age and sex. The treatments include:

a. Control (grazing only).

b. Grazing + dura stalks.

c. Grazing + groundnuts tops.

d. Grazing + cut hay.

Feeds will be offered to appetite during the period March through June. Animals will be weighed monthly. Also signs of maturity and fertility will be recorded e.g. age at service, age at first calving and calving interval.

Resources:

1. Animals: forty animals need to be purchased from local markets. This requires about LS 5200 assuming average cost/animal = LS 130.
2. Buildings are needed for these experiments. These include pens with watering and feeding facilities.

3. Funds to cut hay and to buy groundnuts tops from farmers. It is estimated that about 5 tons are required from each supplement. Assuming a price of LS I per 100 LB of GN, this amount will cost about LS 110 + labor and transport. Dura stalks will cost much less. Hay is already being made from station funds.
4. Senior Staff, Drs. B. Fadlalla, R. Cook and T. Bunderson.
5. Technicians.
6. Vehicles: Including 4x4 vehicles and a truck.
7. Two SATEC animal-drawn carts.

References:

Fadlalla, B. (1974/75). Annual Report of the Gezira Res. Sta.

WSARP RESEARCH PROPOSAL

IDENTIFICATION:

Station: Kadugli

Experiment Number: 9b

Beginning Season for Research: Fall 1983

Subject of Research: Supplemental Feeding of Cattle During the Dry Season

Principal Investigator: Dr. Bunderson, Range Ecologist

Collaborators: Dr. Fadlalla, Animal Nutritionist; Dr. Cook, Livestock Scientist; Dr. Teitelbaum, Socio-Anthropologist; Dr. Patrick, Agricultural Economist.

PROPOSAL:

Title: Supplemental Feeding of Cattle During the Dry Season.

Part II: Dry Season Feeding of Cut Hay from Native Grass to Cattle of Cooperating Sedentary and Transhumant Herders.

Time Frame: Hay Cutting and Storage: September - Early October, 1983. Feeding: March - June, 1984.

Objective: The principal objective of this study is to assess the costs and benefits of feeding grass hay to livestock during the dry season, and to make more efficient use of the forage before its value and biomass decrease.

RATIONALE:

Rangelands in South Kordofan are not grazed significantly by livestock until the dry season when forage has declined sharply in both quantity and nutritional value. The loss of productive, nutritious forage is particularly evident in areas, such as the Nuba Mountains, which are dominated by coarse, fast-maturing annuals. After migratory herds reach the south, the available herbage is basically dead standing straw and litter with nutrient

values well below the maintenance requirements of livestock. Moreover, the risk of fires is high at this time because of the large accumulation of combustible material resulting from insufficient wet-season grazing.

In the absence of adequate grazing during the rains, coupled with poor quality pasture in the dry season, a program of forage conservation would clearly improve animal nutrition and productivity, as well as the utilization of range resources. Storing grass as standing hay is generally a poor method of conservation. If the dry season arrives before grass has set seed, reasonable quality forage is possible, but grasses more often mature before the rains end. The product is standing straw rather than standing hay. Although still edible, the nutritive value of this forage is usually below subsistence levels. Large amounts are also lost through decomposition and insect attack.

It is proposed here that cut-native hay in the Nuba Mountains can provide a valuable source of supplemental feed for improving animal nutrition during the dry season. Methods of cutting, storing, and feeding hay are detailed below.

METHODOLOGY:

Harvesting Operations

Areas selected for cutting hay will be determined by the composition of herbage in terms of productive and palatable species. It is likely that hay will be cut exclusively from dark cracking-clays since those soils contain some high-yielding desirable species which mature later than most plants found on other soils. Cracking clays also contain isolated stands of

tall perennial grasses which remain green longer than annuals, and thereby provide opportunities for lowering the risk of damage by rain.

Selected areas will be harvested at the flowering stage by local, sedentary workers using hand-cutting tools. The hay produced should have a crude protein content of 8-10%. Earlier cutting would undoubtedly result in higher quality hay, but yields would be lower. Also drying is more difficult if grass is cut during the height of the rains when the chance of spoilage is high.

Cut grass will be left to dry and cure in the field for two days, and then gathered by hand and loaded on animal-drawn carts. The dried grass will be stored in stacks in the open, and placed on dry ground to reduce the danger of termite attack.

Feeding Experiments

Animal Selection:

Transhumant and sedentary livestock producers will be contacted for participation in a program of supplemental feeding. Approximately 20-30 cattle should be selected from each of the two livestock systems. Animals used should be males and females that are relatively young in age to demonstrate clearly any benefits derived from supplemental feeding (e.g., weight gains, milk yields, ages at sexual maturity and first calving, etc.). A control group of animals is needed for each of the experiments to document differences which result from providing supplemental hay. Control groups of animals should be similar in composition to those receiving supplementation.

Timing, amount and quality of hay fed:

Hay will be provided to the selected groups of animals on a daily basis during the critical part of the dry season, i.e., from mid-March to late June. One third to one half of the normal dry matter intake will be fed to cattle as supplemental hay. This means that approximately 1.2-1.9 kg of hay will be provided daily to each animal, assuming that the average weight of an animal in this study is 150 kg, and dry matterm consumption is 2.5 kg/100 kg livestock. Thus, for a total of 60 cattle and 100 days of feeding, 7.2-11.4 metric tons of hay will be required.

The nutritional value of hay will be assessed prior to the start of the feeding study. This will be conducted as described in part I of this proposal.

An important part of this study involves the actual timing of feeding hay, and the distinct possibility of reducing the time and energy spent moving to and from water and grazing. A common practice during the dry season is to graze cattle in the mornings as far as 15 km from the cattle camp, and to bring them back for watering in the early afternoon. After a short rest, the animals are again taken out for grazing until dusk. though the distances travelled are shorter. By feeding hay to animals after watering, it should be possible to eliminate the need for the second period of grazing, and thereby conserve the energy that would otherwise be expended in this effort.

Animal responses to supplemental feeding:

The age, sex and weight of each animal, including those in control groups, will be recorded at the beginning, mid-points,

and end of the study. Females two years of age and older will be pregnancy tested, and milk yields of lactating cows will be monitored through the period of hay feeding. Differences between animals receiving supplemental hay and those in control groups will be statistically analyzed for significance. The benefits derived from supplemental feeding with native grass-hay will be balanced against the costs of cutting, storing and feeding. Assessments of the former are obviously more difficult than the latter since benefits from increased animal productivity are more long-term in nature.

REFERENCES

Heady, H. F. 1960. Range Management in East Africa. Government Printer Nairobi, 125 pp.

Pratt, D. J. & M. D. Gwynne 1977. Rangeland Managment and Ecology in East Africa. Hodder and Stroughton, London, 310 pp.

Stoddart, L. A., A. D. Smith & T. W. Box. 1975. Range Management. McGraw Hill Book Co. New York, 532 pp.

October 1982

Identification

Station: Kadugli

Experiment No.: 9

Date of Proposal: October 1982

Beginning Season for Research: November 1982

Subject of Research: Nutritional Factors Affecting Livestock Production in South Kordofan

Principal Investigators: Drs. B. Fadlalla, R. Cook, and T. Bunderson

Duration of Project: One Calendar Year

Overall Objective: To define nutritional factors limiting sedentary livestock production in South Kordofan in a herd of cattle with limited grazing. To provide information for effective adaptive strategies to alleviate those constraints.

Immediate Objective: To investigate forage nutritive value and its variability with season. The following will be considered:

1. Quantity of forage on offer from a given area of land at a given period of time.

2. Quality of forage on offer e.g.
   a. Chemical composition of forage, should include proximate analysis and minerals e.g. Ca^{++}, PO_4^{--}
   b. Digestibility
   c. Intake of DM.
   d. TDN, DE, DCP.

Rationale: There is need to determine the relative importance of the different components of forage nutritive value for various reasons:

1. Almost all of these components can be corrected by supplementation.
2. They change with stage of maturity of the plant and there is need to know when concentration is highest.
3. They are sometimes interacting e.g. low crude protein content is associated with low digestibility and low voluntary intake of DM.

4. The levels of nutrients can be compared with published requirements of livestock and with performance data collected from performance experiment (See Expt. 16).
5. A detailed knowledge of the nutritional factors affecting performance will allow an explanation of results from grazing and feeding trials, thus proper interventions can be implemented.

Summary of State of Knowledge:

Experience with tropical range shows that crude protein content falls sharply and crude fibre content rises significantly as plants mature compared with temperate herbage. As a result, digestibility and voluntary intake decrease. Weight loss of variable magnitude follows. The practice of feeding common salt suggests a deficiency of sodium and/or chloride ions. As common salt is not pure, it may be contaminated with trace minerals thus acting as a salt mixture. Deficiency of phosphorus is also suspected as judged by reports of low soil phosphorus in the Kadugli area.

Methods:

The study will commence by preliminary studies on the research farm. It will then be extended on farms using experimental animals staying with a selected sedentary herd with unrestricted grazing and the station's migratory herd.

(A) Research farm:

The following parameters will be investigated.

1. Quantity of forage on offer at any given time from a given area will be determined using metal squares dropped randomly on given transects. Herbage will be cut at about 3" above ground level and weighed.
2. Proximate analysis and mineral analysis will be done on samples observed to be similar to those selected by animals.

3. Digestibility of forage will be determined *in vitro* on forage samples observed to be similar to those selected by grazing animals. A two-stage technique using enzymes celluase and pepsin will be adopted (Mcleod and Minson, 1978).
4. Voluntary intake of DM will be measured as follows.
   a. Total faeces will be collected using 4 steers fitted with harnesses and bags. These steers will be allowed a preliminary period of two weeks for adaptation. Faeces will then be collected for a 6 day period during which grazing behaviour will be observed and samples similar to those selected by the steers will be collected. Intake of DM will be calculated from the relationship:

$$\text{DM forage ingested} = \frac{\text{DM faeces} \times 100}{100 - \text{digestibility of DM}}$$

WSU is developing a technique for determining digestibility and DM intake of grazing animals using DAPA as a marker (Koes and Nelson, Unpublished). The technique allows the determination of digestibility by taking only samples of the faeces instead of total collection and laborious observation of grazing behaviour and was found to correlate well with digestible energy. It will be valuable for this program to have contacts with the scientists involved in developing this approach at WSU.

5. TDN will be determined from DM intake, DM digestibility and percentage of nutrients in the DM.
6. ME and DE will be determined from equations developed by Blaxter (1975) or by using a bomb calorimeter if available.
   b. Similar work will be carried out with a sedentary herd with unrestricted grazing and with the station migratory herd (if it is found to be possible). The advantage of this approach is that it allows for selection by animals. Dominant plant species will be determined during each experimental period.

Resources:

1. WSARP Senior Staff Drs. B. Fadlalla, Dr. R. Cook and Dr. T. Bunderson.
2. Technicians.
3. 4x4 vehicles.
4. Weighing scales for both cattle (available) and calves (NA).
5. Laborers
6. Laboratory equipment.
   a. Moisture extraction oven (large capacity).
   b. Equipment for proximate analysis (50% available).
   c. Balances (I top loading; I analytical).
   d. Chemicals for proximate analysis and enzymes cellulase and pepsin for the determination of *in vitro* digestibility.

e. Canvas harnesses and bags (can be made locally).

f. Troughs and buckets for weighing faeces.

g. Bomb calorimeter.

NB. All measurements will be taken at four critical periods of the year characterized by distinct variation in quality and/or quantity of range e.g. November, February, May and August.

This proposal emphasizes the importance of establishing a basic nutritional capability. Such a capability will support not only the livestock nutrition studies but also the agronomic forage studies because:

1. Implementation of on-farm trials with forage supplementation require a basic knowledge of nutritive value of forage species being considered.
2. Development of and/or introduction of new forage species also require an evaluation (on a seasonal basis) of their nutritive value.
3. Integrated livestock/crop systems where crop residues may be cut, stored and fed also will require some basic analysis of nutritive content.
4. Also work will be done to standardize, simplify and improve analysis methods so that analysis can be carried out without a fully functional nutritional lab at Gazala Gawazat and El Fasher.

References:

1. Blaxter, K.L. (1975), Metabolizable energy and feeding systems for ruminants. In Proc. Nutr. Conf. for Feed Manufacturers No. 7. Ed. H. Swan and D. Lewis. Butterworths, London.

2. Koes, R.M. and Nelson, T.R. (unpublished).

3. Mcleod M.N. and Minson (1978), The accuracy of the pepsin-cellulase technique for estimating the dry matter digestibility *in vivo* of grasses and legumes. Animal Feed Science and Technology, 3,277-287.

WSARP RESEARCH PROPOSAL

Identification:

Experiment No.: 10

Station: Kadugli

Title: Introduction of Forage Legumes into the Cropping Systems of Transhumant and Sedentary Groups in South Kordofan

Principal Investigators: Dr. Bunderson, Mr. Abu Sabah, Dr. Gingrich

Cooperators: Dr. Teitelbaum, Dr. Fadlalla, Dr. Patrick
Range and Pasture Administration, Kadugli

Time-Frame: Planning Phase: February and March 1983
Implementation: June 1983 for 3 years.

Objectives and Long-Term Implications:

The immediate aims of introducing forage legumes to the cropping systems of South Kordofan are:

1) to improve the nutritional plane of sedentary and transhumant herds of cattle during the dry season, thereby improving animal production;
2) to increase the productivity, grazing quality, and utilization of fallow land;
3) to improve and maintain soil fertility levels, particularly in terms of available nitrogen, leading to:
   (a) an effective shortening of the fallow period;
   (b) reductions in the relative amount of land in fallow vs. that under cultivation;
   (c) reduced effort and time in clearing new or long-abandoned land;

The successful introduction of forage legumes into sedentary and transhumant systems of cultivation has enormous implications. These are summarized as follows:

a) Reduction in Fallow Land

A significant reduction in the amount of land under fallow has important ramifications regarding natural succession of vegetation (structural and compositional changes) on land drawn out of bush-fallow cultivation. Simply stated, areas previously fallow will turn into rangeland which, in the absence of frequent fires, will develop more desirable and productive species for grazing. The relationship between the amount of land in fallow and that under cultivation is expressed by the following simple equation:

$$\text{Area}(km^2) \text{ in fallow} = \frac{\text{Area } (km^2) \text{ currently cultivated x years in fallow}}{\text{years consecutively cropped prior to fallow}}$$

In ratio rather than absolute terms:

$$\text{Ratio Index for fallow land } (Rl_f) = \frac{\text{years under fallow}}{\text{years in fallow \& cultivation}}$$

For the system of bush-fallow cultivation in South Kordofan, it is clear that a significant shortening of the fallow period will result in a large reduction in the area of land under fallow. (A more detailed example of this effect is provided as an appendum). In terms of rangeland improvement, the only danger is that natural succession may lead to a problem of bush encroachment in the absence of suitable controls, one of which is the current bush-fallow system. This in turn may result in a higher incidence of biting flies due to improved habitat factors (e.g. breeding sites).

b) Improvements in Range and Livestock Condition

The natural improvement in range productivity (see (a) above), combined with the provision of high quality forage from legume sources will increase the livestock carrying capacity of the region and the level of animal health and nutrition. In addition to forage quality (which will help meet the protein and mineral requirements of the animal), increases in the abundance and availability of grazing will contribute significantly to reducing animal stress and high energy expenditures. The results will lead to improved livestock productivity and opportunities for increased animal off-take.

c) Integration of Crop and Livestock Production

The cultivation of forage legumes on fallow land offers an ideal starting point for better integrating crop and livestock production. This is relevant not only within specific systems such as various sedentary and transhumant groups, but also between these systems.

d) Reduction in Conflicts

The factors mentioned above could significantly reduce the scope for conflict and competition between different farming and pastoral communities. The effect would improve the efficiency of resource utilization, while simultaneously reducing adverse consequences such as the incidence of burning and its detrimental impact on grazing conditions.

Rationale

The objectives and implications outlined above are derived from diagnostic surveys associated with sedentary and transhumant groups (see research proposal 13), as well as range resource evaluations (proposals 8, 12, and 14). Constraints specifically identified in relation to this proposal include:

1) animals in physically poor condition during the dry season, particularly cattle; this is due to inadequate forage quality and availability, and also to high levels of energy expenditure caused by long-distance movements to and from water and grazing;
2) range and fallow land of low grazing value and productivity; this is a result of the high frequency of burning and cultivation which prevent desirable changes in botanical composition through natural succession, i.e., the development of range and fallow land is maintained or depressed at early seral stages of succession by burning and fallow-systems of cultivation;
3) low crop yields, indicative of soil exhaustion, following several consecutive years of cultivation without sufficient use of crop rotations or legumes; poor crop yields were often accompanied by *Striga* infestation although this is not necessarily associated with depleted soil fertility.
4) poor integration and complementarity between crops and livestock demonstrated by the inefficient use of crop residues and by-products for animal feed.

The introduction of productive, well-adapted forage legumes will contribute significantly toward alleviating these constraints.

Methodology:

On-farm forage legume trials are planned this season in three locations: one with Baggara transhumants in Hamra, the other two with Nuba sedentary groups at Hajar Ranaba and Bilingya. The forage legume selected for use is a naturalized perennial, *Clitoria ternatea*, which is not only adapted to the area, but produces good quality forage, establishes rapidly, competes well with and smothers weeds, grows with tall grasses and can be intercropped with sorghum (Skerman, 1977; Whyte et al. 1969; Gezira Agron. Recs; pers. comm with Abdalla, Idris, and the Range and Pasture Administration, Kadugli).

All trials will be researcher-managed on individual farmer's fields at each location. The procedures employed will be organized as follows:

1) plots one feddan in size will be selected at each location on representative cracking clays that have been fallow for at least three years;
2) land preparation techniques will follow the traditional practice of *harig* clearing in which old standing grass is burned at the end of June to kill newly germinating weeds after the start of the rains;
3) planting will be carried out using the traditional long-handled tool for check-row planting; seed rates will be based on recommended levels for rainfed cultivation on cracking clays;

4) weeding will be conducted early if at all using the traditional short-handled, flat hoe;

5) the legume crop will be harvested by hand using sickles at the end of the rains, and stored as hay for supplemental feed to cattle during the peak of the dry season; measurement of yield and nutritive value will be made at this time;

6) the cut hay will be stored on a wooden platform to reduce the risk of termite attack, and to improve the drying process;

7) the cost of producing and storing the legume hay will be assessed as well as the benefit to animals receiving it;

8) the number of animals receiving hay as a supplement during the dry season will depend on the quantity of hay produced; the amount fed daily per individual animal should not be less than 30% of the dry matter intake, and the feeding period should be a minimum of 60 days.

9) liveweights, body measurements and milk yields of animals receiving hay will be taken prior to and after the hay-feeding period; the results will be analyzed and compared with a control group;

10) the land under the forage legume will be divided into two segments with a cropping sequence as follows:

(a) fallow-forage legume (1yr)-sesame (1yr)-sorghum

(b) fallow-forage legume (3yrs)-sesame (1yr)-sorghum

these different cropping patterns will be accompanied by assessments of changes in soil fertility; sesame and sorghum

yields under the above sequences will be compared with adjacent plots left under traditional fallow and followed by the normal sesame-sorghum pattern;

(11) the level of care and management needed in maintaining a good forage crop following initial establishment will be evaluated for both of the above sequences;

(12) perceptions regarding the acceptability and adoption of forage legumes into the cropping systems of transhumant and sedentary groups will be monitored over time; initial successes will be followed up by expanding the number of on-farm trials, and other species of legumes will be tested for adaptability under farmers' conditions.

In addition to the above experiment, a research managed on-farm trial will be conducted with a legume-grass mixture on a ¼ feddan plot with a transhumant farmer in Hamra. The legume selected will be C. ternatea, as above, with an indigenous annual grass, Brachiaria obtusiflora. This grass is a productive, highly palatable species common to the cracking clays of the Nuba Mountain region, and is recommended as a pasture crop (Range and Pasture Administration; Gezira Agronomy Records; Idris, pers. comm.). The species grows well with C. ternatea under natural conditions (pers. observation). Together, they should be more effective in weed competition, and should also produce greater yields. Procedures for land preparation, cultivation, hay production, and feeding will follow the same format as presented above. (Approximately ½kg of grass seed was collected by the rge. ecologist.)

References:

Abdalla, Suleiman, 1981. Range and Pasture Administration, personal communications.

Hussein, Idris. 1982. Director of UNSF, New York, personal communications.

Gezira Agronomy Records. Unpublished papers. Fodder and Rotation crops.

Ibrahim, El Sadig Bedawi, 1982-1983. Range Officer and Pasture Administration, Kadugli, personal communications.

Skerman, P.J. 1977. Tropical Forage Legumes. Food and Agric. Organization of the United Nations, Rome, pp. 609.

Whyte, R.O., G. Nilsson-Leissner and H.C. Trumble. 1969. Legumes in agriculture, FAO, Rome.

Range and Pasture Administration, 1981-1983. Kadugli and Khartoum, personal communications.

Resource Requirements:

Senior Staff	% Allocation of Time
Dr. Bunderson	8.0
Mr. Abu Sabah	5.0
Dr. Gingrich	2.0
Dr. Teitelbaum	1.0
Dr. Fadlalla	1.0
Dr. Patrick	1.0
Technical Staff	
Junior Technician	20.0
Senior Technician	20.0
Equipment:	
4-wheel drive vehicle	8.0
60 m tape	8.0
one 10kg and one 100kg scale	8.0
lab facilities	2.0
100 m of string	8.0
30 burlap sacks	8.0
drying oven	2.0
soil augers (2)	5.0
50 sampling tins for soils	10.0
hand calculator	8.0

Appendum on the Effect of Shortening the Fallow Period

Given some basic assumptions, an approximate analysis of the current bush-fallow system of cultivation is presented in simplified form, and then extrapolated 10 years from now after introducing forage legumes.

Current Situation

Average rate of rural population growth	= 3.0% compounded annually
Average rate of farmland expansion	= 3.0% compounded annually
Area of cracking clays in the cultivation cycle for the Nuba Mountains Central Districts	= 4,836km^2 (HTS, 1980)
Average length of cultivation	= 6-10 years (mean of 8)
Average length of fallow	= 8-20 years (mean of 14)
Ratio indicator for fallow land (RI_f)	= 63.64
Ratio indicator for cultivated land (RI_c)	= 36.36
Area of cracking clays in fallow	= 3077.5km^2
Area of cracking clays under cultivation	= 1758.5km^2

After 10 years following the successful introduction of forage legumes

Area of cracking clays under cultivation assuming no change in the average length of cropping	= 2363.3km^2 (% change + 34.4)
Average length of fallow (shortened by introduction of forage legumes	= 6 years
Ratio indicator for fallow land(RI_f)	= 42.86
Ratio indicator for cultivated land (RI_c)	= 57.14
Area of cracking clays in fallow	= 1772.7km^2
(percentage change)	= - 42.4%
Area of cracking clays in the cultivation cycle	= 4136km^2
(percentage change)	= -14.5%

In the above example, the total amount of land in fallow and cultivation changed by a factor of 14.5%, representing 700km^2. However, the area under fallow was reduced by 73.6% representing 1304.8km^2. Both are sizeable areas in terms of their potential effect on range and animal production, and opportunities for better integration of crops and livestock. This is particularly true if one considers the amount of increase that would occur in fallow and cultivated land assuming no change in the fallow period over the next 10 years. (The value for land in the cultivation cycle would be 6499.7km^2 with 4136km^2 in fallow.) The implication of this is clearly significant, and hence a model based on improvements in the accuracy of the figures presented above is being developed.

OCTOBER 1982

RESEARCH PROPOSAL

Identification:

Station: Kadugli

Experiment Number: 11

Title: Nature, Extent and Impact of Burning and Measures for Fire Control

Principal Investigators: Dr. Bunderson, Range Ecologist; Dr. Teitelbaum, Socio-Anthropologist.

Collaborators: Dr. Fadlalla, Animal Nutritionist; Dr. Patrick, Agricultural Economist.
Range and Pasture Administration, Kadugli, El Obeid, and Khatroum
Forestry Department, Kadugli, El Obeid and Khartoum
Ministry of Agriculture, Regional and National Levels
Local, Regional and National Governments

Time Frame: October 1982 - June 1984

Objectives: The principal objective of this study is to determine the nature and extent of burning in the Nuba Mountain Region in terms of:

(1) The area burned each year.
(2) The reasons for setting fires and the people responsible.
(3) The impact on the ecology of the area.
(4) The perceptions of various socio-economic groups regarding the beneficial and detrimental effects on agricultural activities.

Methods for potentially controlling fires will form an important part of this research, with an approach which focuses on people and various programs of extension.

RATIONALE

Burning is a common and widespread practice in South Kordofan, and it is carried out for a variety of reasons by different groups of people. Fires begin shortly after the rains and continue through much of the dry season. Land-Sat imagery coupled with extensive field observations show that a high percentage of the region is

burned on an annual basis. Although fires have played a major role in modifying the structure and composition of vegetation in Africa, particularly in preventing the encroachment of bush, their impact and usefulness varies according to the intensity, timing and frequency of burns (Heady, 1960; 1975; Harrington, 1980; Pratt and Gwynne, 1977; Pratt, 1967; Scott, 1967; West, 1965). In general, fires set once every three to six years at the end of the dry season are sufficient to control bush without harm to herbaceous components of the vegetation. Earlier and more frequent burning tends to cause extensive damage to perennial herbs, as well as to woody species. This occurs because it promotes new leaf growth, often out-of-season, which depletes carbohydrate reserves needed for normal plant and root development. The consequence is a steady reduction in plant vigor and productivity, ultimately leading to changes in plant cover and species composition toward undesirable, fire-tolerant vegetation. Early dry season fires also cause excessive exposure of the soil, and increase topsoil loss through wind erosion and run-off.

The pattern of burning exhibited in the Nuba Mountain region is believed to have had a severe detrimental effect on the range ecology of the area. The proposal here is to quantify the practice of burning in terms of its extent, frequency, and timing, and to evaluate its causes in relation to the impact on agricultural productivity. Such a study is essential before some of the major constraints to various production systems are fully appreciated.

METHODOLOGY

The extent and frequency of burning over the region will be assessed from a series of Land-Sat imagery at a scale of 1:250,000. Ideally, the photographs should cover a period of about 10 years in order to gain an accurate evaluation of the frequency of fires over a given area as well as the percentage of land that is burned on an annual basis. The results will help determine the yearly loss of forage through fire, and the impact of burning on the environment and ecology.

Observations on the pattern of burning will also be made during ground surveys associated with range-use practices, and sedentary and transhumant production studies (see research proposals on these topics). Interviews will be conducted with prominent members of various communities to determine the reasons why fires are set, and their perceptions regarding their beneficial and detrimental effects. In addition, people in the process of setting fires will be interviewed on-site to obtain more direct information on the causes and reasons for burning particular areas. The actual impact of fire on the structure and composition of the vegetation, and its influence on livestock grazing, are under investigation in separate research proposals (see Rangeland Classification and Evaluation; and Bush-Control Studies for Range Improvement).

With the existing pattern of burning in South Kordofan, it is likely that some measure of fire-control will be necessary to prevent further environmental degradation and loss of valuable

forage as well as to improve range productivity and quality for increased livestock production. Although fire lines have been used with some degree of success in various parts of Africa, including Sudan, their effect is mainly one of fire containment rather than prevention. Construction of fire lines is also extremely expensive, and the benefits derived from such a program may not warrant the cost. It is proposed that a more effective method of fire control would be achieved by establishing a policy regarding the use of fire, and to extend that policy to the people through an efficient extension program. This would obviously require the support and cooperation of the government administrations and ministries at the local, regional,and perhaps national levels. Some measure of enforcement would also be necessary particularly in the initial phases of the program's implementation.

The organization and content of a policy and extension program on fire control would be dependent on the results of this research, and close communications with government entities concerned with agricultural productivity and the management of the country's natural resources.

REFERENCES

Heady, H.F. 1960. Range Management in East Africa. Govt. Printer, Nairobi, 125pp.

Heady, H.F. 1975. Rangeland Management. McGraw-Hill. New York, 460pp

Harrington, G.N. 1980. Grazing Arid and Semi-Arid Pastures. In: Grazing Animals, by F.H.W. Morley (ed), Elsevier Scient. Publ. Co., Amsterdam.

Pratt, P.J. & M.D. Gwynne. 1977. Rangeland management and ecology in East Africa. Hodder and Stroughton, London. 310pp.

Pratt, P.J. 1967. A note on overgrazing of burned grassland. E. Afr. Wildl. J. 5:178-179.

Scott, J.D. 1967. Advances in pasture work in South Africa. I. Veld Herb. Abstr. 37:1-9.

West, O. 1965. Fire in vegetation and its use in pasture management. Mimeo. Publ. No. 1/1965. Commonw. Bur. of Past & Field Crops Hurley, Great Britain, 53pp.

WSARP RESEARCH PROPOSAL

Identification:

Station: Kadugli

Experiment No.: 12

Title: Range-Use Patterns and Livestock Productivity of Transhumant Baggara and Sedentary Nuba Systems in Kordofan

Principal Investigator: Dr. Bunderson

Cooperators: Dr. Fadlalla, Dr. Teitelbaum, Mr. Abu Sabah, Dr. Cook, Dr. Patrick
Department of Animal Production, Kadugli
Range and Pasture Administration, Kadugli

Time Frame: Reconnaissance Phase: (complete) Sedentary - July to December, 1981
Transhumant - April to June 1981 (short distance)

Diagnostic Phase: Sedentary - September/October 1982
March 1983 to April 1984

Transhumant - January to April, 1982;
(short distance) September/October 1982;
February 1983 to April 1984

Transhumant - July 1983 to June 1984
(long distance)

Objectives:

The short-term aim is to provide a better understanding of the transhumant Baggara and sedentary Nuba systems of livestock management in order to identify key ecological and socio-economic constraints affecting range-livestock productivity. The resulting information will be used for assessing and developing appropriate interventions to improve and stabilize livestock productivity for traditional producers over the long-term.

Literature Review and Rationale:

Literature on the Baggara transhumant and Nuba sedentary systems of livestock management is meager from the biological stand-point. Most

research has been anthropological or economic in nature, with limited agricultural content, resulting in only superficial treatments on the animal production and ecological components of the systems. (Cunnison, 1960, 1962, 1963a,b, 1966, 1976; Ahmed, 1976a,b; Haaland, 1975, 1980; Johnson, 1974; Iten, 1979; Manger, 1980; Mustafa, 1980; Nadel, 1947; Stevenson, 1965). The agricultural and ecological studies available tend to follow a classical rather than production systems approach to research (Harrison & Jackson, 1958; Harrison, 1955; Andrews 1949; Lebon, 1965; Tothill, 1948; Smith, 1949), and some are too general in assessing range-livestock aspects of the systems (HTS, 1981; Wickens & White, 1979; GTZ, 1977; RMR, 1975, 1976).

The research described herein is designed to identify key elements, inefficiencies, and constraints of the transhumant and sedentary systems of range-livestock production in Kordofan. Proposed activities are closely allied to research proposal 8 on range resource classification and evaluation; they also complement the socio-economic surveys of the transhumant and sedentary systems (proposals 15 and 2), but with an orientation toward more technical components.

Specific areas of study are divided into three basic categories at the household level:

1. <u>Season Patterns of Range-Utilization and Associated Grazing Practices</u>

   a) nature, timing, and flexibility of seasonal migrations of movements and reasons for these

   b) seasonal grazing and watering characteristics of range and milk herds of cattle, and small ruminants in terms of

   (i) allocation of labor for herding and watering responsibilities

(ii) timing of grazing and watering, including movements between these areas, and the fariqs (i.e. time of day distances travelled, and time spent at these various activities and different locations)

(iii) types of water sources used on a seasonal basis and along migratory treks, and factors determining watering rights

(iv) selection of areas for grazing (including crop residues) in terms of soils, topography, vegetation types, and availability of preferred plant species

(v) foraging behavior of cattle, sheep, and goats with respect to diet, plant species preferences, amount of grazing-time in different range-soil communities and harvested fields, and the timing of various activities (feeding, ruminating, walking, standing, shading, lying down, and combinations of these)

(vi) effect of forage conditions and water availability on items (ii) to (v) above

(vii) impact of burning and cultivation (traditional and mechanized) on water and forage availability, and response to these

c) decision-making process and responsibilities concerning items (a) and (b) above

d) conflicts between different groups (pastorialists and farmers) over access to grazing, water, use of harvested fields, and crop damage by trespassing animals.

2. Herd Structure and Productivity of Different Species of Livestock and Associated Husbandry Practices

a) herd size, composition, and productivity of cattle, sheep, and goats distinguished by age, sex and physiological status as shown below:

Cattle	Sheep and Goats	Physiological Status
0-2 months	0-1 month	Sex
3-6 months	2-4 months	Castrated
7-12 months	5-7 months	Immature
13-24 months	8-12 months	Mature
25-36 months	13-24 months	Pregnant w/o suckl.yg
37-48 months	25-36 months	Pregnant w suckl.yg
4-6 years	37-48 months	Not pregnant and dry
7-9 years	4-6 years	Lactating and not pregnant
over 9 years	over 6 years	

b) herd productivity will be analyzed using data in (a) above, augmented by informal interviews with livestock owners for information on the following:

(i) reproduction, calf (young) survival, and recruitment rates
(ii) male to female ratios, particularly in calf, immature and mature age classes
(iii) parturition intervals
(iv) seasonality of conception and parturition
(v) frequency of twinning and triplets in sheep and goats
(vi) age at weaning
(vii) age at first parturition, and first twinning in small ruminants
(viii) calving, kidding, and lambing histories of all females examined in assessments of herd composition
(ix) milk yields and seasonal changes in these (see also proposal #9)
(x) mortality and causes by sex, age, and physiological condition classes(includes abortions)
(xi) total off-take including mortality
(xii) relationship between the average and range of variation in the above production parameters with grazing conditions as they change from season to season and year to year

c) husbandry practices and seasonal variations in these in terms of:

(i) division of cattle into milk and range herds and reasons for this
(ii) milking practices and separation of young from mothers with regard to the timing of these activities and the relative proportion of milk taken for consumption or sale
(iii) bull selection and breeding
(iv) culling procedures, and the selection of animals according to species, age, sex, and physiological status for sale and various types of consumption
(v) food and mineral supplementation, including salt, in terms of the types, amounts, frequency, and cost of supplements fed, and the selection of animals for the benefit of these supplements
(vi) measures taken and opportunities available in the care of weak, injured and diseased animals

3. <u>Identification and Discussion of Constraints with Pastoralists to Develop Suitable Interventions for Alleviating these</u>

Analyses of data gathered in (1) and (2) above should focus on key nutrition and health/disease factors which influence animal productivity (i.e. growth, maturation, reproductive performance, mortality, milk yield, and off-take). The following in particular should be evaluated:

a) physical, ecological,and socio-economic factors affecting

(i) grazing conditions in terms of quality, distribution, and availability of forage on a seasonal basis
(ii) sources, distribution, and availability of water
(iii) utilization of crop residues and by-products

b) the efficiency and adequacy of grazing and husbandry-managment practices in relation to:

(i) human labor requirements
(ii) protein and energy demands of animals
(iii) energy expenditure of animals travelling to and from water and grazing, and amount of time available for grazing
(iv) range-utilization patterns
(v) nutrition and care of young animals, particularly calves
(vi) food and mineral supplementation, particularly in the dry season for young, pregnant, lactating, and weak or sick animals
(vii) selectivity in breeding
(viii) culling practices and off-take
(ix) health care and measures for disease prevention and control

c) environmental, biological, and infrastructural factors associated with the incidence, avoidance, and control of major diseases, parasites, and biting insects

d) the nature and efficiency of marketing facilities for traditional producers

Information derived from the proposed research will provide a sound basis for developing appropriate interventions directly relevant and applicable to the needs and constraints of traditional pastoralists in Kordofan. Properly used and modified, the information generated should be adaptable to groups in other geographical regions where similarities in agricultural activities and environmental characteristics exist. The result should be an overall improvement in the long-term productivity and stability of traditional agriculture in Western Sudan.

Methodology

Research proposed closely follows the farming systems approach. Secondary sources of information will be used to help design and implement reconnaissance surveys to identify target groups according to (a) homogeneity in terms of agricultural activities and environmental characteristics (recommendation domains), and (b) their relative importance to the area's agricultural economy.

Within these domains, representative transhumant fariqs and sedentary villages will be selected on the basis of reasonable logistical access, and demonstrated potential for cooperation. Selected groups will form the fundamental units in carrying out definitive, diagnostic surveys and observations following the exploratory phase. The actual number of transhumant fariqs (both short and long-distance) involved should not exceed 10, and may be nearer 6 in order to develop confidence and mutual trust between researchers and producers, as well as to reduce logistical constraints and loss of continuity. Sedentary Nuba villages selected will likely number 3 or 4 because of their larger size relative to fariqs, and also for reasons similar to those stated above.

The diagnostic process is iterative and dynamic in nature, and will involve close interactions and informal interviews with individuals and groups, as well as extensive and intensive observations on animal herds and related activities. Interviews and discussions will not follow a fixed or systematic pattern, but rather will use a topical outline that is both specific and flexible in content. In many instances, diagnost surveys will involve an integrated effort of more than one discipline to examine technical or socio-economic aspects that are consistent with the

objectives of the proposal.

Information gathered from interviews will be augmented by direct field observations, some of which will be quantitative for components requiring specific technical input (e.g. seasonal patterns of range-use and foraging behavior of livestock; herd composition and productivity; diagnoses of various diseases, parasites, and biting-insect problems). Many of these activities will require examining individual animals and entire herds, and also following these during movements to and from grazing and water at different seasons.

Literature Cited

Ahmed, Abdel G.M. 1976. The question of pastoral nomadism in the Sudan In: A.G. Ahmed, Some aspects of pastoral nomadism in the Sudan.

Andrews, F.W. The Vegetation of the Sudan. 1948. In: Tothill, J.D. ed. Agriculture in the Sudan, Oxford Univ. Press, London, 974p.

Cunnison, I. 1962. Some social aspects of nomadism in a Baggara tribe. In: Philosophical Society of the Sudan. Proceedings of the 10th Annual Conference. Khartoum Univ. Press, Khartoum.

_____ 1963. Subsidiary nomadic movements of the Humr. The Geographical Magazine 1: 25-30. Khartoum Univ. Press, Khartoum.

_____ 1966. Baggara Arabs. Oxford: Clarendon Press.

_____ 1976. Some social aspects of nomadism in a Baggara tribe. In: A.G. Ahmed: Some aspects of nomadism in the Sudan, pp. 65-80.

Haaland, G. 1975. Some economic and ecological aspects of traditional systems of livestock management. Anthropoligiska Studier 15:21-29. Dept. of Soc. Anthro. Stockholm, Sweden.

_____ 1980. Social organization and ecological pressure in Southern Darfur. In: G. Haaland, ed.: Problems of Savannah Development. pp. 55-106.

GTZ, 1977. Nuba Mountain Region Development Potential Survey, Vols. 1 & 2 Agrar-Und Hydrotechnik GMBH, Essen, for the Democratic Republic of the Sudan.

Harrison, M.N. 1955. Report on a Grazing Survey of the Sudan. Khartoum mimeographed 250 p.

_____ & J.K. Kackson. 1958. Ecological Classification of Vegetation in the Sudan. Sudan For. Dep. Bull.No.2.

HTS, 1981.

Iten, O. 1979. Economic PRessures on Traditional Society. Social Econ. Series XXIX Vol/Bd 8, European Univ. Press, Bern. 163 p.

Johnson, D.L. 1974. Changing patterns of pastoral nomadism in North Africa. In: Hoyle, B.D. ed.: Spatial aspects of development. John Wiley, N.Y.

Lebon, J.H.G. 1965. Land Use in Sudan. Bude Geographic Publ. 191 p.

Manger. L. 1980. Cultivation Systems and the Struggle for Household Viability under Conditions of Desert Encroachment. In: G. Haaland ed. Problems of Savannah Development, pp. 133-166.

Mustafa, M.A.R. 1980. A comparison of sedentary cultivators and nomadic pastoralists and their market integration in the Radoam Area of S. Darfur. In: G. Haaland, ed.: Problems of Savannah Development. pp 107-132.

Nadel, S.F. 1947. The Nuba. Oxford Univ. Press. London.

Resource Management and Research Ltd. 1975. Pilot Livestock Census of South Kordofan, Vol. 3. Khartoum, Min. of Agric.

Smith, J. 1949. Distribution of tree species in the Sudan in relation to rainfall and soil texture. Sudan For. Dept. Bull. No. 4.

Stevenson, R.C. 1965. The Nuba People of Kordofan. Univ. of Khartoum MS thesis.

Tothill, J.D. 1948. Agriculture in the Sudan. Osford Univ. Press. London 974 p.

Wickens, G.E. & L.P. White. 1979. Land-use in the southern margins of the Sahara. In: B.H. Walker, ed.: Management of Semi-Arid Ecosystems.
Elsevier Sci. Publ. Co. N.Y.

Resource Requirements

Senior Staff	% Time
Dr. Bunderson	35.0
Mr. Abu Sabah	20.0
Dr. Fadlalla	10.0
Dr. Cook	10.0
Dr. Teitelbaum	10.0
Dr. Patrick	10.0

Graduate Students	% Time
Ms. Michael	10.0
Mr. Gadir	10.0
Technical Staff	
Junior Technician	10.0
Senior Technician	20.0
Equipment	
4-wheel drive truck	35.0
Camping gear (1 tent, 4 chairs, 5 cots, 5 sleeping bags, 1 table)	35.0
Hand Calculator	35.0
Lab. Facilities	5.0
100 cotton bags (50 x 40cm)	100.0

WSARP RESEARCH PROPOSAL

Identification:

Station: Kadugli

Experiment No.: 13

Title: Bush Control Studies for Improving Rangeland Productivity and Utilization in South Kordofan

Principal Investigator: Dr. Bunderson, Range Ecologist

Cooperators: Dr. Fadlalla, Animal Nutritionist; Dr. Cook, Livestock Production Scientist; Dr. Teitelbaum, Socio-Anthropologist.

Time Frame: March-October 1982: Identification and delineation of treatment plots and assessment of vegetation composition within each.

October 1982-June 1984: Implementation and monitoring of bush control trials and initiation of a large-scale bush control program using a farming systems approach. Subsequent treatments and evaluations to be made every two to six years.

Objectives:

The long term aim of this research is to improve the carrying capacity and utilization of rangelands in the south through bush control and to develop the integration of sedentary and transhumant components in the region to achieve this objective. Intermediate objectives are:

1) To find practical and cost-effective methods of reducing the density of bush, such that the establishment and productivity of the herb layer is enhanced, with maximum use of the wood harvested in the process.
2) To better understand the impact of fire on bush species in this area and its possible adverse effect on the composition of herbaceous vegetation.
3) To evaluate the use of goats for more efficient utilization of wood vegetation, much of which is currently lost to the range-livestock system, while simultaneously controlling the encroachment of bush and increasing livestock productivity and off-take.

Rationale:

The wooded savannas of South Kordofan contain a significant proportion of

productive woody vegetation, particularly on jebel hillsides and in the clay plains where dense woodland thickets are not uncommon. Yet despite its abundant and high quality forage, browse production largely goes unused. This is due to the fact that the ungulate community is composed primarily of cattle and sheep, predominantly grazers, with fewer numbers of goats and camels, mainly browsers. Wildlife, which were apparently common in the area at one time, have been virtually eliminated from the region due to emigration away from the rising human and livestock population densities and expanding cultivation, as well as to excessive, uncontrolled hunting. It is likely that the structure and density of woody vegetation were quite different in time of former wildlife abundance, and that bush encroachment was less of a problem.

With the current mix of domestic livestock in South Kordofan, the numbers of browsing animals are insufficient to make efficient use of the woody vegetation. Left unchecked, a serious problem of bush encroachment results. This in turn affects the growth and development of herbaceous vegetation, leading to a significant reduction in the carrying capacity of the range.

The occurrence of bush problems over much of South Kordofan clearly demonstrates a need for control measures. Moreover, due to the absence of adequate browsing, tremendous quantities of productive woody vegetation, even in areas where bush is not excessive, are lost to the range livestock system. This loss is all the more evident since woody vegetation remains green and nutritious well into the dry season, and long after the forage value of grass has declined. Research herein proposed is aimed at reducing the density of bush with effective, inexpensive methods, in order to increase the carrying capacity for livestock, and to achieve more efficient utilization of the range.

Literature Review:

Although no published data exist on bush control in South Kordofan, information is well documented in East and Southern Africa where problems are likely

to be similar to those encountered in Western Sudan. In general, vegetation in savanna areas of tropical Africa tends to develop into a bush or woodland climax unless natural succession is diverted or arrested by extraneous factors, such as fire and heavy browsing (Bogdan 1954; Heady 1960; Knight 1965; West 1965; Glover 1968; Savidge 1968; Laws 1969; Bourliere and Hadley 1970; Pratt and Knight 1971; Harrington and Ross 1974; Ross, Field, and Harrington 1976; Caughley 1976; Bunderson 1981).

In many parts of the world, the financial benefits of bush control are well established, but such information is usually absent in tropical Africa. However, for land of high potential, the economics for controlling bush are not really in doubt, while in drier regions more quantitative data are needed (Pratt and Gwynne 1977). The amount spent economically is related to the present value of land, expressed as the gross annual return per unit area, and the increase in productivity that is likely to accrue.

Methods for bush control vary greatly in cost but there is no single method suited to all situations. Fire, hand and mechanical cutting, chemical treatment, browsing, or various combinations of these have all been used as methods of bush control. The degree of success is dependent on local conditions and types of trees/bush present. In South Kordofan the number of troublesome species is large and their response to different treatments may be variable. Using information available in the literature, the effective minimizing adverse effects on herbs will be employed.

Methods:

Research will be organized into central and support thrust components. The latter will involve applied research on the station lands where the effectiveness and vegetation impact of various bush control treatments will be tested and monitored over time. The central thrust activity involves an on-range experiment of bush reduction with sedentary and transhumant charcoal makers.

Because the second approach demands the control and manipulation of a large tract of land, it may be necessary to conduct the research on a segment of station land which is representative of the bush problems existing in the Nuba Mountain region. Details of each research prpgram are presented below.

Bush-Control Treatment Studies:

Approximately ten hectares will be set aside on the station's experimental land where methods for controlling bush will be studied for the purpose of rangeland improvement. The assessment of fire as an effective tool in controlling bush in this area, and its impact on herbaceous composition, will play a major role in these studies.

Identification of a suitable piece of land will proceed by systematically surveying the entire station land on foot. Site selection will be determined by the following necessary features:

1) The density of woody species over 2 m in height must exceed 1000/hectare.
2) Soils and vegetation should be characteristic of dark, cracking clays.
3) The above soils and vegetation must be homogeneous in structure and composition.
4) The site must not consist of a single species stand, but rather must contain a number of common trees and shrubs, among which are more than one troublesome species.
5) The site should show signs of rapid bush encroachment, i.e. woody species must reflect a wide range of height and age class distributions rather than one entirely of mature trees.
6) The area chosen must not conflict with other research station activities such as agronomy and range-livestock experiments.

Once identified the site will be delineated into a total of eight plots, each measuring 0.5 hectares in size, except one of the goat treatments, which will measure 1.0 hectares. Plot and treatment layout is depicted in Figure 1.

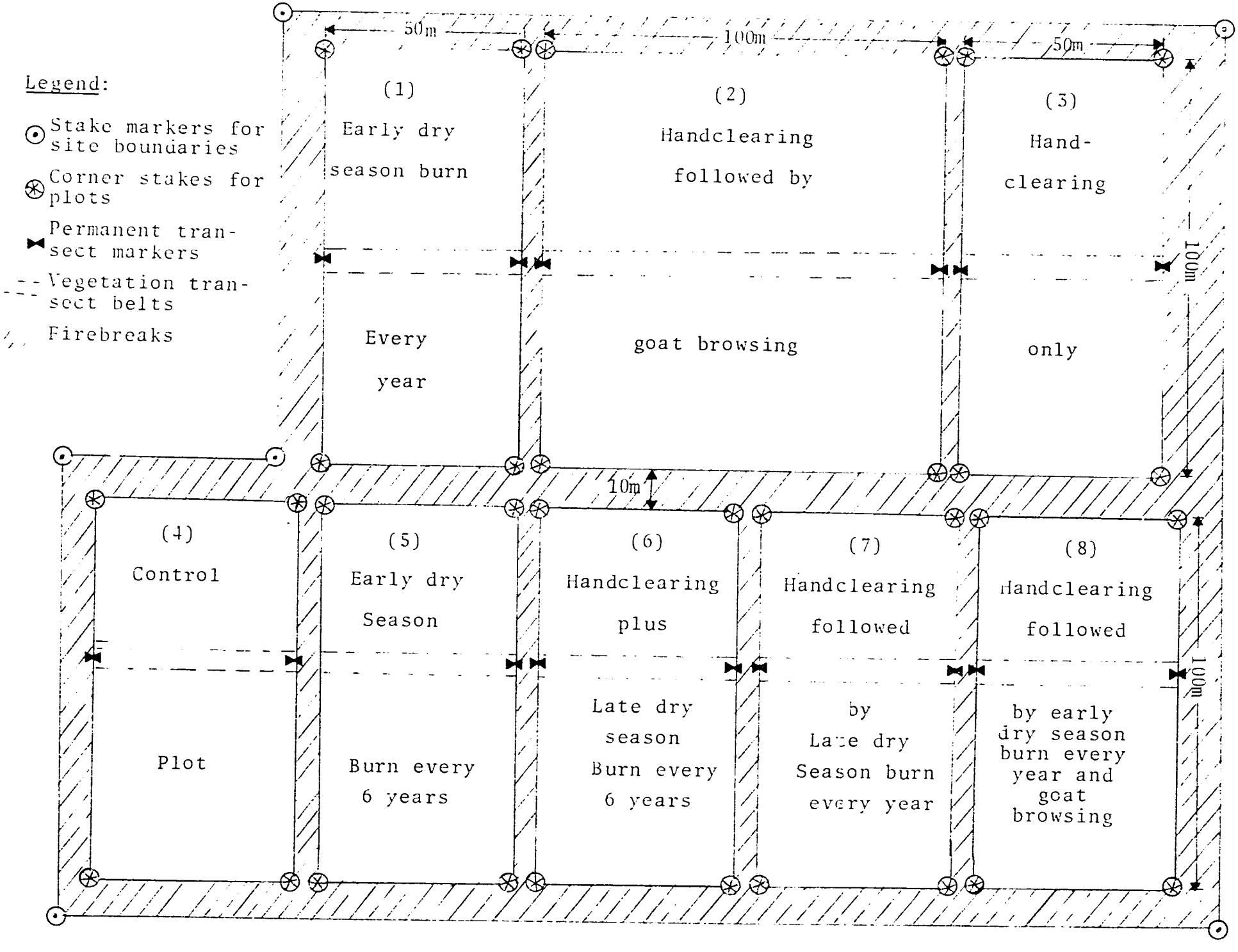

Figure 1: Design and Layou of Bush Control Plots

To avoid unnecessary time and cost, only the treatment using goats will be fenced off. Others will be marked by steel-angle stakes driven into the corners of each plot.

Firebreaks will be established around the entire site and between indivi-ual treatment plots. Prior to treatment application, the woody and herb composition of each plot will be determined, so that subsequent changes in vegetation can be quantified and related to the effect of the treatment. The sampling procedure will entail the use of a permanent transect belt, 4 m wide, running across the width of each plot at the mid-point (see Figure 1). The ends of the transect will be marked with a 1.5 m steel stake driven 1 m into the ground. All woody vegetation found within the transect belt and greater than 0.1 m in height, will be recorded by species and height categories. Herbaceous cover and composition will be determined at the end of the growing season using a two-point frame and two plots at one meter intervals along the center line of the transect (for more details see Methodology section of the proposal for Rangeland Classification and Evaluation).

Treatment implementation will begin at the end of the rains in late October/early November 1982. Early season burns will be conducted as soon as the grass is sufficiently dry to carry a good fire. Late season burns will be set during the period of April-June depending on the amount of combustible material available. Handclearing[1] of plots will be carried out in early November, leaving approximately 10% woody cover for shade and forage diversity. Subsequent treatment with goat browsing in plot (2) (see Figure 1) will follow as soon as there is sufficient regrowth.[2]

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1. Mechanical cutting will be limited to handclearing due to the high cost of machinery and unavailability of fuel and parts. Moreover, the advantage of handclearing is that it is selective and can be combined with charcoal making for more efficient use of the range.

2. Woody debris will not be burned on site, but moved out so as not to confuse the results and causes of vegetation change.

Goat browsing should be intensive over a short period of time to achieve optimum effect on regrowth. The stocking rate used will depend on the estimated carrying capacity of the plot following clearing and the time over which browsing is required. Since some useful production and nutrition data on goats may result from this study, particularly for carrying capacity determinations, the time of browsing may be extended from the ideal of less than one month to as much as three months.

Although chemicals may result in a complete kill of bush with no regrowth or damage to grass, their cost is often prohibitive. This is particularly true in Sudan and hence the use of arboricides is not planned.

'On-Range' Bush-Control Experiment:

The likelihood of acquiring a large piece of land outside the research station for conducting various types of severe manipulation is low. For this reason, it may be necessary to use a portion of unimproved land on the station for an 'on-range' bush-control experiment. The area selected should be 100-200 hectares in size and dominated by clay soils with a high density of woody vegetation.

The experiment will entail: 1) engaging sedentary segments of the population to hand-clear bush under supervision to a level where about 10% woody vegetation remains, 2) to combine hand-clearing with charcoal making of the cut vegetation, and 3) to stock the cleared land with sufficient numbers of goats and possibly other species to control regenerating bush.

Ideally, the sedentary group used for bush clearing should be professional charcoal burners recruited from areas around Kadugli. The charcoal makers will receive all benefits and cash returns derived from the sale of charcoal. Other incentives may include the provision of station water to the people as well as some transportation to Kadugli.

Transhumant and nomadic herdsmen will be contacted in an effort to obtain

their participation in the program whereby a certain number of goats, cattle, sheep, and possibly camels will be grazed on the cleared land for a specified length of time. The numbers of animals used will depend on the carrying capacity of the area following clearing. Emphasis will be placed on goats and camels as these animals are primarily browsers. The land should be intensively stocked for maximum impact on bush regeneration. Increased forage production and land with reduced bush cover should provide sufficient incentives for transhumant participation. If station land is used access will be provided to improve grazing which otherwise would not be available.

The success of this bush control experiment is dependent on effective browsing on bush regrowth since hand clearing alone is unlikely to be sufficient unless repeated at frequent intervals. On a much larger scale this implies a need for greater numbers of browsing ungulates in the south. It is proposed that under proper management substantial increases in goat numbers could improve the utilization and carrying capacity of range resources in South Kordofan, while simultaneously effecting bush control. Moreover, livestock productivity, including commercial off-take, could be raised significantly if efforts are made to encourage and develop a more efficient marketing infrastructure with strong ties on international trade. Such a structure would help provide a self-regulating mechanism for maintaining livestock numbers in balance with the food supply and for increasing the economic stability of the household.

It is perhaps worthwhile to note the relationship between goats and overgrazing. The perception that goats cause environmental degradation is somewhat misleading since this is basically a function of management rather than the feeding habits of a particular animal. Regardless of the species, range deterioration will result if there are too many animals, particularly during the critical times of the year. Overgrazing in many areas is initiated by other species

of domestic livestock such as cattle and sheep. Their absence is due to their inability to survive in the degraded environments they produced. By contrast, the presence of goats in these areas produces a belief that the animals are associated with, and therefore responsible for deteriorating conditions. Although goats in the absence of proper management can certainly aggravate the situation, their valuable role within the household must be recognized because:

1) goats are the only species capable of effectively utilizing these areas due to their fastidious feeding habits, and
2) they are impressively productive in terms of milk yields, reproductive performance, etc.

For these reasons goats provide an important if not essential source of food and economic security to the inhabitants of desert and degraded environments.

RESOURCES REQUIRED

Staff	Allocation of Time
Dr. Bunderson, Range Ecologist	10%
Dr. Fadlalla, Animal Nutritionist	2%
Dr. Cook, Livestock Production Scientist	2%
Dr. Teitelbaum, Socio-Anthropologist	2%
One Driver and Assistant Driver	10% each
One Senior Technician	10%
One Junior Technician	10%
Four Field Laborers	20% each

Land, Equipment, and Animals

100-200 hectares of unimproved station land for large scale bush control program

10 hectares of station land for bush control plots with fencing materials for one hectare

10 goats for bush control plots

50 steel stakes 1.5 m in length

One compass

One 60 m measuring tape

One 4-hweel drive vehicle

REFERENCES

Bogdan, A.V. 1954. Bush-clearing and grazing trials at Kisokon, Kenya. E. Afr. Agric. J 19:253-259

Bourliere, F & M. Hadley 1970. The ecology of tropical savannas.

In: R.F. Johnston, P.W. Frank, C.D. Michener (Eds). Ann REv. of Ecol. & Syst. No. 1. Ann. Rev. Incorp. Palo Alto, Calif.

Bunderson, W.T. 1981. Ecological separation among wild and domestic mammals in an East African ecosystem. PhD dissertation, Utah State Univ. Logan, U.S.A.

Caughley, G. 1976. The elephant problem - an alternative hypothesis. E. Afr. Wildl. J. Vol. 14 : 265-285.

Glover, P.E. 1968. The role of fire and other influences on the savanna habitat, with suggestions for further research. E. Afr. Wildl. J. 6: 131-137.

Harrington, G.N. & I.C. Ross 1974. The savanna ecology of Kidepo Valley National Park. I. The effects of burning and browsing on the vegetation. E. Afr. Wildl. J. 12: 93-105.

Heady, H.F. 1960. Range Management in East Africa. Govt. Printer Nairobi, 125pp.

Laws, R.M. 1969. The Tsavo Research Project. J. Reprod. Fert. Suppl. 6 : 495-531.

Pratt, D.J. and M.D. Gwynne 1977. Rangeland Management and Ecology in East Africa. Hodder & Stroughton, London 310pp.

Pratt, D.J. & J. Knight 1971. Bush control studies in the drier areas of Kenya. V. Effects of controlled burning and grazing management on Tarchonanthus/Acacia thicket. J. Appl. Ecol. 8:217-237.

Ross, I.C., C.R. Field & G.N. Harrington 1976. The savanna ecology of Kedepo Valley National Park, Uganda. III. Animal populations and park management recommendations. E. Afr. Wildl. J. 14: 35-48.

Savidge, J.M. 1960. Elephants in the Ruaha National Parks, Tanzania-management problem. E. Afr. Agric. J. 33 (special issue): 191-196.

West, O. 1965. Fire in vegetation and its use in pasture management, with special reference to tropical and subtropical Africa. Memeogd publs. Commonw. Bur. Past Fld. Crops 1/1965: 1-53. Farnham Royal, England.

WSARP RESEARCH PROPOSAL

Identification:

Station. Kadugli

Experiment No.: 14

Date of Proposal: September 1982/Updated May 1983

Beginning Season for Research: Start of Dry Season 1982

Subject of Research: The Social and Economic Organization of Transhumance in South Kordofan - Factors Affecting Production Among Agro-Pastoralists

Principal Investigator: Dr. Joel M. Teitelbaum, Socio-Anthropologist

Co-Investigator: Dr. Babo Fadlalla, Animal Nutritionist

Assistance of: Barbara Michael, Associate-in-Research
Mahmud Awas Mekki, Trainee
Ahmed Ali Ahmed, Junior Technician

Special Market Study: Dr. Patrick

Cooperating Entities: WSARP from the Range-Livestock Section, Dr. Bunderson, Dr. Cook, other staff on a contribution basis, Rural Economy Dept. U. of Khartoum, Kordofan Regional Government, Office of Nomadic Affairs, Ministry of Agriculture, Range Department.

Linked Studies: Range-Use Patterns and Livestock Productivity. Dry Season Supplementary Feeding Sentinal Migratory Herd (Range-Livestock Section). Ag. Marketing Study (Socio-economic Section, Dr. Patrick).

Proposal Title: TRANSHUMANT PRODUCTION SYSTEMS STUDY (A diagnostic and monitoring study of the organization and household management of migratory herding and cultivation in the central districts of South Kordafan and the impact of change).

Duration: Twenty months (November 1982 through June 1984)

Overall Objective:

The basic aims of this study are to obtain qualitative and quantitative data sufficient to describe and diagnose the transhumant nomad system of the target area. The study will identify the constraints to production in migratory herding and cultivation practices across the annual cycle.

The intermediate objective is to clarify the variables in this system that encourage transhumants to adopt a more sedentary mode of livestock and crop management and to determine the incentives and constraints that perpetuate transhumance. Also included are the factors that promote "nomadization" of settled farmers. The study will demonstrate the existing stragegies of household use of range, water and soils in transhumance.

Results of this study will provide diagnostic data for application to on-range, in-herd, and on-farm research by WSARP staff in the design of improved production methods. Agricultural scientists will be assisted in taking into account cultural acceptability factors affecting the introduction of changes among transhumants.

The monitoring portion of the study will provide longitudinal information to assess the socio-economic impacts of WSARP interventions on the agricultural well-being of transhumant households. It will also show the effects of improved production practices on tendencies toward sedentarization and nomadization. The effect on marketing practices and on transhumant household consumption levels will also be assessed.

Background and Literature Review:

The literature on livestock raising in Western Sudan has characteristically divided people into distinct ethnic (or tribal) groups, each associated with a limited mode of exploitation of the land and with very different modes of livestock raising. However, more recent literature on South Kordofan and Darfur (Hunting Technical Services 1981; Haaland 1975; Roden 1972) points to a need for research on the existing systems of production and their trends over time, rather than equating culture with fixed economic systems. In the past, major pastoral nomadic groups in Western Sudan took their names from the most highly prized species of domesticated livestock. Thus, the Baggara are identified with cows, the Jammaliya with camels, the Kabbabish with sheep. The "cattle complex"

in which the idiom of cultural values is expressed through a breed with special characteristics has been described for the Nuer and Dinka tribes (Evans-Pritchard and G. Lienhardt 1940), while an attachment to the nomadic life has been the dominant theme of other anthropological publications (Cunnison 1965, Asad 1967). In reality, the pastoral transhumants do not usually limit their husbandry to a single species, but combine the raising of a major livestock animal, such as cattle or camels with that of small ruminants such as goats and sheep, or vica versa. Specifically in rainfed zones where regular cultivation is possible, the major food supply of transhumant nomads comes from their cultivation of grain on established plots of land, followed by livestock milks and meats and purchased foods.

Since the 1950's there are references in the literature to the "sedentarization" of many transhumant nomads and their transformation into village-dwelling farmers associated with a decline in herd ownership. Yet these new "traditional" farmers retain their tribal identity. The Sudanese government has a policy of obliging or encouraging nomads to settle and join government-sponsored agricultural schemes, but this occurs less in Kordofan than elsewhere.[1]

Although large numbers of the Baggara cattle grazers of South Kordofan have "settled out", others remain transhumant and there is substantial evidence of inter-household groupings between them to form a combined management system for cropping and livestock transhumance knows in the literature as Agro-Pastoralism (Delgado 1979, Swift 1976, Teitelbaum 1980).[2]

At the other extreme is the typical sedentary farm household which is thought to raise few livestock and to keep them close to their villages year-round without seasonal migration to the North. This type of farming system is most closely identified in the literature with the various Nuba tribes of South Kordofan, each associated with a distinct mountain range and plains area. Since together

the many Nuba tribes make up 60% or more of the population of rural South Kordofan, their role in livestock raising can also be substantial (Sudan Census 1954-73).

However, the modes of existence of settled Nuba farmers, transhumant Baggara nomads, and other smaller groups in this province have altered significantly since the beginning of the 20th century, especially with the establishment of the Anglo-Egyptian Condominium and the coming of Sudanese independence in 1956. The total population of the province has nearly doubled each generation to more than 1.4 million in 1982. Over half the Baggara tribes (numbering about ¼ of the total) have become sedentary and operate farming similar to that practiced by Nuba cultivators. Another process has been observed (Haaland 1976, Roden 1972) in which settled farmers, both Baggara (and other Arabs) and Nuba have "nomadized", i.e. changed their livestock management practices to follow the transhumant pattern between southern and northern ecological zones on a seasonal basis. This phenomenon deserves scrutiny by means of socio-economic research to determine the current incentives to nomadization after a lengthy period of sedentarization. Factors beyond ethnic differences seem to be at the basis of both these human ecological tendencies and the variables that constrain or encourage them require identification.

The literature does not contain data on the constraints to livestock and crop production associated with the transhumant mode or the impact of sedentary life styles on animal production. A Hunting Technical Services study (1981) (limited in scope) found no significant difference between the productivity and survival rates of sedentary and transhumant cattle herds in South Kordofan. Other authors suggest a significantly higher production of meat and milk along transhumant herders of Baggara-type cattle. Sudan government agencies have tended to view transhumant nomads as resistant to changes that would improve crop and livestock production and as creating conflicts with settled farmers that reduces grain field output. Planners have considered the semi-nomads to

be backward, "irrational anachronisms" who would disappear with the modernization of farming. However, the more recent tendency in South Kordofan is toward increased levels of transhumance by more people with larger herds in response to the rapidly inflating price of livestock for meat in northern markets (Mohamed 1976).

Many Nuba households have purchased Baggara-type cattle, crossbred them with their own small type of cow and sent them on the northern migration during the rainy season. As with settled Baggara, this is done either by an entrusting arrangement with existing transhumant households or by developing a herd large enough to justify the householders becoming transhumants themselves. The estimated rate of sedentary nomadization, according to the literature, is on the order of 1% per annum. As this process is cumulative over time it can add to the already increasing burden of transhumant migration across the rangelands of Kordofan each year (Haaland 1976, Roden 1972).[3]

The impacts of increasing the number of animals on seasonal ranges have been documented by Bunderson and others in Kordofan (WSARP Annual Report 1980-81). The grasses of Northern Kordofan's sandy soils are likely to be seriously over-utilized leading to ecological degredation, if not desert land. However, plentiful grasses and other forages on the clay soils of the Nuba Mountains area in South Kordofan are an under-utilized, renewable range resource. <u>From a resource base perspective the long-term productivity of South Kordofan ranges favors increased maintenance of livestock herds in the Nuba Mountains region, i.e. more sedentary herding/grazing patterns.</u> It appears that short-term benefits of a seasonal nature tilt many livestock keepers toward the transhumant pattern.[4] These countervailing tendencies are in need of systematic research proposed here (Dwyer Report, WSARP 1981). The research issues for this study include:

1) The organization of transhumant agro-pastoralism

2) Variables leading to sedentarization and nomadization

3) Human factors involved in migratory livestock and range productivity

4) Socio-economic impact analysis of improved production and the marketing response to it

Proposed Methodology:

This methodology is based on a Farming Systems approach in incorporating recommendations from the WSARP Mid-Term Evaluation. The method of data collection is based on a longitudinal panal sample of a selected number of representative households. The research will take place in four overlapping phases:

Phase I will be accomplished during the first three months and will be a reconnaissance of migrant herding camps during their southward migration and crop harvest.

Phase II beginning in February 1983 will initiate diagnostic interviews with households from several transhumant camps spread throughout the central Nuba Mountain region. The interviews will determine their dry season movements and related production constraints as well as the social and economic characteristics of the component households engaged in agro-pastoralism.

In Phase III the previously interviewd household panel will be revisited during the northward migration in the following rainy season and during their return to the south July through November 1983). Data will be collected during transhumance as well as the organization of the migration.

Phase IV will monitor the data on the impact of WSARP interventions and will be collected at any or all points in time.* Interim reports will be submitted for Phase I and II, with a final report on Phases III and IV at the end.

The project study area is limited to the corridor in the Central Districts of South Kordofan within 50 miles of Kadugli during the dry season and the sandy area between Debeibat and El Obeid (N. Kordofan) during the rainy season.

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*In Phase Iv no beginning versus ending evaluation data collection effort is anticipated. Monitoring data on interventions with panel households will provide data points throughout the life of the study. (See WSARP Mid-Term Evaluation, p.25).

Reasons for siting the study in this area include:

1) The need to follow a complete annual migration cycle to obtain diagnostic information and follow-up with benchmark data on households receiving interventions.

2) Personnel and resources available at Kadugli Station are not sufficient to cover all of South Kordofan (and parts of Northern Kordofan) in one field study effort. The longitudinal distances covered create a travel problem due to anticipated shortages of transport and fuel. The WSARP El Obeid Station facilities will provide rainy season access to fuel and field back-up. Later the study can be widened to look at transhumance in the Eastern and Western Districts of South Kordofan and parts of Southern Darfur.

3) Many of the problems and some constraints have been preliminarily identified on ranges in the Kadugli area by WSARP range scientists and social scientists. Research efforts to define the transhumant system will focus on coordinated research activity among WSARP team members in this area.

4) The area to be studied includes a majority of one Baggara tribe, the Hawazma, with whom preliminary reconnaissance has been initiated.[2] It also is used by the adjacent Messiriya Zuruq tribe, allowing for comparative data collection.

5) Households from a variety of Nuba tribes settled within driving distance of Kadugli have been identified as subject to nomadization. Settled Baggara in the area have also re-nomadized. Hence, the locale provides a microcosm of the variables and factors to be researched.

Sampling and Follow-Up Procedure:

The decision to use a panel sample for this study is based on the field situation in which a longitudinal research effort is to be made on a limited number of transhumant households and their associated groupings over a complete migratory seasonal cycle. An informal survey on relatively fewer households is expected to provide essential "systems" diagnostic information needed for use in on-farm, in-herd, on-range research; it is preferable to an extensive cross-sec-

tional formal survey of many more households. This is because the variables to be examined are processual in nature rather than frozen during a single month or season of the year. Other data derived from previous studies from the literature will be compared to the panel study results.[5]

Several transhumant camps containing up to ten households will be studied during successive phases. The households will be stratified according to three major criteria: 1) the number of large livestock (cattle) per household divided into large herds, middle-size herds, and small herds (dividing points to be determined by natural clusters of herd numbers); 2) the type of household, i.e. transhumant, of transhumant tendency, or of sedentary tendency; 3) the cultural characteristics of the households, meaning their tribal identity and values associated with livestock and farming, among the Hawazma and Messiriya Zuruq of the Baggara, and the Moro, Mira, or other nomadizing peoples among the Nuba.

A series of three illustrative case studies of specific types of households will be carried out during Phases II, III, and IV by the anthropological method of participant-observation in combination with sample data derived from the panel study schedule. The three case-types are:[6]

1) A transhumant Baggara household that maintains its migratory pattern on a regular basis and demonstrates the constraints and opportunities of a persistent strategy of semi-nomadic transhumance for the owners of a middle-sized, "typical" herd.
2) A sedentarizing household that has begun to settle out of the transhumant stream and adapt to a more limited movement of herd animals within an area of the Central Districts in South Kordofan.
3) A formerly settled household (preferably of Nuba tribal background) which has entered the transhumant system recently and adopted migratory practices to an increasing extent.

Although the concentration on herd management involved in transhumance tends to be on cattle herds, this study will also collect relevant social and management information on small livestock such as goats and sheep which can adapt to both the transhumant and sedentary modes of existence. Beasts of burden such as camels and donkeys will also be examined for their role in the migratory process, as will crop cultivation practices.

In sum, the intent of this methodology is to study transhumant households in the context of their constraints and incentives to greater production. The study will also test the proposition that transhumance to North Kordofan may affect total productivity and lead to further environmental losses. Up to 60 households are anticipated in the panel sampling segments; three households in the case-study segment.

Social Marketing:

A critical element in WSARP's realistic approach to increasing the productivity of transhumant livestock involves raising the commercial offtake of livestock to prevent over-stocking the range. Over-stocking risks ecological deterioration and increased levels of group conflict for resources. Social marketing represents an approach to this issue in which the transhumant household members' relationship to markets is studied in relation to the internal division of labor, management structure, and incentives and constraints on sale of livestock and livestock products. Without this component it may be counter-productive to overcome the biological constraints on livestock production, thereby simply raising the total number of animals on the range.

This topic area includes a study of gender roles in livestock marketing linked to the system of ownership rights in livestock of household herds. It also requires investigation of the disposition of the proceeds of livestock sales across the annual cycle, including re-investment in animals, expenditures for cost of production, and household consumption and ritual expenditures. In

this portion of the study, the Senior Social Scientist will concentrate on the role of the men in livestock marketing with the assistance of an outside research organization, while the Associate-in-Research will focus on the role of women in livestock and milk marketing practices and in household consumption (i.e. meat and milk products, live animals, skins, beast-of-burden, manure, as well as crop production and consumption).

Marketing Channels : A special study of livestock marketing channels for transhumants will be initiated in cooperation with the Rural Economy Department, U. of Khartoum. A qualified Master's degree student will perform this field-work (July 1983 - June 1984) with guidance from socio-economic section senior scientists and under supervision of Rural Economy Department faculty. The focus of this study is the socio-economic impact of existing marketing channels on transhumant producer household perceptions and livestock market behavior. This study is linked to the WSARP Agricultural Marketing (Livestock) Study, No. 2.

Quality of Life Index:

A simplified index of the quality of transhumant life and measures of change in consumption patterns of transhumants compared to sedentary households will be constructed using the Panel sample population data. This will allow a Phase IV assessment of changes over time linked to WSARP interventions that aim to improve livestock and crop production as well as distinguish the effects of exogenous factors. The Phase IV data component is intended to demonstrate socio-economic impacts of induced change in transhumant herd management and land use on the product households. This type of data will then serve as an instrument for monitoring the human effects of technical improvements in the production system. It will also identify second generation constraints and problems associated with change. The method used allows assessment of the degree to which various production improvements can raise the standard of living for transhumants *vis a vis* sedentarized livestock raisers in South Kordofan.

Once an index is established using the panel study methodology further diagnostic and interaction data can be collected beyond the time frame of this 20 month research effort as a continuation of the research process. Second generation studies will also focus on transhumants in the Eastern and Western districts of South Kordofan and the adjacent area of Southern Darfur which has a similar system of migration. The latter studies can begin in 1984 with the advantage of a developed quality of life index and a better definition of systems characteristics from South Kordofan's Central districts determined by this study.

Staff Resources and Organization:

Given the limited staff availability and time constraints, the study will operate via informal diagnosis and intervention monitoring.

Senior Researchers	Junior Researchers
Dr. Teitelbaum (P.I.),	Barbara Michael
Dr. Babo, Dr. Bunderson,	Graduate Student
Dr. Patrick	Technician

The study will be reviewed by interdisciplinary staff of the Kadugli Station. In addition, a project typist will be utilized to prepare written reports for the study.

Researchers will carry out household interviews during a period of three months in Phase II and two months in Phase III. During Phase I they will spend at least on month carrying out reconnaissance and selection of the sample households panel. Social scientists will (in addition to the above level of effort) spend an extra two months each over the period of the research project on case studies. The writing of reports during and at the end of the study will take a total of two to three months of senior researcher time. Approximately one month of a visiting consultant's time will be used here also. The research effort is expected to utilize over the 20 month period 40% of principal investigator's research time, 60% of junior researcher time, and 20% of typist time.

Physical Resources and Equipment Required:

	Level of Use
Four-Wheel Drive Vehicles (1) (With driver, maintenance, etc.)	33%
Typewriter, English, portables (1)	40%
Cassette Recorders & Cassettes (2) (Battery-run units)	40%
Electronic Calculators (4) (Hand Held)	30%
Camping Equipment (1 set) (For 2 or 3 persons)	25%
Office Space and Typing Service (For 3 persons)	40%

This study also requires access to the project aircraft for travel to North Kordofan during migration, to Khartoum, to Southern Darfur, and to international scientist organizations.

Justification for Research:

The purpose of this research is to provide on-going and adaptive information on transhumance to range-livestock and other scientific staff engaged in on-range in-herd research design and to assist on-station research applications aimed at improving the productivity of livestock, range, and soils. The study will provide data on critical factors that currently constrain or enhance productivity and on the acceptability of improved practices among transhumants and sedentarizing herders. It will zone the transhumant systems of the area with their inherent tendencies. Writings by specialists in pastoral systems on Sudan and elsewhere, such as Swift, Delgado, Cunnison, Haaland, and others, point to the need for understanding the clusters of causation that influence transhumant households in their movement and activities. This knowledge is essential to the successful adoption of improvements as part of the Production Systems model of research and demonstration.

Outputs:

The results of this proposed research will feed smoothly into on-range and in-herd experiments by range and livestock scientists at Kadugli and assist in on-farm agronomic studies also. It will also fit with research in agricultural economics on marketing and the availability of appropriate incentives for herd owners. Specific products include three or more publications. The first will contain reconnaissance findings and ethnographic profiles of the sample household panel (Phase I). The second will be the result of the dry season interview schedule and the selection of initial interventions (Phase II). The final report will include the results of Phases III and IV, including the wet season migration and the case studies. It will also contain a report on monitoring socio-economic impacts of WSARP interventions and on the social marketing of livestock and the quality of transhumant life.

As this study is intended to provide regular feedback to inter-disciplinary researchers within WSARP and in other agencies, there will be seminars and consultations with the entire WSARP research network and meetings with regional, national, and international scientists. A paper on the transhumant system will be presented at an international meeting by the principal investigator.

NOTES

1. "An examination of the (planners) method. . . for the development of traditional agriculture shows that there is an undeclared objective in these plans, namely to settle the pastoral nomads." (Haaland 1976: 42)

   "Agro-pastoralists (in Sudan) are being subjected to various socio-economic pressures and forced to abandon one of the two activities - herding - and change into agricultural laborers with low wages and even lower standards of living."

2. Preliminary evidence of the frequency of Agro-pastoral household clusters in South Kordofan is shown by the results of a May 1982 field census of a subsection of the Hawazma tribe (dar Sholongo) of Baggara Arabs. A Dar Sholongo major lineage consists of twenty-four minimal lineages living along the north-south axis between Kadugli and Dilling during the dry season. Of the household clusters that make up a minimal lineage, eleven (46%) engaged in transhumance, while thirteen (54%) were settled farmers or had other sedentary occupations. Eight of the eleven transhumant clusters (73%) left household members behind to cultivate grain fields while the rest migrated with the livestock to North Kordofan. However, all thirteen settled groups sent livestock on transhumance with members of migratory households, often contributing young men or boys as herders for the rainy season. Cattle ownership varied considerably in numbers. The largest herds were owned mainly by a few transhumants and a couple of wealthier settled households. The majority of middle-size herds (60 - 100 cows) belonged to transhumants. A sizeable percentage (eight out of thirteen - 62%) of settled groups had small herds of less than thirty cows, while only two transhumants (18%) had small herds.

3. "The important fact here is that the profit a cultivator may make on his agricultural enterprise can only to a very limited extend be reinvested in the factors of agricultural production. The only investment objects are livestock and most importantly cattle. The profitability of this investment is restricted by ecological conditions . . . During the rainy season diseases caused by insects and muddy soil make it a great risk to keep cattle

there. This problem is solved by leaving the cows in the care of the Baggara, who take the herd to a more favorable area in this season. The owner gets the calves and the Baggara get the milk. . cows are thus the farmer's most important wealth and the more he has, the greater his concern for their welfare and the more will risky contracts with the Baggara worry him. The alternative way to solve this problem is the cultivator to migrate with the cattle himself . .(and'. solve this dilemma by establishing themselves as nomads. When they have accumulated twenty to twenty-five cows . . . they adopt the longer migrations of the Baggar." (Haaland 1972).

4. "Nomadization. . . is an end-product of a series of decisions that (a sedentary farmer) considers optimal at various stages in his economic career. The sedentarized Baggari on the other hand would more systematically gear his economic activities towards accumulation of the capital necessary to return to a pastoral life. . There are limits to how far a (wealthy) Baggari is willing to go in order to continue as a nomad if this costs him increasing disadvantage." (i.e., opportunity costs) (Haalnad 1972).

5. The panel survey is a well-established method of collecting social data relevant to change over time. Because it documents trends, the size of a panel study sample is typically smaller than that of a cross-sectional survey. Decreased household sample size, possibly affecting statistical reliability, is compensated by the increased number of consistent data points on the continuing members of the sample. This allows for a better indication of trends toward change away from the central tendency for a selected population that is already well known. Panels are usually chosen by drawing the sample on a matched basis from a demarcated population universe rather than from the general population. This methodology is especially appropriate to the study of South Kordofan transhumants who represent a highly specific segment of the total population, easily identified, who undergo change through increase and attrition around a core of established tribal and household activities. In a project aimed inducing livestock management changes that increase productivity, the establishment of a panel of transhumants providing diagnostic data serves as a continuing source of information for ongoing impact analyses; i.e. the effects of introducing changes found by project research to offer improved opportunities for more production through constraint elimination. Hence the panel establish-

ed in this research project will serve as a basis for monitoring changes in the middle (and possibly the longer) term by way of future research proposals. If a household is lost from the panel for any reason it can be replaced by another such household. Nevertheless, the panel sample is large enough to handle some attrition.

6. The case-study method of participant-observation is standard practice by research anthropologists in a variety of contexts. Case-studies are especially useful to illustrate the interactions of statistically significant factors in a living context over time. Because this research project is aimed at demonstrating, the production-related changes in transhumance requiring mid- to long-term periods, the choice of key types of households for case analysis is a useful mode of investigation; it can lead to insights on the acceptability of improved methods of livestock management depending on the cluster of constraints and incentives impinging on a household, rather than treating each such factor in isolation. Case-studies also provide the underlying context for the development of an index of household well-being as part of this research effort to examine the socio-economic impacts of research-based changes in mode of production to overcome existing constraints.

7. Panel Interview Topics:

The data needed for project research development on the transhumant production system includes the following topics:

1) Cultural characteristics and social composition of transhumant camping units (fariqs) by season; the schema of relationships between households in each camp.

2) Household demographics, kinship network, and chronological history of each household's pattern of migration and sedenterizing tendencies.

3) Livestock census - herd size and composition by household from season to season. Births, deaths, offtake, and turnover rate of the age/sex structure of herds. Diseases experienced and perceived causes of death. Production constraints due to transhumance (drawn from Range-Science Livestock Section studies).

4) Herd management techniques - grazing patterns, watering patters, and migratory movements. Perceived attractions of transhumance for herd management and observed production constraints on more sedentary herding.

5) Social marketing practices - livestock sales and purchases by season and location; incentives due to price differences; and market-related constraints on improved productivity of the herds. Also, effects of taxation on marketing choices.

6) Labor supply and the division of labor in herding and transhumant cultivation, with emphasis on labor-related constraints on livestock and crop production.

7) Fixed economic assets and moveable assets; income derived from herds and outside sources of income. Relationship of transhumant household consumption levels to their style of life and investment in herds.

8) Transhumant household variations in production strategies and openness to improved modes of livestock raising.

9) Cooperative linkages between transhumant households and associated sedentary households through livestock, labor supply, and cultivation via sharing of resources and mutual aid. Effects on production.

10) Constraints to production resulting from inter-tribal conflict between nomadic groupings and as a result of competition for land-use and water with settled farming groups; costs of settling disputes.

11) Livestock and crop-related government services and interventions affecting the productivity of transhumant activities.

12) Acceptability of improved range use patterns to transhumants in light of WSARP on-station and range research results for South Kordofan.

8. Data Processing:

This data will be collected using an interview instrument to be developed on the above topics during the reconnaissance (Phase I) for a panel sample of up to sixty households. The panel will be matched for households showing a central tendency toward transhumance while including various degrees of sedentarization and nomadization.

The assembled raw data will be transferred onto a coded Visa-card Edge-Punch system for mechanical (hand operated) aggregation of data points and analysis of key variables. This data-processing technique is well established as a rapid and easy way to generate tables and statistical associations between clusters of factors that define the production system parameters. The availability of

the Visi-card file will permit quick access to data to extract information for use by other researchers focused on the social and behavioral aspects of their proposed interventions for transhumants.

The Brisch-Vistem Visi-card system (see attached sample card with edge-punch holes) has well-known advantages for this genre of field study in the social sciences: a) its simplicity and ease of use; b) its low cost; c) the rapid manipulation of coded variables in response to inter-disciplinary research needs; d) the visibility of written hard-copy data on the edge-punch card to reveal additional information (as statistical associations) grouping households along combinations of variables. Also, given the longitudinal (prospective) nature of the research methodology, the Visi-card system permits linear addition of data points for storage on extra cards and insertion of additional variables into the existing card code file, without need for reprogramming or other delays. The data-cards also permit researchers to obtain a nutshell view of the characteristics of individual households over time to understand trends in their transhumant pattern and changes in productivity associated with sedentarization and nomadization. Once micro-computer facilities become available the hard-copy data entries on the edge-punch cards may be transferred onto the electronic system for replication, rapid retrieval, and increased analytical power.

WSARP RESEARCH PROPOSAL

Identification:

Station: Kadugli

Experiment No.: 15

Date of Proposal: October, 1983

Beginning Season For Research: October, 1982

Subject of Research: Animal Production/Health Evaluation in Two Sentinel Herds

Principal Investigators: Drs. Fadlalla and Cook

Duration of Project: One Calendar - Year

OVERALL OBJECTIVES: To identify those major health and production constraints which limit and/or reduce livestock production in Southern Kordofan. To provide necessary information for effective implementation of adaptive strategies to overcome identified constraints.

Proposal:
Title: Evaluation of base-line production parameters and a disease/vector/pest syndrome in sedentary and migratory herds as determined from three sentinel herds.

Intermediate Objectives: To determine the following parameters on on a seasonal basis:

1. Milk yield from lactating cows
2. Birth weights of all species
3. Quarterly live-weight gains for all species
4. Fertility/pregnancy status for all adult cows (over 3 years)
5. General animal health status
6. Evaluation of ecto-parasite burden
7. Evaluation of blood samples
8. Evaluation of faecal samples
9. evaluation of bitingfly populations

Rationale: One of the fundamental problems faced by the Kadugli Research Station is the development of effective strategies which will enable traditional producers to more effectively utilize their resource base for agronomic and livestock

production activities. In Southern Kordofan, one strategy for increased utilization of the livestock resource base is to better define the seasonality of disease and nutritional constraints so as to better utilize available range and forage/crop residue resources on a year-round basis. Animal disease problems are considered by livestock producers to be the major reason why herds must leave Southern Kordofan during the rainy season and seek northern grazing areas. It is also true this time of year that forage reaches its peak nutritive value, with nitrogen and mineral content decreasing as one begins the dry season. It is during this time of year, the early dry season, when most of these migratory herds return to the South. Improvement in the year-round animal health situation would have immediate impact on sedentary producers who normally graze their cattle in the South on a year-round basis and might provide an incentive for the migratory sector to spend a longer time in the South, either by leaving later in the year, or returning earlier, or both. Such changes would not only increase animal productivity in the South but would also result in less grazing pressure in the North where range productivity is at a low level.

To evaluate the seasonality of several production parameters and the disease/pest/vector syndrome, what is not suggested is an in-depth, comprehensive survey of many sedentary and migratory herds. What is proposed, however, is to use several sentinel herds, representing the sedentary and migratory systems, to generate base-line production/health date. While such a study

may well not be representative of all sedentary and migratory situations, it is felt that problems of major impact will be elucidated, and that interventions in these major areas will have the greatest impact. In addition, complementary studies will be carried out using these three herds to evaluate range utilization and common grazing practices, as well as trials to determine the Total Digestable Nutrients in commonly available forages at various stages of bloom. (These studies are elaborated in accompanying proposals).

One of the fundamental reasons given by migratory producers for moving their livestock to Northern grazing areas during the rainy season, is the "fly and mud problem" in the South during the rainy season. Preliminary observations by the authors of several cattle herds, both in the North and the South, show a markedly superior general condition for migratory herds than for sedentary herds. (These observations were made during the rainy season.) In addition, preliminary discussions with several migratory livestock producers indicated several potential disease problems faced by year-round livestock production in the South, namely; trypanosomiasis, heartwater, babesosis, Rinderpest, and enzootic pneumonia. (This list is only tentative and is based not on clinical diagnosis, but on clinical signs as described by the herders.)

Design: This production/health study is proposed to continue for one calendar year. Two sentinel herds (one sedentary with limited grazing, and one migratory herd) will be evaluated and sampled four times per year.

In each herd every attempt will be made to keep herd management practices consistent with those of respective existing traditional practices. Prophylactic medical care will be implemented in accordance with existing services available to livestock owners, and sick-animal treatment will be done on an individual basis, based on a definitive diagnosis. Nutrition will be the same as that available to the respective sectors at large.

Animal production and health parameters will be determined quarterly; i.e. at the commencement of the rains, June/July; at the end of the rains, September/October; during the early dry season, December/January; and during the late dry season, April/May. Samples will be taken as listed previously and as detailed below:

- milk yield will be determined daily for all lactating cows. Date of parturition will be recorded, the mammary gland evaluated for pathology, and total milk yield from an epsilateral rear and front quarter will be determined. Total milk yield (for non pathological quarters) will be calculated as twice the epsilateral yield. Following traditional practice, milk intake for the calf will be equated to ½ the total milk yield. Cows will be milked twice a day.
- all animals will have their live-weight recorded quarterly using weigh scales.

- all animals will be examined relative to their general health status, with particular attention to the integumentary, gastrointestinal, and cardio-pulmonary systems.
- 10 animals of each species will be critically examined for ectoparasites, especially ticks. Tick infestation will be recorded as light (0-10 ticks), moderate (10-50 ticks) and heavy (as greater than 50 ticks). This quantification is impirical and not meant to quantify disease challenge. Such an analysis requires infectivity studies, and these studies along with tick identification will be carried out at the Tick and Tickborne Disease Unit, Central Veterinary Laboratory, Soba, using specimens sent from Kadugli.
- whole blood and serum samples will be taken from all animals. PCVs and serum protein will be determined. Blood slides will be examined for the presence of hamoprotozal parasites, and serum will be stored frozen for possible future immunological evaluation.
- faecal samples will be taken and examined for parasite ova.
- another aspect of this study involves an evaluation of biting fly problems. Studies have shown that biting flies pose no real threat to livestock in Southern Darfur, because of the wide spread use of trypanocidal drugs. However, biting flies were found to play a role in initiating cattle movements to more northern grazing areas; did cause a loss of condition to more northern grazing areas; did cause a loss of condition due to the extreme irritation and loss of grazing and watering time. Utilizing a portable

canopy trap, developed in Nyala, it is proposed to measure the biting fly populations on the research station farm, and in the areas of the other two sentinel herds. In addition, these traps will be evaluated for their potential to reduce biting fly populations in limited areas.[2] The formalized design of this phase of the study must wait arrival of the research station entomologist and further discussions with ODA, Khartoum.

Collaborative Activities: It is planned that the Veterinary Department in Kadugli and WSARP agree to seconder, part time, a veterinarian to work on the project. Such a person would be a necessary resource for the Project and a liaison with the Veterinary Authorities. It is also planned to enlist the collaboration of Dr. Suleiman, a veterinarian responsible for animal health with SATEC's animal traction program.

RESOURCES: WSARP Scientific Staff: Dr. R. Cook, 0.3 man-years,
Dr. B. Fadlalla,
Station Entomologist

Technicians: One laboratory technician (0.5 man-years)
One field technician (1.0 man-years)
Two herders (1.0 man-years)
One driver (1.0 man-years)

Laboratory facilities; electricity, refrigerator/freezer, hematocrit centrifuge, general centrifuge, dark field/phase contrast compound microscope, glassware and reagents.
Field equipment; vehicle, large animal portable scale, small ruminant portable scale, sample collection equipment, portable refrigerator. Animal purchase of additional 50 sheep and 50 goats to be added to the present sedentary and migratory herds. Identification of sedentary herder.

REFERENCES:

1. Langdrige, W.P. unpublished ODA report, "Tsetse and Typanosomiasis Survey of Southern Darfur and Southern Kordofan Provinces," March 1981.

2. Hall, M.J.R., unpublished ODG report, "Proposal for a tsetse and trypanosomiasis survey of Southern Kordofan," April 1981.

3. Hall, M.J.R., unpublished ODA report, "British Overseas Administration and Sudan Government, Tsetse and Trypanosomiasis Survey Report," December, 1981.

WSARP RESEARCH PROPOSAL

Station: Kadugli

Experiment No.: 16

Date of Proposal: October, 1982

Beginning Season of Research: October, 1982

Subject of Research: Preliminary Study and Evaluation of Livestock Production Systems in Southern Kordofan

Principal Investigator: Dr. R. Cook

Co-Investigators: Drs. Fadlalla and Bunderson

Overall Objective: To familarize myself with the livestock production systems of the sedentary and migratory owners and to define adaptive strategies to overcome some major constraints to livestock production in Southern Kordofan.

Duration of Project: Initially 2 months, after receiving a vehicle

Title: An overview of livestock production systems in Southern Kordofan.

Intermediate Objectives: To identify some major constraints to livestock production in Southern Kordofan Province

Design: The implementation of adaptive and applied research strategies for improving traditional livestock production requires some familiarity of the target system. Discussions with producers and observations of agronomic/livestock practices will help to focus future research activities in the livestock production sub-sector and better enable research staff to allocate research station resources.

Visitations to farms and migratory producers will be undertaken, involving all senior members of staff to a greater or lesser degree depending on the nature of the visit and the system visited. Collection of relevant livestock system data will be undertaken by the social scientist and agricultural economist, in their already developed socio-economic survey questionnaire. (A sample coded

format for compiling livestock survey data is attached. This format was developed at Washington State University, and it is presently used for compilation of livestock production data from a CRISP, small ruminant project in Kenya.) It is suggested that all survey data be directly coded on to pre-printed cards, in duplicate, and that one card be sent to WSU for computer entry and the other be permanently filed in the Kadugli Research Station Library.

Resources:

WSARP Staff: Dr. R. Cook, 0.5 man-years/for initial 2 months. Vehicle, portable cassette recorder and cassette tapes, blank. Driver, (0.5 man-years/for initial two months).

WSARP RESEARCH PROPOSAL

Station: Kadugli

Experiment No. 17

Date of Proposal: June, 1983

Title: Livestock Production Systems In Northern Kordofan:
I. Camel Production Systems in Dar Kababish

Principal Investigators: Dr. R. Cook; Mr. Ahmed Hashim, Mr. Adam Ali Mohammed, Mr. Ali Sheikh Eldein

Co-Investigators: Dr. W.T. Bunderson, Dr. B. Fadlalla, Dr. Neil Patrick, Mr. Abu-Sabah; Dr. Sirage, Senior Veterinary Research Officer, El Obeid; Dr. A. Sulieman, Director, Department of Natural Resources, El Obeid; Mr. Abdullah Tief, Livestock Officer, Sodiri

Duration: 1983

Summary:

This proposal represents the first in a series of proposed Project activities focusing on livestock production in Northern Kordofan. Since traditional pastoralists of this Region have a comparative economic advantage in the production of camels and sheep over traditional pastoralists in other Regions, attention will focus on improving productivity within these herds and flocks in a fashion which will maintain or improve the fragile natural resource base of this area.

The initial diagnostic strategy to define camel and sheep production in Northern Kordofan will emphasize three broad areas; evaluation of the forage resource base and an assessment of livestock impact on this resource base; evaluation of the animal component and an assessment of its potential for improved productivity; and, an evaluation of the marketing system and an assessment of the potential

for improving off-take. These three areas will be addressed in a concurrent fashion.

Camels were selected as the initial species for study because they represent the most important livestock resource in the northern areas of Kordofan and Darfur. In fact, 40% of the Sudan's national camel herd are resident in Northern Kordofan. Dar Kababish was selected as the area for initial activities because it represents the principal camel producing area of Northern Kordofan.

Introduction

According to FAO statistics (1977), there were well over 14 million camels in the world, 10 million of which were to be found in Africa. Within the African continent, Somalia and the Sudan have the largest herds, with Sudan's herd numbering in excess of 3 million. The largest camel populations in Sudan are recorded for Northern Kordofan, Kassala, Northern Darfur, Gezeira, and Southern Darfur Provinces, with over 40% of the National herd located in Northern Kordofan. The major tribes owning camels in excess of 16, on a National basis, but West of the Nile, the Kababish, Hawawir, Kawahla, Shenabla, Hamar, and Maganeen are the most dominant with respect to camel production.

The camel is an important export commodity in the Sudan, contributing approximately 50% of the total foreign exchange earnings derived from livestock during the period of 1971-1977. During the period of 1968-1972, on the average, approximately 55,000 head of camels were exported annually, generating revenues of over LS. 2,400,000.

During the same period, cattle exports earned slightly less than £ 1,000,000 annually, while sheep earned slightly over £ 1,000,000. Gillespie (1967) stated that there had never been a time when the value of camel exports were not in excess of the combined value of cattle and sheep exports. In fact, the total earnings from camel exports is likely much higher than the official estimates, owing to the unrecorded movement of large numbers of camels to neighboring countries.

Camels also provide meat for domestic consumption. In 1976/77, over 15,000 head of camels were slaughtered in the Sudan, amounting to a per capita consumption of camel meat/offal of approximately 1 kg/annum, or 9,000 tons annually. Camel meat apparently does not compete with either beef or mutton sales, providing as it does, a less expensive meat alternative. Data for domestic consumption during the period of 1971 - 1976 were relatively constant, with no significant increases indicated for the near future.

In addition to their importance as a meat source, camels also fulfill an important role as beasts of burden. In Northern Kordofan, the Kababish are known for producing pack animals with great endurance and heavy loading capacity, as well as fast racing camels which command high prices on the international market. Moreover, the future expansion of animal traction in Western Sudan could well provide an additional market for camels from this region. Traditionally, camels are also an important source of milk, wool, and hair.

The largest concentration of camels in Northern Kordofan is found

in Dar Kababish (1978). In this area, camels have traditionally utilized wet-season grazing areas in the north, north-western part of the Dar, moving south to the region between Umm Badr and En Nahud during the dry-season. (Note maps I and II.) Recently, because of low rainfall and poor grazing, this traditional migratory pattern has been pushed further South, at both its northern and southern extent.

Dar Kababish is an area of approximately 32,000 kms^2, located between latitudes $14^{o}N$ and $16^{o}N$. It is an area characterized ecologically as arid to semi-arid with an annual rainfall of between 100 mm - 250 mm and an evapotranspiration of 1600 mm - 1800 mm annually. Sandy soils, interspersed with loamy sandy, clayey areas, predominate in the area. The vegetation is dominated by annual grasses and thorn scrub, predominately A. millifera.

According to the 1973 census, the population of Dar Kababish was 200,000 and increasing at a rate of 2.5% annually. The predominate ethnic group in the area was Arab, with Westerners and Nuba comprising about 15% of the population. Household classification data from this census indicated that during the period of 1956-1973 there was a tendency for sedentarization, with the percentage of nomadic household decreasing from 80% to 69% of the population, while sedentary households increased from 17% to 30%.

Recent livestock figures for Dar Kababish are not available, but the 1969 livestock tax figures listed 255,000 camels, 642,000 sheep, 65,000 goats, and 125,000 cattle for the entire area.

This represents a total TLU (Tropical Livestock Unit) of 518,000. By comparison, 1979 FAO livestock figures listed a TLU of 18,478,000 for all of Sudan. It is likely, however, that Dar Kababish has a much higher TLU presently than the cited figures indicate because tax figures are notoriously underestimates of actual animal numbers, and the past twelve years have probably witnessed a significant increase in the number of animals present in the Dar.

Due to topographical and climatogical factors, camel husbandry in Northern Kordofan has been classified as pastoral nomadism (Abd El Garraf, 1979), with animals continuously moving in search of pasture and water. Camel herds are generally managed as separate breeding and working herds. Because intact male camels become very aggressive during the rutting season, breeding herds usually contain only one breeding male at a time, to cover 35-50 females. Working camels and those camels destined for sale are usually maintained in herds of only males, many of which are castrates. For working camels, castration is generally done after the animal reaches 6 years of age. If done before this age there often leads to a deterioration in bone and muscle development, while heavy work is generally postponed until the camel is 6-7 years old. The average working life-span ranges from 6 - 16 years.

Female camels have their first calf at 4-5 years of age, weaning their calf at approximately 12 months. Following weaning, females come into estrus, calving again in about 12 months, resulting in an average calving interval of 2 years. On average, breeding females

will produce 6-8 calves during their life-time. (Further details are contained in appendix I).

Being herbivorus, camels obtain their food by browsing trees and shrubs, and grazing. Under natural conditions, camels will eat a wide variety of plant types. Although very little information is available on camel feeding habits under natural conditions, Maxwell (1938) noted that in the goz areas of Northeastern Kordofan, Cenchrus bifloris is the only grass eaten, while Rullia patula, Leptadenia spartum, Crotalaria thebica, Caylusea hexagyna, and Salsola baryosma represent the major shrubs consumed. Acacia laeta, Ziziphus spina-christi, and Leptadenia protechnica are the principal browse species consumed, both during the rains as well as during the summer and winter months. Supplementation is common in herds in the area, with salt (atron, dhereri, milich) given every 14-21 days during the rainy season and every 7 to 10 days during the dry-season.

The watering of camels depends on the breed, season of the year, and type of work being done. Breeding herds are generally watered every 10 to 20 days, with weekly waterings not uncommon during the dry-season when succulent browse/forage is scarce. Depending on the frequency of watering and work performed, camels drink between 8-20 gallons of water during a single watering, tolerating water losses up to 30% of their body weight if extended over 30-40 days.

Under natural conditions, camels are exposed to many diseases, several of which play an important role in limiting production. Of most importance are: trypanosomiasis, soroptic mange, calf diarrhea, and internal parasitisms. Anthrax, rabies, contagious necrosis of the skin, tetanus, camel pox, and botrimycosis are occasionally seen.

From a public health standpoint, camel diseases require attention because camel milk is often consumed without heating, increasing the hazards from tuberculosis and brucellosis.

The marketing of camels is usually done by specialized merchants, often involving the producers themselves, without the participation of middle-men. Camel trading with Egypt apparently started in Kassala Province, but today has spread to other regions, with Meidob, Zegadea, Kababish, Kawahla, and Hawair tribes accounting for approximately 60% of the trade. Camels destined for export or internal consumption are purchased at major camel trading markets, treked to markets in El Obeid and En Nahud, and then via the "40 days road" (See Map III) to Egypt or Libya. During the latter trek, camels are herded in groups of approximately 50 animals, generally with one herder. Animals exported to Saudi Arabia are moved on hoof to Port Sudan. Regarding exports to Egypt, the agreement between Sudan and Egypt stipulates that each exporter must sell 25% of his quota to the Egyptian Government at a fixed rate, while the remainder can be sold on the open market. The annual off-take from camel herds in the Sudan is estimated at between 3 and 6%.

Data collected during a preliminary exploratory survey to south-western Dar Kababish in February/March, 1983 (Report submitted in April, 1983), indicated that both camel and sheep production in this area was quite low, with production indices of 0.12 and 0.36 respectively. In general, poor nutrition and disease were the primary constraints limiting production.

Because of the importance of camels and sheep to the traditional

pastoralists in this part of the Project area, and because of the potential improvement possible in camel and sheep production in the area, these studies are proposed to better define this production system (s) and to identify possible interventions which will improve the productivity of these herds and flocks.

Methods and Procedures:

The evaluation of camel and sheep production systems in Northern Kordofan, and the identification, formulation, and initiation of interventions for these systems will follow the production systems approach adopted by the Project. Diagnostic surveys will be utilized to identify homogenous production systems. However, some modifications of the classical agronomically biased, farming systems approach may be necessary when addressing these migratory livestock production systems. The methodology to be utilized for these studies is outlined below and falls into two general categories: (1) a general approach to systems diagnosis, and (2) a specific activity approach.

The classical farming systems approach emphasizes the need for an initial interdisciplinary diagnosis of production systems. This approach, while efficient in examining intensive, agronomically based, production systems within a limited geographical area may well not be the most efficient, not even the most appropriate approach when addressing extensive, migratory livestock production systems which may span several ecological zones. The constraints posed by limited professional staff and limited, logistical field support are greater in the analysis of extensive livestock production systems, than in the analysis of most agronomic systems. The

allocation of staff time necessary to initiate and maintain interaction with migratory pastoralists becomes limiting, especially when multi-disciplinary teams are an a priori in initiating diagnostic activities. To overcome this constraint, while maintaining multi-disciplinary input in all phases of activity development and implementation, the following approach will be used.

(1) Diagnostic surveys will utilize a Project-developed zoning guideline. This guideline, which highlights important, inter-disciplinary topic areas for system identification, will serve as a basis for interviews and discussions with producers.

(2) Field activities will, whenever possible, include appropriate staff from Regional and National Agencies.

(3) As soon as feasible, and prior to initiating any further activities in the same area, the senior staff involved in the field exercise will give a research seminar, where data collected will be presented and discussed. These seminars should culminate in a series of recommendations for future activities in the area.

During initial evaluations, three components of the livestock production system will be emphasized. Firstly, animal management and general husbandry will be described, focusing attention on; management of newborn animals, reproductive efficiency, nutritional management, disease prophylaxis, and the production/disposition of meat and milk. Secondly, as assessment of animal foraging/browsing habits will be made, in conjunction with range evaluations,

to determine the potential environmental impact of the predominate livestock species being considered. Thirdly, an assessment of the existing marketing system will be made, paying particular attention to market forces at the producer level and its impact on off-take.

Preliminary data (appendix I) indicate that significant improvements in livestock production are possible for both camels and sheep in Dar Kababish. Given the fragile nature, and in many places deteriorated state, of the environment in Northern Kordofan, an early assessment of animal environmental impact and potential for improved off-take, will preceed any attempt to disseminate improved production techniques which will likely increase animal numbers. The initiation of specific activities will conform to this general strategy, the specific, developmental strategy outlined in the Preliminary Survey Report of April, 1983.

For the present series of studies on camels, Mr. Mohammed Ali Mohammed, son of the Nazir of the Kawahla Tribe, has expressed an interest in working with the Project. Mr. Mohammed is educated and understands the objectives of our activities which improves the likelihood of his continued cooperation with Project staff. In addition, both his and his father's influence have already been of assistance in preliminary discussions concerning camel marketing. Their cooperation may also make it easier to establish future relations with smaller, less-well managed producers in the North. A camel disease study will be conducted

in the herd of Sheikh Ibrahim, Abu Zaima, where chronic mange has already led to considerable losses and reduced productivity in a herd of 150 camels. In Phase II of this study on sheep production systems it is hoped that similar cooperation can be established with key sheep producers and marketers.

Specific Activities:

Part A.

Title: An Evaluation of Camel Feeding Habits, Nutritional Requirements, Range Carrying Capacity, and Potential Environmental Impact. I. Preliminary Evaluation of Wet-Season Camel Feeding Habits, Nutritional Status, and Range Assessment.

Objectives: (1) Identify the type(s) of vegetation preferred by camels

(2) Assess camel nutrient requirements

(3) Assess the impact of camels on the range with specific reference to desired vegetation types

(4) Provide essential base-line data to assist in determining range carrying capacity

(5) Provide additional insight into traditional camel production practices.

Materials and Methods:

This study will involve an evaluation of feeding habits and intake of both lactating and non-lactating camels during their wet-season grazing period. Five camels from each physiological group will be studied for two days each, noting vegetation preference and collecting

total fecal output. Vegetation samples will be collected for later chemical analysis. Concurrently, range evaluations will be made, paying particular attention to dominant species and their relationship to animal feeding habits. Two different locations will be used to overcome any possible location bias due to variations in vegetation types between sample areas. Such studies would be conducted four times a year, early wet-season, late wet-season, early dry-season and late dry-season.

Discussion:

These studies are aimed at determining camel nutritional requirements, total voluntary intake, and feeding habits, which are necessary to determine carrying capacity and to assess the potential of the forage resource base to sustain camel production at its present level. This data will also provide insight into why particular migratory patterns may have been exploited, and more importantly, where other alternative routes may be developed and how they should be managed.

Well suited, as they are, to arid, semi-arid ecological areas, camels in Northern Kordofan are under increased pressure each year to migrate further South because of poor rainfall and deteriorating range conditions in the North. The fragile nature of this northerly eco-system makes it highly vulnerable to irreversible degradation through, poor land-use practices, eg. over-stocking, deforestation, and shifting cultivation. The development of improved livestock practices, designed to increase production, will be developed within the context of a rational range management system.

In Northern Kordofan, there is little room for error when balancing production on the one hand and environmental preservation on the other. As already stated, implicit in a rational strategy for improving livestock production is the need to assess the causes of this environmental crisis and determine the role, if any, that livestock are playing in this degradative process. This assessment is essential in order to develop interventions which will not exacerbate the existing problems.

Part B.

Title: Effect of Market Forces on Camel Off-Take and Future Trends in Market Demands

Objectives: It is proposed to undertake, concurrently with animal production activities, a study of camel marketing activities, initially focusing on the following:

(1) quantification of camel exports and establishing market trends, supply/demand

(2) identification and description of the existing camel market structure, noting any seasonality of sales and its relationship to potential off-take incentives/or dis-incentives, and pricing policy.

(3) definition of decision-making at the producer level regarding animal sales.

Materials and Methods:

This preliminary study will utilize information acquired from selected producers in Dar Kababish, merchants, resident in El Obeid, Hamaret El Sheikh and Mazrub, as well as export data

compiled by the Livestock Meat Marketing Corporation in El Obeid and Khartoum. The preliminary objective is to assess the present market with respect to supply and demand.

Discussion:

In order to develop a strategy for improving livestock production in Northern Kordofan which will be compatible with ecological preservation, the Project must have a basic understanding of the interaction of existing market forces with animal off-take. The initiation of interventions which could substantially increase production, will inevitably increase animal numbers, and therefore must be done in a market climate which encourages off-take. If considerable potential for sustained and improved off-take does not exist, then the Project should critically examine any efforts to increase herd production before improvements are made in the existing market system.

Part C.

Title: To Evaluate the Potential for Improvements in Productivity

(1) to examine traditional practices regarding the care and rearing of pre-weaned camel calves.

(2) to examine and evaluate management practices regarding lactating females, paying particular attention to nutrition, milk production, and breeding.

(3) to examine how and why specific migration routes are chosen and relate this information to nutritional data generated from Study I.

(4) to examine the role that disease plays in constraining production and what management practices are utilized to control disease problems.

Materials and Methods:

Many of the activities included in this study will be done concurrently with those of Study A. Two camel herds will be utilized, one located near Abu Zaima during the wet-season and the other near Umm Badr/Hamarat El Sheikh. This study is basically a diagnostic activity concerned with observations and discussions with producers. The immediate objective is to determine the potential for improved productivity and identify areas for possible interventions.

During an exploratory survey to Northern Kordofan in February and March, 1983, producers were questioned regarding constraints to camel production. Most producers cited animal diseases and inadequate forage/water as the primary constraints. Concerning animal diseases, mange (gerub) and helminthiasis (hilar) were singled out as the most important problems in adult camels, not from the mortality standpoint, but from their negative impact on production (meat, milk, and calves). Discussions with the veterinary staff in Sodiri confirmed the importance of these parasitisms. In several herds, visited during this survey, chronic mange had resulted in a significant number of deaths, but more importantly, had dramatically reduced productivity in virtually all herds examined. In one herd of 100 animals, none of the females had calved during the 1982 calving seasons. While chronic

mange does not apparently represent a wide-spread problem in the area, the continued use of one parasiticide could well lead to resistance problems in the future.

Because of the importance of hilar and gerub in this camel producing area, and because treatment of these diseases is common practice, it is proposed to try an in-herd trial with a new parasiticide, previously untested in camels. This parasiticide, because of its mode of administration, being an injectable as opposed to the presently used pour-ons, because of its long-term residual activity, and because of its dual action against both mange and internal parasites, appears to be well suited for implementing an effective prophylactic program against these two diseases, especially if it is shown to be as effective in the camels as has been the case for cattle.

In addition to these two diseases in adult camels, many producers cited a diarrhetic syndrome in pre-weaned calves as a very important constraint to production. Attempts will be made to examine and identify the etiology of this syndrome. Identified cases will be clinically examined and blood and fecal samples will be taken for laboratory examination and evaluation (mocrobiological examination is planned for the Veterinary Research Laboratory, El Obeid). In addition, the dams will be examined for udder health, milk quality, and dietary composition.

The initial descriptions of this syndrome during a visit to this area in February/March 1983 indicated the possibility of a clostridial or salmonella involvement. If this proves to

be the case, then the potential exists for producing an autogenous bacterin. This vaccine could then be used in implementing a calfhood vaccination control program. If a vaccine were produced, then strategic, prophylactic programs could be evaluated in a sentinel camel herd.

Discussion:

Further study of the camel production system should identify potential areas for improving production, both in the areas of improved nutrition and disease control. In addition, management decisions regarding migration routes, requirements for animal food and water will provide important information on the utilization of the nutritional resource base of the area. An attempt to identify a better, improved medication to control two of the most important diseases in the area could have an important impact on improving productivity if it is decided in the future to promote its use on a wide scale (providing of course it proves to be efficacious). The solution to the calf diarrhea syndrome is likely a long-term proposition, however, identification of its etiology could well identify improved husbandry practices, designed to reduce its incidence.

Potential Ecological Significance of Proposed Livestock Production Studies

Arid, semi-arid environments represent a dominant eco-system in the Project area. Substantial portions of this eco-system have been, or are in the process of deteriorating due to inappropriate land-use practices. Nevertheless, these areas are resident to more than 60% of Sudan's camel population, 30% of the sheep

population, and 20% of the cattle population, not to mention a significant percentage of the human population within the Project area. The livestock of these regions generate more than 60% of the total foreign exchange earnings derived from livestock exports, in addition to supporting the resident human population. Unless steps are taken to improve range management practices in these arid, semi-arid environments, this National resource will be lost forever.

Because of the fragile nature of these areas when compared to areas of higher rainfall, they lend themselves to few, rational alternatives for exploitation. Many of these areas are unsuited for cultivation or for intensive livestock production. Moreover, attempts to introduce livestock species not well-adapted to the climatic conditions, or to increase the numbers of such species, generally requires manipulations of the environment which are not consistent with its long-term preservation.

Camels and desert sheep represent two species of livestock that are well-adapted to these conditions. Both these species have a considerable potential for improved productivity, especially if they do not have to compete for scarce food resources with other livestock species or for improved range areas with marginal shifting cultivation. Appropriate interventions within these camel and sheep production systems offers the opportunity to measurably increase economic returns resulting from improved productivity while, at the same time, preserving the environment.

The three studies outlined in Part I of this proposal will provide important preliminary information regarding the suitability and the potential for increasing camel production in Northern Kordofan. If there proves to be a rationale for undertaking activities to increase camel production, then these studies will provide a foundation for developing a future Project strategy focusing on camel production systems.

References:

Annual Bulletin of Animal Resources Statistics, Issue No. 1, 2, 3. Animal Resources Administration, 1978.

Animal Health Year Book (FAO), 1977.

Bennett, S.C.J., E.R. John, J.W. Hewison, Agriculture in the Sudan, Animal Husbandry, 1954.

Gauthier-Pilters, H., and A.I. Dagg, The Camel, University of Chicago Press, 1981.

Gillespie, I.A. Nomads of the Sudan and Their Livestock in the Twentieth Century, 1966. (Secondary sources)

Hassan, H.M. and O.H. El Dirani, Livestock of the Sudan, Camels, 1979.

Hassan, Y.M., A Note on the Effect of Dehydration On a Camel, Sudan J. Vet. Sci. and Anim. Hisb., Vol. 12 (2)

Mukasa-Mugerwa, E., The Camel (Camelus Dromedarious) A Bibliographical Review, ILCA monograph NO. 5, 1981.

Maxwell-Darling, R.C. Notes on the food of Camels on the Red Sea Coast and in Northeastern Kordofan, 1938 (Secondary source)

Sudan National Livestock Census and Resource Inventory, Vol. 31, The Results of an Aerial Census of Sudan, Aug. 1975 - Jan. 1977.

Sudan National Livestock Census and Resource Inventory, Vol. 27, Results of the Herd/Disease Questionaire Survey, 1975/76.

Resources Required:

Senior Scientific Staff:

Dr. R. Cook: 8 weeks, July 1, 1983 - July 21, 1983.
Aug. 14, 1983 - September 7, 1983.

Dr. W.T. Bunderson, 2-4 days during early August.

Technical Staff:

Mr. Ahmed Hashim: 8 weeks, July 1, 1983 - July 21, 1983.
Aug. 14, 1983 - September 7, 1983.

Mr. Ali Sheikh Eldin: 10 weeks, July 1, 1983 -
September 7, 1983.

Support Staff:

Mr. Juma Yaro, 8 weeks, as for Hashim.
2 Driver Assistants, 8 weeks as for Hashim.

Equipment and Materials:

Vehicle 2848, 8 weeks as for Hashim
Benzine, 2160 miles/6.5mi gallon/ = 332,31 gallons/
44 gal./drum = 7.6 drums.

Vehicle Spares:

2 new innertubes, 7.60 x 16
in-line fuel filter
fan belt

Laboratory Equipment:

Sample equipment and medicines on hand
Camera + film: on hand
Cassette P.corder + batteries: require 20 AA batteries

Camping Equipment:

1 6-man tent - 8 weeks
6 blankets "
6 mattresses "
charcoal stove "
6 stools "
1 large lantern "
1 cooler, large "
2 gasoline cans "

References Continued:
Sudan National Livestock Census and Resource Inventory, Vol. 27, Results of the Herd/Disease Questionaire Survey, 1975/76.

Resources Required:

Senior Scientific Staff:

Dr. R. Cook: 8 weeks, July 1, 1983 - July 21, 1983.
Aug. 14, 1983 - September 7, 1983.

Dr. W.T. Bunderson, 3-4 days during early August.

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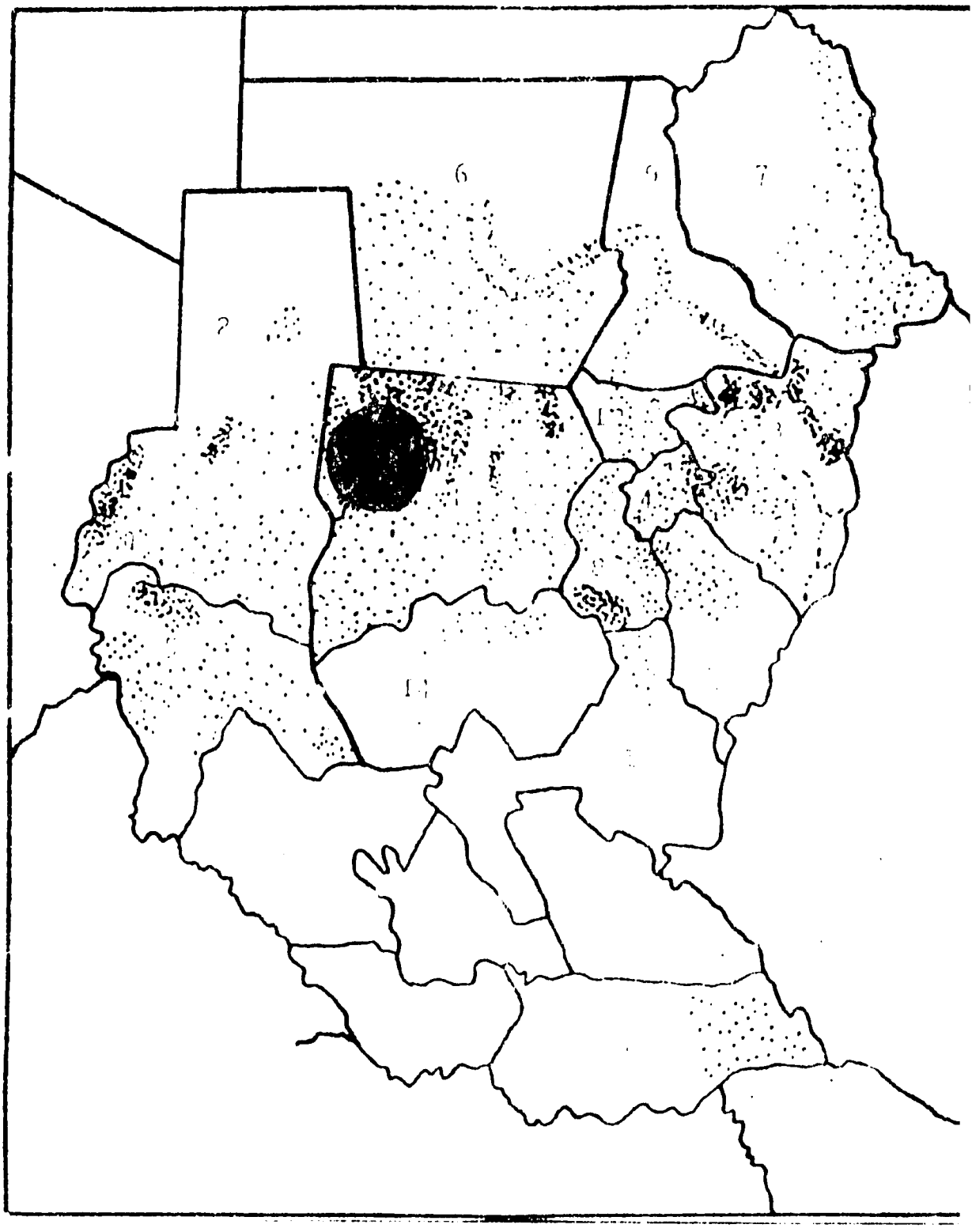
6 mattresses "
charcoal stove "
6 stools "
1 large lanters "
1 cooler, large "
2 gasoline cans "

MAP I

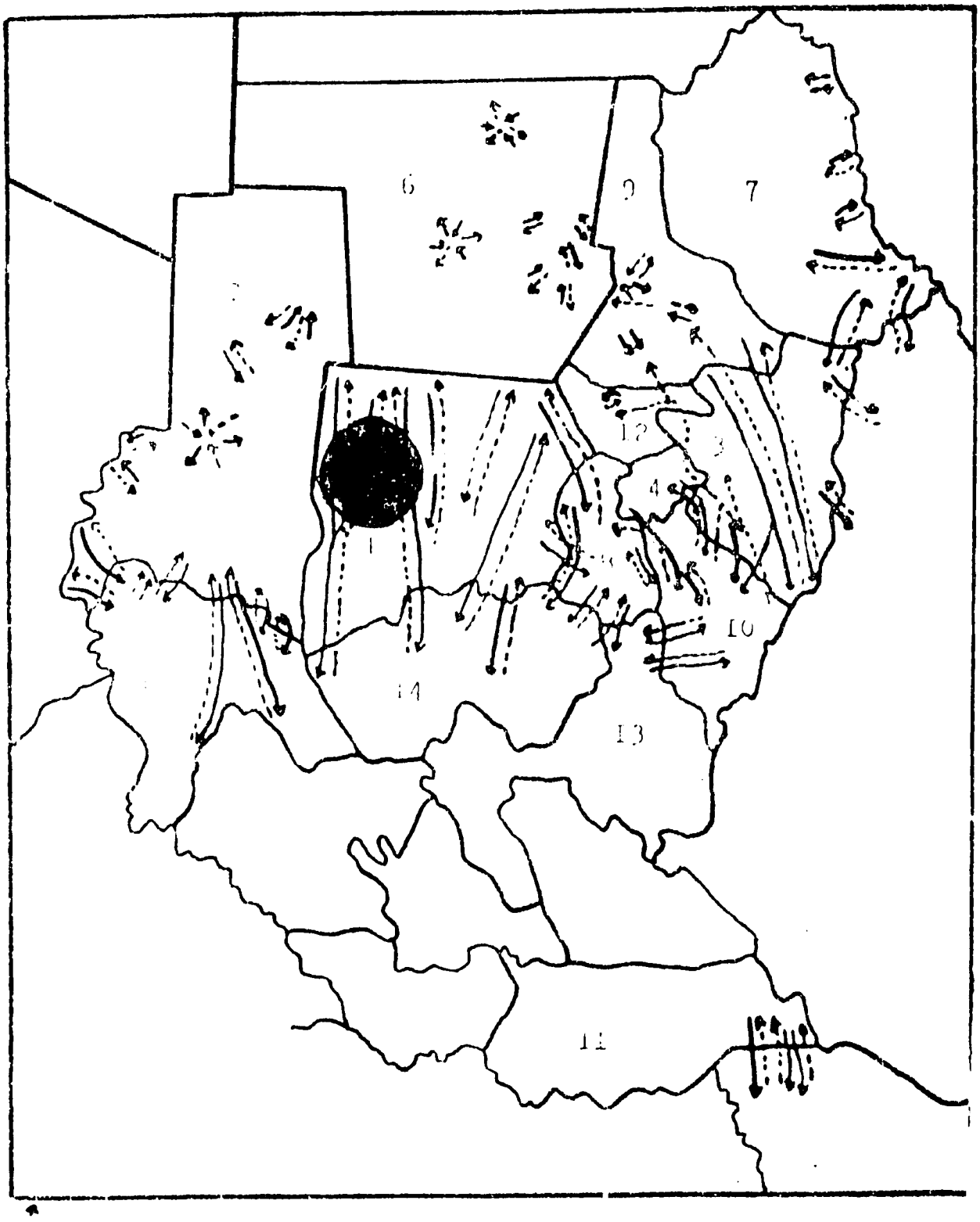
WET-SEASON CAMEL POPULATION DISTRIBUTIONS



Sudan National Livestock Census and Resource Inventory
1977

MAP II

CAMEL WET-SEASON ——, DRY-SEASON———' MIGRATION ROUTES



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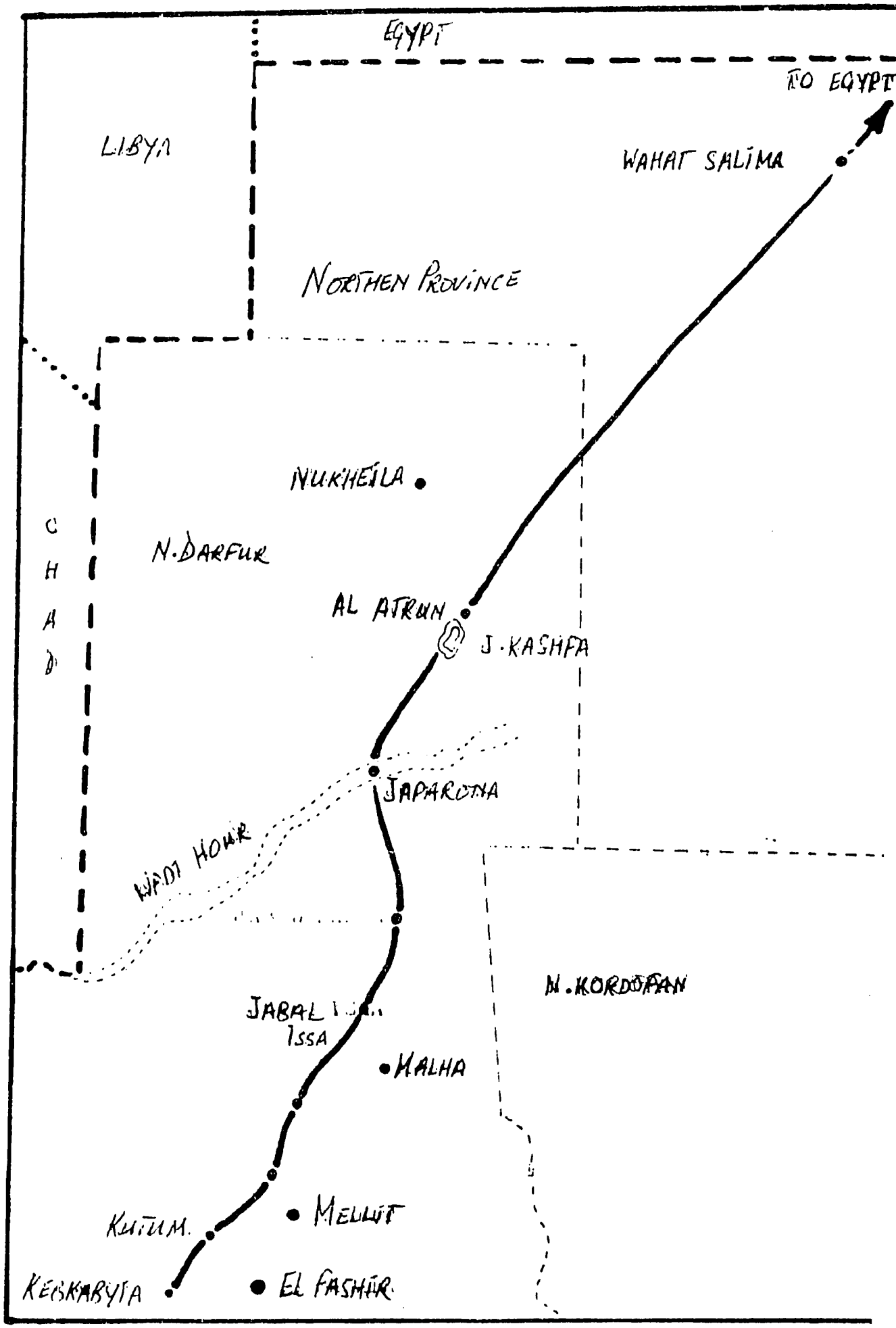
EGYPT
TO EGYPT
LIBYA
WAHAT SALIMA
NORTHEN PROVINCE
NUKHEILA
CHAD
N.DARFUR
AL ATRUN
J.KASHFA
JAPAROMA
WADI HOWR
N.KORDOFAN
JABAL ISSA
MALHA
KUTUM
MELLIT
KEBKABYIA
EL FASHIR

11/Livestock Sector: The major species of livestock kept in these areas are camels and sheep. Goats are also kept, but generally in numbers far less than either camels or sheep. Cattle are rarely kept - livestock owners said that cattle require watering too frequently and the disease situation (Rinderpest) makes cattle too risky.

SPECIES	AGE 1st PARTURITION	PART. INTERVAL	#OFF-SPRING LIFE FEM.	MILK PRODUC	%BREEDING FEM. IN HERD	%BREEDING MALE IN HERD	NEONATAL MORTALITY	ADULT MORTALITY	PRODUCTION INDEX	DISEASES
Camel	3½-4yr.	24 mo.	5-8	2-4# per 2 teats	65-70%	1%	45-65%	less 5%	0-12	1. Calf diarrhea 2. mange 3. Internal & external para. 4. Trypanosomiasis

11/Livestock Sector:

SPECIES	AGE 1st PARTURITION	PART. INTERVAL	#OFF-SPRING LIFE FEM.	MILK PRODUC.	%BREEDING FEM. IN HERD	%BREEDING MALE IN HERD	NEONATAL MORTALITY	ADULT MORTALITY	PRODUCTION INDEX	DISEASES
Sheep	2 yrs.	12 mo.	3 - 6	1# per 1 teat per 6-8 mo.	55-65%	less 10%	40-30%	20-30%	0.36	1. Pneumonia 2. Intestinal parasites 3. Diarrhea/ lambs

NOTE: Concerning livestock marketing several attempts to discuss marketing systems, problems, etc. with merchants in El Mazrub and Umm Badr were not rewarding. Merchants were reluctant to discuss their private affairs with total strangers - understandable. However, Mohammed Fadol, Nazir of the Kawalla, gave the name of a camel merchant in El Obeid who will be contacted within the next few weeks. Regarding the sale of camels; Mazrub is the largest market in the area and the majority of camels are sold as 5-7 year old castrates for export. The present price is Ls 290-340. Sheep are sold to merchants for for the Omdurman market at 8 mo. of age. If a family can afford to retain several for fattening & later sale they will for the price is much higher. Price for 8 mo. lamb is Ls 35-50, for a 1½ year-old, fat ram it is Ls 125-150. (on the high side).

WSARP RESEARCH PROPOSAL

Identification:

Station: Kadugli

Expt. No.: 18

Date of Proposal: June 16, 1982 (revised June, 1983)

Beginning Season for Research: Summer 1982

Subject of Research: Sedentary Farmers of South Kordofan

Principal Researchers: Neil Patrick and Abu Sabah

Cooperating Entities: University of Kentucky, INTSORMIL group at El Obeid, Range and Livestock Section and Agronomy, Soil and Water Section of WSARP

Proposal:

Title: South Kordofan Sedentary Production Systems Survey

Duration: 18 months

Overall Objectives: To more fully define the sedentary agricultural production system in Southern Kordofan as a means to identify production constraints, set research priorities for the Kadugli Research Station and identify appropriate modes of extending research results.

Brief Literature Review of the Study Area:

To date, a limited but useful set of secondary sources has been assembled on various aspects of crop and livestock husbandry and agricultural characteristics of the land and climate of southern Kordofan Province. (See South Kordofan Province-Basic Agricultural Data, GOS, 1980). Located in the Western Savannah Region of Sudan, this area occupies 138,000 km^2 divided into four administrative districts which roughly coincide with geographic variations. The North and South (Central) Districts together fall mainly within the Nuba Mountain ranges, which are composed of discrete

low ranges of rocky massifs and foot slopes surrounded by cracking clay plains, with seasonal water courses. The swampy south along the Bahr El Gazal River has clay soils with sandy ridges draining south toward rivers and lakes. The Western District has no mountain chains, consisting primarily of undulating clay plains, sand ridges, and deeper sandy soils in the north. The Eastern District is partly Nuba Mountains with flat, sandy soils in the north and along the eastern border of White Nile Province.

As pointed out by Hunting Technical Services Rural Planning Unit Study for South Kordofan (1982) there are six major soil types in South Kordofan with a variety of sub-classifications: cracking clays, non-cracking clays, sand, deep sand, coarse rocky soil, and mixtures of sandy clay. (No data on Eastern District). (See also D.C. Findly, Nuba Mountain Soil Survey). The rainy season extends from May to mid-October with average annual rainfall varying from 850 mm of precipitation in the far South to 450 mm along the Northern boundary. The cropping season varies from 109 to 128 days from north to south with local variants in the Nuba Mountains due to altitude and rain shadow pockets.* Both the amount and distribution of rainfall are keys to successful cropping and types of crops grown by traditional farmers. Ethnographic studies and Sudan Government census data (Nadel, 1948; R.C. Stevenson, 1965; Wood, 1972; HTS, 1981 Sudan Census 1954 and 1973; Roden, 1972) show that the vast majority of the inhabitants

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*Hunting Technical Services defines the cropping season as the period between beginning and ending significant rains of 5 mm or more. The actual growing season is somewhat longer as evidenced by the raising of crops with 150-160 day growing periods.

of South Kordofan are rural farmers and herders engaged in traditional shifting hoe cultivation and range fed grazing of ruminant livestock. The current population of the province exceeds 1.5 million of which only 10% live in communities of more than 2500 persons. Kadugli is the largest town, with about 40,000 inhabitants. The majority of the people (60%) belong to one of many Negroid Nuba Mountain tribal groups, each with its own language. The Baggara Arabs are partly transhumant, comprising 25% of the population; and smaller ethnic and tribal groups make up the remaining peoples including West African migrants and settled farming groups. Also a village and town dwelling minority of Northern Arabic speaking merchants is scattered throughout the province. The African populations are mainly of traditional religious beliefs (some converts to Christianity and Islam) and the Arabic-speaking populations and immigrants are primarily Islamic, with a few Christain (mainly Coptic) merchants.

The agricultural economy depends for the most part on crop and livestock production on clay and sandy soils. The main subsistence foods are sorghum, millet, sesame, cowpeas, okra, and other vegetables as well as milk and some meat. The main cash-crops are sorghum, sesame, peanuts, and some cotton; sale of livestock, especially cattle for export to the North, has recently emerged as the leading export product due to the decline of upland cotton production (and prices) while cattle prices have inflated rapidly.

The two main groups of sedentary farmers using traditional dryland tillage and husbandry methods are the various Nuba groups

and the Baggara tribes. Each group formerly had a distinctive type of subsistence exploitation (sedentary hill-farming Nubas and semi-nomadic Baggara livestock raisers). However, over the past few generations Nuba groups have colonized the clay plains through downhill migration and the majority of Baggara have Spontaneously settled on the clay plan as well. Today both groups engage in similar, evolving forms of hoe cultivation appropriate to the local soil and water conditions. Meanwhile, local populations and immigrant horticulturists have settled around permanent water sources and developed a small-scale irrigation agricultural sub-system. Less than one-fifth of the population still practices nomadic transhumance, a subject for another research proposal, although they possess the majority of the livestock (see Cunnison, 1966; 1972; Haaland 1980; Liendhart 1932; Khogali 1980; Abu Sabah 1981; Harvard 1981; Hunting 1981).

In historical perspective the literature defines six distinct types of farming/herding systems in South Kordofan:

1. Small farmer sedentary montane cultivation and herding
2. Clay plains and mountain foothill sedentary farmers/herders
3. Small-holder mechanized farm tenants on clay plains
4. Dinka clay floodplain farmer/herders in the South
5. Deep sand villager millet/peanut farmers in the North
6. Transhumant migratory herders

(see Nadel, 1948; Roden, 1972; Wood, 1972; HITD, 1981; Reeves and Grankenburger, 1982; Cunnison, 1966, Aravjo, 1982).

This research proposal will focus on the traditional small farmers and herders on or near the cracking plains, sand and floodplains throughout Southern Kordofan. i.e. farming system types #1, #2, and #5. The literature (see above) suggests that at present

the main type of crop grown by sedentary farmers is a staple sorghum grain on the clay plains and the foot-slopes of mountains; millets are staples in sandy areas.

The literature has identified several major agricultural problems throughout South Kordofan that limit productivity among small farmers and herders. For crop yields, these factors are listed in order of observed importance from secondary sources: 1) inadequate rainfall, 2) ill-timed rainfall, 3) increased cropping without rotation, 4) witchweed (striga) infestation of grain crops, especially sorghum and millet, 5) agricultural pests and plant diseases; insect pests, weaver birds, wild animals, and a variety of plant diseases especially grain smut, 6) labor bottlenecks during peak periods of farming effort, especially in land-clearing, weeding, harvesting, and threshing, 7) livestock depredations and conflicts between transhumant nomads and settled farmer groups, and 8) post-harvest storage losses.

In addition, various authors have cited the traditional agronomic practices (such as: hand hoe cultivation, poor quality seed, and cropping systems that deplete soil fertility); lack of adequate infrastructure, and inadequate price incentives as causes of low yields of crops. (See Hunting Technical Services, 1981, and Youngblood and Franklin, 1982).

The major identified causes of low sedentary livestock yields and constraints on improved sedentary range production include (in order of importance):

1) poor animal nutrition - due to lack of dry season forage and water,
2) burning of range lands preventing growth of perennial grasses,
3) overstocking of certain ranges, especially in sandy (northern) areas,
4) extension of cultivations and depletion of soils and forages,
5) poor animal health control, insect pests and disease transmission,
6) unimproved livestock breeding methods, and
7) conflict between livestock raisers and farmers for land/water use.

(See Hunting Technical Services, 1981, and Haaland, 1976).

Methodology:

Building on the work by Araujo, Wood, Hunting Technical Services, Reeves and Frankenburger, and others the proposed research will define the production systems of South Kordofan, with the primary objective of identifying problems faced by the sedentary farmers and constraints to increased productivity. As a continuing effort the first step of such research is an exhaustive review of previous work from published literature and personal visits with investigators. The methodology builds on preceding studies.

The proposed research will take place in the area of Southern Kordofan defined by Hunting Technical Services (1981) as the Central Planning Area* (see fugure 1). The reasons for limiting the project to the Central Planning Area are as follows:

1) Anticipated shortages of transport and fuel will limit distances traveled to the Central Planning Area surrounding the Kadugli Research Station.

2) Personnel available in Kadugli are not sufficient to cover the entire South Kordofan in one major survey effort.

3) The Central Planning Area, consisting of the Nuba Mountains and cracking clay plains, is the most relevant area for research at Kadugli during the first year, and provides continuity with preceding research results.

The project will consist of two stages. The first stage involves the selection of villages in each of the pre-defined agro-ecological zones of the relevant target area (study district). A rapid reconnaissance survey will be conducted in each of these villages. The results of this survey, along with information from other sources, will be utilized to check definitions of agro-

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*This area consists approximately of the Northern and Southern Planning Districts of South Kordofan.

ecological zones, confirm and selection of villages for the in-depth survey (stage 2) and provide baseline data from which the survey instrument can be designed. This stage will take place in January 1983.

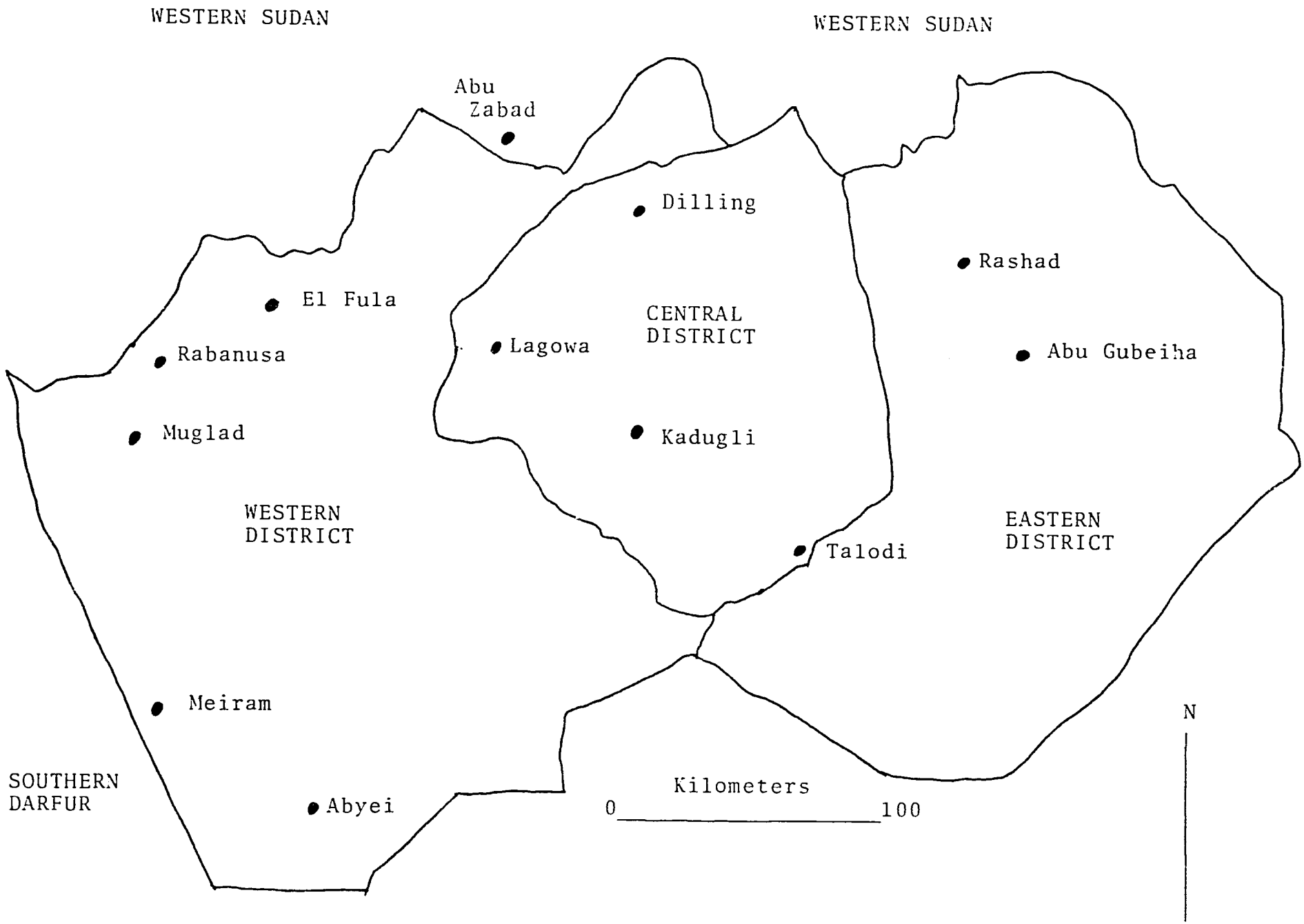
The second stage will be the in-depth Production Systems Survey designed to more completely delineate the crop aond livestock production systems, identify and verify constraints to increased agricultural output, and highlight the points and linkages in the production system where appropriate interventions can be performed. In each of the villages selected, 7-8 farm households will be interviewed. A total of approximately 120 interviews is anticipated. These interviews, of 2-3 hours duration each, will be conducted by separate interviewers (following appropriate training) under constant supervision by a project senior scientist.

Survey interviews will require approximately three weeks level of effort. However, due to other research responsibilities and unforseeable difficulties it will probably take 6-8 weeks to complete. The quantitative data recorded on the survey instrument will be coded and analyzed using both manual and electronic methods through SWARP and Washington State University.

During the data analysis when production constraints have been statistically identified, a visit will be made to some of the selected villages, plus a small number of other villages, to verify the existence and importance of the constraints. The visit will be accomplished by a team of scientists including an Agronomist, an Animal or Range Scientist, and a Social Scientist. This will also allow the biological scientists to begin development of additional, relevant research activities.

In addition to the collection of survey data on production systems, a small participant-observation sample of 3-5 households in each selected village will be interviewed to obtain diachronic information on household budgets and

Figure 1: Development Districts of Southern Kordofan



consumption patterns. This information is important to enable a comparison of farmer household production and consumption patterns. This information will also permit analysis of subsistence production versus commercial production of various crops in the farming system mix.

A preliminary market inventory will also be accomplished at each selected village to ascertain availability of agricultural output markets and sources of consumer goods.

During the 1983 growing season selected visitations will be made to the previously interviewd farm households to verify data, increase the data base and provide continued contact with farmers and villages.

Figure 2 shows an activities schedule for this proposal.

Resources Required: Personnel

	Level of Effort
Dr. Neil Patrick, Agricultural Econ.	30%
Mr. Abu Sabah, Social Scientist	15%
(2) Sudanese Trainees*	50%
(1) U.S. Research Assistant	25%
(3) Extentionists	15%
(2) Junior Technicians	30%

Resources Required: Equipment and Support

	Level of Use
Two Vehicles	50%
Typewriter (with typist)	30%
Copy Machine	10%
Electronic Mini-Computer/Calculator	50%
(10) Hand-held calculators	50%
Camping equipment for 12 people	20%

Justification for Research:

In order to design on-station and on-farm research that is responsive to the needs of sedentary farmers in South Kordofan, a great deal more must be learned regarding their production systems, their consumption patterns and

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*Trainees are graduates of Sudanese Universities selected to join WSARP in specific disciplines. After six months fieldwork with WSARP/Kadugli they may become eligible for Masters Degree training in the U.S.

Figure 2: Schedule of Activities

	1982								1983											
May	June	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Literature review------																			
Planning and development--																			
	Visit area and possible survey sites																		
					Begin development of questionare														
						Select villages													
								Finalize and test questionare											
									Conduct survey										
											Analyze data----------								
											Prepare first report								
													Verify data						
														Finalize first report					
															Prepare final report				
																		Finalize final report	

critical constraints to production. The research here proposed along with previous efforts will ascertain these factors. Writings by leaders in Farming Systems Research (FSR) such as Norman, Collinson and Hildebrand and others stress the importance of surveys such as that proposed by WSARP/Kadugli on Sedentary Farming Systems as appropriate and meaningful applied research.

Outputs:

The results of this proposed research effort will show up clearly in WSARP's capacity to design and conduct agricultural research trials that are responsive to the needs of sedentary farmers in South Kordofan and other areas of Western Sudan. Specific tangible outputs will include at least two publications. The first paper will contain a summarization of constraints to agricultural production in the Sedentary Farming System of the Nuba Mountains area. This publication is expected to be ready for reproduction in July, 1983.

The second publication will include a detailed description of the agricultural production system(s) of the Central Planning (target) area of South Kordofan, and baseline social and economic data such as: social organization, consumption patterns, and crop and livestock budgets. This publication is alated for reproduction in November, 1983.

APPENDIX

RATIONALE FOR AGRONOMIC RESEARCH STUDIES IN KADUGLI

Overall Objective: To devise cropping systems well suited to the limited resources of traditional agricultural producers in South Kordofan, and compatible with their total production system which will maintain or restore soil fertility, increase yields and yield stability.

Rationale: South Kordofan consisting of approximately 138,000km^2 has been divided into four physiographic regions: Nuba Mountain, Western Plains, Southern Alluvial Plains, and the Eastern District. Because the WSARP research center is located in the Nuba Mountain Region, most of the research during the early years will be concentrated in this region.

According to Hunting Technical Services, the main soil types in this area are:

1. Jebel - shallow soils, outcrops of granites, mica schists, and quartzite. Some cultivation. Approximately 7,122km^2 or 25% of the area.
2. Jebel footslopes - coarse and medium textured soils, shallow (100cm), and poor structure. Contains most of the people and home and near farms. Approximately 4,333km^2 of 15% of the area.
3. Plains residual - reddish brown, medium to fine texture, clay mineral predominately kaolinite, mildly to moderately acid, very hard surface, and very dry. Very little cultivation. Approximately 3,189km^2 or 11% of the area.

4. Eroded, shallow, and/or gravelly cracking clays - topography more undulating than dark cracking clays causing more run-off and less water entering the soil. Cultivated very little but could be cultivated more if population pressure becomes greater. Approximately 2,537km^2 or 9% of the area.
5. Alluvial complex - found along streams, usually not cropped. Approximately 1,410km^2 or 5% of the area.
6. Dark cracking clays (Vertisols) - contain most of the cultivated crops, high clay content (60% average), clay mineral predominately montmorillonite, self mulching, much swelling and cracking, low in N and available P and medium to low in K, high CEC, alkaline, non saline, non sodic, pH between 6.5 and 8.0. Approximately 10,260km^2 or 36% of the area. Most of the initial effort will be concentrated on these soils.

Undoubtedly poor physical properties of the cracking clay soils contribute to low yields, yet little is known concerning depth of wetting following rains and depth of root penetration. The Soil Survey Association Report No. 94, 1978, states that the soil physical properties in relation to climate limit production on cracking clay soils.

Sorghum and sesame comprise about 70% of the cropped area in the Nuba Mountain Region. Hunting Technical Services estimate average sorghum yields of around 450 kg/ha in the northern part of the region to around 750 kg/ha in the southern part. This same group estimates the average yield sesame to be about 450 kg/ha.

Average rainfall for South Kordofan ranges from approximately 500mm in the North to around 800mm in the South. Average annual rainfall over the past 40 years has been around 750mm at Kadugli in the Southern part of the Nuba Mountain Region. Essentially all of this precipitation occurs between the months of May and October and varies considerably between years and locations and within the rainy season itself. Length of growing season is determined entirely by the rainfall pattern within the province.

Usually farmers in the Nuba Mountain Region, and South Kordofan in general, grow a crop continuously for several years. Sometimes sorghum and cowpeas are grown together in a random manner with sorghum always predominating. Cropping continues until the soil becomes so depleted of nitrogen, or in the case of sorghum Striga increases to the point where cultivation is no longer profitable. This may require from 8 to 10 years. The farmer then abandons the land for a period of approximately 8 to 10 years hoping to restore fertility or reduce the population of Striga during the idle period. No attempt is made to keep the land fallow as it usually reverts to grass and shrubs during this idle period.

There are several aspects of the prevailing cropping system which cause operational inefficiencies. First, a farmer must maintain ownership or use rights of two to three times the amount of land he intends to crop each year. One-half to two-thirds of this land must lie idle providing little or no economic benefit.

Second, this vast land holding, relative to the amount of land actually cropped makes it necessary that for most farmers, at least

some of the land is located a far distance from the village, creating transportation, supervision, and management problems. Problems of this type reduce yields and profits even more.

Third, during the idle period the land naturally revegetates with a high proportion of trees, brush, and other plants which must be cleared before cropping again. This activity is time and effort intensive.

In their South Kordofan Rural Planning Livestock Production Report, HTS classifies cattle raising into two groups: sedentary and migratory, with the majority of cattle falling into the latter group. Farmers who are primarily cultivators but who own some livestock make up the sedentary group. In general, the livestock are herded by the children and usually do not wander more than a days distance from the farm home.

In the migratory system the transhumants travel with their herds from south to north as the rains begin, usually in June-July, and then move back south between September and November as the rains cease. Several reasons are advanced for these migratory practices which include the assurance of an adequate level of forage during the year, escaping mud and biting flies, and ethnic preference.

If cropping systems could be devised which included soil enriching forage legumes would the migratory practices continue at their present level? Why couldn't idle or "fallow" land be utilized to produce a soil building legume fodder? Why couldn't

those soils not suitable for extensive cultivation (Lithosols, Red-brown Alluvial/Colluvial, Red-Brown Residual, and Dark Grey, shallow gravelly cracking clays) be seeded to adapted forage legumes and grasses? However, no forage production system should be initiated until an attempt is made to control indiscriminate burning.

Although the "fallow" system does restore some fertility after the lengthy idle period, it seems wasteful of a basic resource. Research is needed to determine whether a legume crop, either for food or fodder, introduced into the cropping system can restore and maintain sufficient nitrogen so that the idle period can be eliminated or at least drastically reduced. Further research is needed to evaluate various food and forage legumes, introduced as well as indigenous, that will fit into these cropping systems or can be used to reseed vast areas with more desirable forage. Various cropping systems should be evaluated on participating farmers fields as well as on the research station giving the farmer some choices. Plant populations, planting methods, tillage, weeding practices, and use of commercial fertilizers should be researched and economically evaluated.

Means of cooperation with the SATEC animal traction group should be investigated. Research is needed to determine any reduction in yield due to the physical condition of the cracking clay soils. Green manuring, vertical mulching, and other methods should be investigated as a means of improving the physical condition.

It is proposed that Cropping Systems Research be divided into individual problem solving experiments.

LIST OF WSARP PUBLICATIONS

Publication No.	Title	Date
1	WSARP General Outline of Early Planning and Implementation Requirements	1979
2	Scope of Work for Initial WSARP Activities	1980
3	Consultant Report on Range-Livestock by Dr. D. Dwyer	1980
4	First Annual Report	1980
5	Summary of WSARP Planning Meeting October-November 1980 including Consultants Reports	1980
6	The Horticultural Resources of the Kordofan Region of Sudan	1982
7	Second Annual Report	1981
8	Consultants Report on Research Station Development by Mr. D. Meinhart	1980
9	Consultant Report on Livestock Production by Dr. T. Wilson	1980
10	Annual Report on Range Research by Dr. W. T. Bunderson	1981
11	WSARP Social Perspectives on Agricultural Research and Development in the Southern Kordofan, Sudan: Systems of Agricultural Production Among the Nuba by Dr. F. P. Aranjo	1981
12	Consulting Report on Range Research by Dr. D. Dwyer	1981
13	Work Plan, Volume I, General Research Program and Plans	October, 1982
14	Work Plan, Volume II, Project History and Functional Structure	October, 1982
15	Work Plan, Volume III, Research Plan for the Kadugli Research Station	October, 1982
16	Review of Seed Program in Sudan	September, 1982

Publication No.	Title	Date
17	Report of Visit to Sudan to Review Fruit Tree Research Program and Related Factors by Dr. A. H. Krezdorn, Consultant	May, 1983
18	Work Plan, Volume IV, Initial Research Proposals--Kadugli Research Station	August, 1983
19	Fourth Annual Report	August, 1983