Table of Contents

List of Tables

The Savannah Range-land of the Sudan

Indications of Recovery in Biomass Productivity and Soil Organic Matter of Sudan's Sahel Region: A Case Study of Northern Kordofan

PREFACE

The Dryland Husbandry Project (DHP) is an effort to bring together a variety of stakeholders in pastoral development, to identify and develop strategies for addressing the crisis of African drylands in the nineties. A network approach will be used to raise issues of mutual concern to researchers, practitioners and, above all, pastoralists, with particular emphasis on sustainable service provision and water management. For further details of the research project see the back page.

The Regional Office of DHP, OSSREA has taken the initiative to launch a **DHP Publications Series** for the Dryland Husbandry Project with the view to exchange and share opinions and experiences on issues of dryland husbandry in the Horn of Africa Sub-region in general and in the DHP areas in particular. The **DHP Publications Series** is a forum where researchers in the Dryland Husbandry Project and others inform the research and academic community, the policy makers and interested individuals and institutions the results of their action-oriented and participatory research, our training, workshop findings, trials research, ethno-veterinary practices, the relevance and use of indigenous knowledge in the project areas.

This is the first issue of the Dryland Husbandry Project (DHP) **Publications Series**. In this issue, we have selected and put together papers that were presented at the National Workshop on **Dryland Husbandry in the Sudan.** The workshop was held at the University of Khartoum in November 1995. These papers, OSSREA believes, could provide the reader information on the status of knowledge on dryland husbandry in the Sudan. This publication could also serve to encourage people with interest to do more with people in the pastoral and agro-pastoral areas in the Sudan. It is our strong believe that in order to understand and to be on top of the problems in the dryland areas in the Sudan, more attention and collaborative work both by researchers and policy makers together with the people at the grassroots is indeed a priority.

Tegegne Teka, Editor

1. Background to the Workshop

Sudan is the largest IGAD member state, with a land area of approximately 2.5 million square kms. Its population is approximately 26 million, 75% of whom live in rural areas. The economy depends predominantly on agriculture which contributes about 30% of the GDP.

Two-thirds of the area of the Sudan is arid or semi-desert. Recurrent droughts have rendered many pastoralists and small scale cultivators in these areas vulnerable to famine and impoverishment. However, the causes of the present crisis in the rural production systems in the country cannot be attributed to drought and desertification alone. Misguided economic policies have played an important role in the deteriorating situation of the population.

Breaking the vicious circle of the ecological stress and the increasing vulnerability of the population of the drylands require an increased production from small-scale cultivation and livestock husbandry. Training and research are needed to re-orient development planning in a new direction that considers interaction among local communities, researchers, extensionists, planners and decision-makers.

One of the major problems of livestock production is the deterioration of range resources. Range rehabilitation and desertification control strategy in the Sudan are based on an ecological approach whereby the corrective measures are chosen to correspond to the environmental conditions which prevail in a specific ecosystem. Pilot demonstration measures are expected to contribute to the rehabilitation and improvement of the grazing resources.

In order to provide successful models for rehabilitation and management of drylands, two typical areas representing the drylands of the Sudan are selected for the activities of this project. The first area is in Northern Kordofan (*El Khuwei*), situated within the semi-desert zone and whose population, beside practising traditional rainfed farming, also keep various types of livestock. The main target groups of this area are the pastoralists - Hamar and Kababish tribes. They are primarily camel, goat and sheep pastoralists. Both the Hamar and Kababish adhere to a complex migration pattern which involves a cyclical movement during the dry season to the south and then northward where they spend the rainy season.

The second area is the Butana in the eastern region which is inhabited by the Shukriya tribe. Unlike the area of the Hamar and the Kababish, whose climate and sandy soils are not suitable for large scale agricultural production, the Butana's climate and soils are suitable for agricultural production. Hence, the pastoralists suffer from large-scale encroachment of both irrigated and rainfed agriculture limiting their movement to marginal areas which are over-grazed.

The present project intends to create an enabling environment for the pastoralists in both areas to maintain a balanced productive system. Hence, the project involves activities for range improvement, disease control and rehabilitation of degraded areas.

The project activities include:

1. In-service training and re-training of extension staff on social dimension of range management.

2. Training of veterinary scouts.

3. Training of pastoralists.

4. Intervention and action research which will focus on indigenous grasses and tree species as well as socio-economic aspects of pastoral production.

In order to launch the activities of the project, this workshop on "Dryland Husbandry in the Sudan" provides a quick review of the status of knowledge and highlight the level of previous research and activities in the selected areas. Hence, the workshop is held with the following objectives.

2. Objectives of the Workshop

1. Provide a background on dryland studies in the Sudan with special emphasis on pastoral communities.

2. Provide the participants with a background on regional and international experiences and research in drylands.

3. Discuss types of research needed on Sudan's drylands and pastoral communities with emphasis on the selected areas.

4. Discuss project activities and recommend improvements.

3. Organization of the Workshop

The National Steering Committee formed a task force of three persons to prepare for the workshop. Their task included the selection of relevant papers to be presented, persons and institutions to be invited and the selection of an appropriate venue. The task force, guided by the National Steering Committee and taking into consideration the objectives of the workshop, contacted appropriate persons and institutions to prepare both background papers and to participate in the workshop (See Annex I).

4. The Workshop

Invitations were sent to more than 30 institutions with interests in dryland husbandry (Annex II). Selected individuals were also invited. The Minister of Agriculture, Natural Resources and Animal Wealth attended the opening session and addressed the participants. Abstracts of papers - more than 200 sets - were distributed to all participants. The workshop was well attended and participants actively contributed to the discussions. The last session, which was devoted to a discussion of future programmes, with emphasis on the present project, yielded a wide range of relevant recommendations to be considered by the National Steering Committee.

5. Recommendations

The recommendations may be divided into two groups. The first group are those pertaining to the project activities and the second are those of general nature related to aspects deemed necessary for proper dryland husbandry.

5.1 Recommendations Related to Project Activities

a) Recommendations on Research

The participants recommended specific research problems to be investigated in the selected areas. The most important are summarized in the following:

Research on indigenous knowledge to cover traditional ways of fodder storage and preservation; indigenous ways of solving conflicts; indigenous ways of range management; indigenous institutions and their role in range management and indigenous classification of plants.

Research on economics of rangelands.

Research on new emerging patterns of pastoralism.

Policies.

How to activate pastoral associations.

Research on seasonal variations in productivity.

Role of pastoral women.

Taxonomy.

b) Recommendations on Appropriate Interventions

Range improvement and management through the involvement of pastoralists.

Re-introduction of "Ahmia".

Introduction of improved breeds.

Disease control through training of veterinary scouts.

Water harvesting to improve range utilization.

c) Recommendations on Training

Training of pastoralists to be veterinary scouts.

Training of extension agents (veterinary and range specialists) on pastoral systems and social behaviour and on how to make use of the pastoralists traditional knowledge.

Training on the use of appropriate technology, e.g. water harvesting, simple methods of re-seeding, and on methods to improve animal products.

5.2 General Recommendations

Need for a land use map.

Studies on land tenure.

Studies on rangelands laws.

Assessment of the potentials of natural resources and recommendations on use according to capability.

Collection and review of previous studies on pastoralism to identify gaps in knowledge.

Repeat of monitoring studies to assess degree of recovery and assessment of biomass productivity.

Establishment of a national herbarium.

Better coordination among institutions working in dryland husbandry.

Dryland Husbandry in Sudan With Emphasis on the Semi-Desert Zone

Mustafa M. Baasher*

1. Need to Qualify Some Words

The word 'desert' has been used to describe certain terrain of land that receives little or no precipitation, and where temperature extremes limit life from multiplication and survival.

The word "dryland" or "Aridland" are sometimes used to describe geographic zones of the world that receive insufficient amounts of precipitation coupled with high temperatures that add to their aridity.

However, ecologists, geobotanists, and world climatologists as well as agronomists have hardly reached any satisfactory agreement in their attempts to define these two words, namely what should come under "desert" and what should be defined as "arid" or "extremely arid".

Sankary (1967), reviewing world vegetation mapping work, gave the vivid example for such disagreement and confusion where, Emberger (1965) recognized desert in areas being placed by Meiges under "extremely arid". He pursued this rather confusing definitions by mentioning that, Emberger placed "extremely arid" in areas where other workers have placed it under "true desert". World plant geographers resorted to the use of the words "true", "proper", and "real" desert.

In Harrison and Jackson's (1955) vegetation map, desert was defined as area receiving an average annual rainfall of less than 75mm. Such areas, included under desert, support wildlife such as the Addax, the Oryx as well as Ghazzelles and Ostriches. This is more or less contrary to the definition of the word "desert".

2. Need to Up-date and Breakdown the Vegetation Map

Harrison and Jackson's version of the vegetation map (Vegetation Map, 1955), and the different vegetation zones descried by them were verified by Lebon (1965) using Koppen's equation. According to Lebon, Harrison and Jackson's vegetation map gave a good fit.

Recent work by Emberger has improved Koppen's work and indicated that such formula needs to be modified by using phytosociological parameters and analytical techniques to rectify certain deficiencies.

A glance at Harrison and Jackson's classification reveals that the semi-desert zone breakdown is rather confusing.

The word "scrub" alone or "desert scrub" are maintained under semi-desert and then semi-desert is further assigned to subzones within the semi-desert.

The montane zone is no more than a solid red patch shown in isolated places without any further breakdown. We know that zonations of vegetation do exist in the Red Sea Hills, Boma plateaux, Jebel Marra and the Imatong which should justify a further breakdown. This will help to work out a reliable land capability and land classification map.

3. Gap in Knowledge to be Bridged

In our attempt to delineate what constitutes the dryland of Sudan and what treatments they should receive; and in order to tap their potential; i.e., effective manipulation of the existing potential, one should

expect that our present knowledge should develop to or reach a reasonable level and be supported by continuous monitoring, compilation of records, keeping of survey records, and carrying on with local research works or adopting applicable research works being conducted under similar conditions.

The need for and the availability of authenticated and reasonably well verified basic data should not be underestimated or dismissed as unattainable or not necessary. Nevertheless, there should be a general acceptance that there are some gaps in our present knowledge (if not many gaps) of Sudan's dryland potential and the physical environment that makes up such dryland.

Leaving things as they are will not help much, but will complicate the problem as time goes. However, areas where information is lacking or need completion are:-

3.1 Assessment and location of underground water - quantity and quality.

3.2 Assessment of surface run-off and guaging of some of the big wadies in the zone e.g. El Hawad, El Atshan, El Sadah, El Mukhazir, El Milk, Howe, Howar, Mugadam, Abu Ghalb Abu Habil, Khor Arab, Wadi Amur and to some extent Barka, Gash and Arab'at.

3.3. Collectionof sufficient meteorological data, e.g. rainfall coverage, temperature (air and soil), humidity, wind speed, solar radiation (computation of evapo-transpiration).

3.4 Soil survey and soil maps to the level of soil groups or soil series and type - their physical and chemical constituents and deficiencies in macro or micro plant nutrients.

3.5 Knowledge of the plant cover to the level of plant community - over and under story and the floristic composition and chemical constituents.

3.6 A good or fair survey of animal and plant diseases and pests of the area.

3.7 A fair knowledge of the fauna and the important wildlife species and their distribution.

4. Finding a Wayout to Make-up for Such Imperfect Knowledge

4.1 Revising Harrison and Jackson's Vegetation map and scrutinizing zonation boundaries and breakdown to sub-zones. Work out further breakdown and improve over present scale. Present scale is 1:8 million.

4.2 Up-date the flora of the Sudan. Review Herbarium collection for better display and observing ecotype and genetical or morphological differences and spread within species.

4.3 Establish some natural history reserves in the order of one to few hectares each in representative areas in the major vegetation zones and subzones. If funds permit carry on to plant association and plant community levels.

4.4 Insist on working a land capability map for the semi-desert zone or the driest part of the dry zone. This will help to single out large areas for the management and conservation of the grazing land. A country-wide land capability and land use map needs much effort and the release of large sum of money. A piecemeal approach might be the answer and should make a short-cut instead of waiting for a country-wide treatment.

4.5 Suggest for working in the dryland areas namely Northern Kordofan and the part of Eastern Sudan that lies in the semi-desert zone (not Butana alone) to adopt and maintain everlasting policy and strategy

of team-work approach. Hence, the creation of a "special dryland husbandry task force" to be formed of the different specialities knowledgeable in dryland husbandry work.

Personnel selected should be technically equipped and qualified to deal with problems of dryland management and development.

4.6 Priorities and allocation of funds should be critically and carefully decided upon with the essential aim of bridging gaps in knowledge and working towards setting out targets and fulfilling developmental scores and optimizing resources use and perpetuation.

4.7 Adoption of simple proven techniques and the introduction of appropriate technology which are sometimes frowned upon by both the recipients and the decision makers as being obsolete or a step to the back. Appropriate technology and simple techniques can effectively be applied to the development of the micro-environments. Micro-environment approach should ensure a better use of the resources at hand. It will help conservation of resources at hand, and to prevent excessive pressure on land resources by checking over-crowding of both man and beast.

4.8 Sudan has leaned too much on raising crops under irrigation where the largest part of the country's inputs in agriculture has gone to irrigated farming. Use and development of natural resources should not be limited to the tapping of irrigation potential alone. Dryland husbandry and specially rain-fed crop raising and range- land management should be activated and their problems tackled.

Rangeland and rain-fed subsistence farming receive less attention. The areas they occupy in the country are the largest and the most vulnerable. Such areas suffer from human and animal pressure and over-use. The need to rectify such abuse and negligence is more than eminent and it is high time to strike a balance and change emphasis in priorities.

4.9 Emphasis should be placed on working out project models to answer some chronic problems pertaining to:

Management of resource use around permanent water points.

Adopting reliable inventory methods for rural water development aiming to equate resource potential to amount and type of water supply to be provided.

Devising ways and methods of securing the needed protection to grazing land and forest stands. There is a very obvious need to suggest methods to ensure protection other than that given by barbed wire or metal fencing.

Establishing grazing reserves (Famine-Annual) and forage banks.

5. Some Possible Intervention in Northern Kordofan

The stabilized sand dunes of Western Sudan in the semi-desert zone enjoys a good stand of grass and tree cover. This falls mainly under Harrison and Jackson's classification - *Semi-Desert Grassland on Sand*. The grass cover is mainly represented by the G*enera Cenchrus* and *Aristida* and occasionally the valuable perennial grass, namely, *Andropogon gayanus. Leptadenia* and *Acacia tortilis subspradiana* constitute the main tree cover as recorded in the past.

Attempts by the Range Management Administration as early as 1957 to carry out work on range conservation, management and rehabilitation were made. In the first place, a fireline grid was worked out

to protect the rangelands from accidental bush and grass fires. Work was limited to Dar Maganin, Northern Hamar and partly Dar Hamid.

Using the existing forest conservation law, two sites were chosen to protect the rangeland and start two grazing reserves, namely Abu Fas Grazing Reserve and Gureih El Sarah Reserve. Beside protection from continuous and untimely grazing, some management plans were worked out and some seeding trials were conducted. Gureih El Sarah received some follow-up and evaluation by different writers and workers. One important result still remains; and that the nomads on those two sites and the tribal administration were convinced and accepted to give such work a try.

The "JUZU" complex has been on focus for some time. Information on this type of spontaneous vegetation depended on notes by Darling (Government Entomologist) and to a greater extent on writings of Sir Newbold. The complex as described by them constituted mainly the following:-

i) *Triraphis permulu* grass

ii) *Aristida papposa* "

iii) *Aristida hertagluma* grass Nissa

iv) *Neruda procombens* herb Sa'adan

v) *Fagonia critica* "

vi) *Zygophellum simplex* "

vii) *Crotolaria sudanica* " Gutub

viii) *Tribulus* spp. "

This interesting and rather forgotten vegetation complex warrants further studying. The Bayoda Desert and the Nubian Desert are said to contain some "Juzu". South of the zone in Northern Hamar and in particular around Eial Bachit and, to a lesser extent, between Bur Salam and Khuwi, a good stand of *Andropogon gayanus* has been observed.

Andropogon was recorded in El Obeid reserve as late as 1962. The genus Andropogon is represented in the Sudan, Somalia, and is considered in the ranges of South America as key range species. In the Sudan two varieties of Andropogon were recorded with two different chromosome numbers. One is quadrimoculatus. The other is bimoculatus.

This brings out the necessity of genetical as well as morphological studies to determine adaptable varieties, ecotypes and attributes that suit dryland and arid conditions. The stretch between Dar Maganin and Dar Kababish house some drought resistant species namely:-

i) *Panicum turgidum* "Tumam"

ii) *Hilaria mutica* "gharaz"

iii) *Indogofora spinosa* "Sangad"

iv) *Oypress spp.* "Deis"

v) *Aristida pallida* Um Sememi

vi) *Aristida hirtagluma* Nissa

None of these plants has received any study. Definitely the plant *Planicum turgidum* has many ecotypes. The quality of the forage, its palatability and tolerance to moisture and grazing stress can be improved. Selection on phenotypic attributes should not cost much and can be done in a relatively short time. These plants, besides their forage value, can be considered as good dune stablizers and sand dune fixers.

Grazing Reserves and Range Protection in General

The problem of protection is one of the most difficult issues in Range and Forest Management and Development. Protection is needed at various stages in plant development and range management as a whole. It is rather expensive if done in a conventional way of resorting to wire fencing.

Ways and methods of realising effective protection should be thought. These should:

i) Encourage establishment of community rangelands and community forests.

ii) Motivate nomads and villagers to make their own efforts of guarding and securing protection to growing plants or reserved areas.

iii) Resort to local orders and the issue of enactment.

iv) Manipulate physical barriers and hilly areas such as Red Sea areas and some Jebels in Northern Kordofan i.e., Abu Fas.

v) Use plants as green fence of such materials as:-

a) *Leptadenia pyrotechnica*

b) *Capparis decidna*

c) *Mearua crassifalia*

d) *Lycium arabicum*

e) *Comiphora spp.*

Equating Water Provision to Grazing Potential and Resource Management

Another problem that needs attention in the semi-arid zone of Western Sudan under open and communal use of the grazing land is control and distribution of livestock watering points. Some suggestions were presented to control and limit range deterioration and over-grazing around water points. Others suggested to equate water provision to the resources on sites for which a water point needs to be installed. Neither of these suggestions was put to practice.

Some Possible Intervention in the Semi-Desert Zone of Eastern Sudan

Red Sea Hills strip is rather a unique area within the set-up. Its omission will deprive workers from exhibiting their excellence. Some of the factors that should be considered to assess Red Sea Hills potential and unique environment are:-

1. Latitude effect

2. Altitude effect

3. Winter and Summer rain peaks

4. Humidity and Sunshine

5. Water harvesting possibilities

6. Presence of salt bush vegetation

7. The inhabitants

Water spreading work had been started in Arba'at as early as 1961 and a huge programme of soil conservation work was once considered as one of the greatest achievements in soil conservation work in Africa. This was no more than the dyke and bunding and water course control work in Erkuwit.

The Butana on the other hand received its quota of water development programme in the period 1950/55 and in 1960/65 in the form of earth-dug tanks (Hafirs). An effective fireline grid has been maintained since 1960.

Land pressure increased and grazing by different livestock as water became continuously available. Cattle numbers increased and with the Gneid, Khashm El Girba Scheme and recently El Rahad, more animals were kept and grazing pattern changed and migration to the south was modified. The valuable grazing species of the Butana were virtually annihilated and destroyed. *Blephoris edulis* which has been recorded in a survey by Harrison and Baasher (1955), covering the area between Jebel Mundra and Suba'ah is no longer there. Vast areas of *Sehima ischaemordes*, the valuable grazing grass locally known as "dambalab", had been destroyed. Two other herbs distribution also either became limited or completely disappeared; namely, *Ipomea cardiosepla* and *Crotolaria maxilaris*.

A Proposed Rangeland Rehabilitation Project

The Butana clay plains are almost stoneless and contain vast open treeless expanse of land which are suitable for the use of tractor-driven implements and for large scale land preparation and plant establishment.

Tractor operation and maintenance and the cultivation of large tract of land are well-known and practised.

It is suggested that several land units of selected grazing land in Butana (between Kaasmur and El Ghatar Hills) be left aside for grazing improvement work. Improvement can take either of two methods or both:-

i) Protecting area for several years to promote natural rehabilitation of plant cover.

ii) Introducing some indigenous or exotic plants to upgrade grazing potential.

Suggested grazing plants include:

i) *Blephoris dulis* ii) *Sehima ischaemordes*

iii) *Cenchrus ciliaris* iv) *Cenchrus setigrus*

v) *Renchosya memnonea* vi) *Crotolaria maxilaris*

vii) *Clitoria terntea* viii) *Phaseolous trilobus*

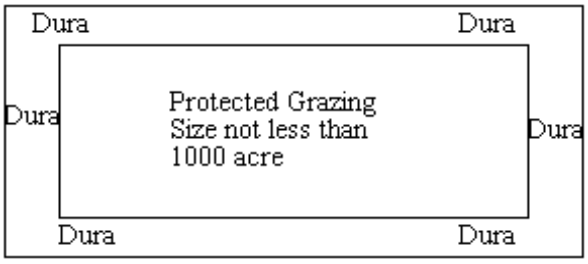
ix) *Indigophora spp.*

Protection is very essential and is considered the key in all range development and improvement.

An effective way is to convince people themselves to do the desired protection. Protection can be partial for few months or total for one year or more than that.

A second way of doing it is to select some guards and give them some incentive by letting them make use of the crop of dura grown or dura stalk if the crop fails in such marginal land.

Around the selected area for protection several rows of crop of dura (five disc plough width) are being established around the area to be protected (see diagram below). Several guards can be appointed either on voluntary basis or on nominal payment together with return from the dura crop or dura stalks.



It is customary that nomads respect cultivation and with partial guarding and an obvious demarcated areas a good protection can be realized.

Community grazing land in the same way as community forest can be tried and adopted as a future philosophy of involving people in grazing resource management and rehabilitation.

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The Savannah Rangeland of The Sudan

Ali Darag Ali

El Sadig Yousif

1. Rangeland Ecology

Rangeland defined as all wildlands that extend within the savannah belt which is considered as not suitable for rainfed farming but for livestock and wild-life grazing. This definition applies to all marginal drylands that extend across the Desert, the semi-desert and the low rainfall savannah ecological zones. This area covers approximately 32.5 million feddans and extends over most of Kordofan, Darfur, Middle and Eastern States (Refer to the Ecological map No. 1).

The vegetation composition and distribution over the predominant ecological zones are entirely attributed to the actions and interactions of the prevailing environmental factors resultant mainly such as climate, soil, topography and the common human and animal activities. These interactions and the resultant ecological zones when coupled with the existence of a network of rivers give rise to wide diversification of land uses.

The ecological zonation map is essential to use to draw land capability classifications which are essential for the projection of the land use map. The latter is essentially used to regulate the location of Agriculture and Natural Resources uses in accordance with the actual capabilities and suitabilities of the predominant agro-ecological zone. All policies with regard to agriculture and natural resources development are usually drafted on the basis of the projected land use map. These policies and laws are usually drafted to prevent interactions that may exist in land utilizations.

2. Land Use Policy and the Size of the Rangeland

Although the country is rich in immense agriculture and natural resources, still the economic planning and development is hindered by the lack of land use maps and policies. The land use laws and policies are only effectively applicable when agricultural and natural resources utilization are defined and projected in proper land use maps.

In the absence of these maps and laws, it is rather difficult to define the actual size of the Rangeland which is currently under use. However, systematic movements of the nomads and areas of their seasonal concentration can be used to indicate the location of Rangeland currently under use (see map No.2).

The size of the Rangelands which are currently under utilization can be indirectly computed when the size of national herd and the average range forage production are determined. According to this information, the size of the Rangeland required to accommodate the grazing of the national herd can be determined as follows:-

The total number of the national herd = 35 million AU (93/94 Census).

Average feed requirement per AU per year = 0.9 - 1.0 Ton/TDN/YR.

Total feed requirement in the form of TDN = 35 x 0.9 = 31.5 million Ton of TDN.

Average forage production in the Form of TDN.

0.5 x 90/100 x 31.4/100 = 0.4 Ton TDN Feddan

The total size of the rangelands required to accommodate the grazing of the national herd =

31.5/0.14 = 225 million Feddans.

As the calculation above indicates, the actual size of the rangeland which is required to support the feeding of the national herd amounts to approximately 225 million Feddans.

3. Current Land Use

There is no accurate census with regard to the actual size of lands currently under use in agriculture or natural resources. However, the agroecological zone and the present agricultural statistic are here used to arrive at an approximate estimates of the current land uses and consequently the actual size of the rangeland which is currently available for livestock grazing.

Table No. 1: Current Land Uses

Agro-Ecological Zones	Total Surface Area (million fed.)	(%) of Total	Area Cultivated		(Mill. Fed.)		Deteriorated or Desertified (mill. fed.)	Forest (Million Feddan)	Range Land (Million Feddan)
			Irrigated	Rain-fed (MECRF)	Traditional	Total			
1. Desert or Desertified	157.08	28.2	7.84			7.84	141.40	7.84	
2. Semi-Desert and Low Rainfall Savannah	165.42	29.7	-	-	40	40	82.71	-	42.72
3. Low Rainfall Savannah on Clay (Control Clay)	80.90	14.6	6.00	18	12	36	Slight	16.18	28.72
4. High Rainfall Savannah and Flood Region and Monit., Vegetation (Southern Clay Plain)	153.33	27.5	?	?	?	?	-	138.00	15.33
5. Total Areas	556.73	100	13.84	18	52	83.84	24.11	162.02	86.77

Source: Recalculated by Darag from Sudan Agro-ecological Zonation and Agricultural Statistics.

Remarks on Table No. 1

1. Desert	:	Cultivated areas are only along the Nile. Grazing along wadis
2. Semi-Desert	:	Areas deteriorated are mainly due to the expansion of rainfed farming. This zone is only suitable for grazing.
3. Low Rainfall savannah on clay	:	The rangeland is suitable for agricultural development. Currently this area is utilized for summer grazing.
4. High Rainfall Savannah and Flood Region	:	90% of this area is forest and wildlife habitat. 60% of the clay plain is suitable for agricultural development
5. Total Areas	:	Desertified areas include the true desert (141.1 million fed.). Desertified areas within the Savannah are only 32.71 million fed. (50% of Semi-desert and low rainfall savannah on sands).

Table No. 1 illustrates the current land uses. Table No. 2 is a summary of the current land uses.

Table No. 2: Summary of the Current Land Use

Current Uses of Land	Total area (million Fedd.)	(%) of total
Desert and Desertified Zones	224.11	40.3
Cultivated	83.84	15.0
Forest + Others	162.02	29.1
Rangeland	86.77	15.6
Total	556.73	100

Source: Recalculated from Table No. 1.

As Table No. 1 indicates the desertified area excluding the true desert (141.4 million Feddans) amounts to approximately 82.71 million Feddans. The area desertified is entirely confined to the rangelands which extend through the semi-desert and the low-rainfall savannah on sand soils.

As indicated in the same tables (1, 2) the available rangeland does not exceed 86.77 million Feddans (15.6%). The size of the rangeland before the spread of desertification does not exceed 177.7 million feddans which is to be considered as 78% of the total size of rangeland (225 million fedd.) estimated as required to support the feeding of the national herd (35 million AU). This unbalanced situation contributes to rangeland degradation and the spread of the problem of desertification.

Previous field surveys and investigation proved that over-grazing and the unplanned expansion of rainfed farming are to be considered among the most important factors causing general land degradation. Any effort regarding rangeland rehabilitation or desertification control must be preceded by the cessation of farming in marginal lands.

4. Rangeland Development

All previous development plans had never given a significant importance to rangeland development until the problem of rangeland degradation and desertification have become a hampering element to economic development since the late seventies.

In the recent 10 Years Development Plan, angeland rehabilitation, desertification control and general environmental conservation have been incorporated. The proposed corrective measures and activities include: range conservation, rehabilitation, improvement and the modernization of rangeland management through the introduction of the ranching system.

5. Past and Current Range Development Activities

5.1 Range Vegetation Survey and Mapping

Since Harrison and Jackson (1958), no genuine work had been done with regard to vegetation botanical composition and distribution. Since Harrison's vegetation map, the vegetation floristic composition has undergone remarkable changes in most of the predominant ecological zones, particularly those which are currently affected by environmental degradation and desertification.

The range vegetation survey and mapping which was carried out by the savannah project (1962-1970), Agrar hydrotechnique and recently by SRAD all are fragmented activities and are limited to very small areas.

Lampry, in 1975, using aerial photo interpretation, surveyed the area affected by desertification within the Northern part of Kordofan. He discovered that the desert boundary which was established by Harrison (1958) had shifted down 100 km into the semi-desert ecological zone. Lampry in his report established the rate of desert encroachment as 5-6 km per year.

According to the request submitted by the Range and Pasture Administration, FAO during the period 1984-1986 conducted a range vegetation survey using aerial photo as well as satellite image interpretation. In this survey, the analysis of the AVHER (Advanced Very High Resolution Radiometer) images which discriminate between green and non-green areas (vegetation and non vegetation) was used in vegetation analysis and mapping. The outputs of this survey were the following:

1. The production of 9 vegetation map, scale 1:250,000 covering a total area of 308,025 sq. km.

2. The production of three Land Use maps, scale 1:11,000,000 covering a total area of 616,050 sq. km. in southern Northern Kordofan, middle and eastern regions.

3. Biomass production map covering the savannah belt (1.2 million sq. km.).

4. Line map (Terrain units) covering the area between Chad and the Ethiopian border, scale 1:1,000,000.

5.2 The Assessment of Changes in Vegetation Composition and Production

5.2.1 Vegetation Composition

General land misuses, coupled with frequent cyclic drought during the period between 1970 and 1995, severely affected vegetation species composition and the overall biomass production per unit area. What was *Acacia senegal* savannah has now become semi-desert grass-land. Much of what was classed as belonging to *Acacia senegal* formation may have once been *Acacia senegal compretom cordofanum* association. The replacement of *Terminalia brownii* by *Dalbergia amara* subspecies was reported to have taken within the low rainfall savannah ecological zone.

Understory herbaceous vegetation is also reported to undergo remarkable changes due to range degradation. The botanical measurement, carried out during the Kordofan Special Fund Project (1962-1965) indicated that the trend in the vegetation composition is toward the development and survival of short-lived annual, rather than perennial, species. Wicken (1962) and Sekerman (1965) related the replacement of perennials by annuals due to the harsh condition imposed by the removal of litter and ground cover by repeated burning. This repeated burning usually causes high surface temperature to the extent that the micro-environment is not suitable for seedling germination.

Recent vegetation measurement, conducted by the Range staff at Elodya Project are illustrated in Table No. 3. As the table indicates, the species composition index within the parameter under measurement amounted to 28.3% in 1988 while in 1993 the percentage composition was reduced to 4.75%. The erosion hazard within the parameter under study increased from 30.2% in 1988 to almost 74.5% in 1993.

These botanical measurements are a full proof that the parameter under study was exposed to severe over-use after the protecting fences were destroyed.

Table No. 3: Analysis of Botanical Measurement Data Collected within Elodya Parameter during 1988 and during October, 1993

Hits along Transect Cluster (1988)	Transect Cluster				Total	Average
	TR1	TR2	TR3	TR4		
(%) Plant sp., Composition	21	10	48	34	113	28.3
Rock	-	-	-	-	-	-
Litter Index	42	43	39	42	166	41
Bare Soil	37	47	.3	24	121	30.2
Total						100

Summary of Measurements

(%) spp. composition = 28.3

(%) Litter accumulation = 41.5

(%) Erosion hazard = 30.2

Total = 100

Hits along Transect Cluster (1988)	Transect Cluster				Total	Average
	TR1	TR2	TR3	TR4		
(%) Species	1	10	3	5	19	4.75
Composition						
Rock	-	-	-	-	-	-
Litter Index	13	11	19	40	83	20.75
Bare Soil	86	79	55	78	298	74.5
Total						100

(%) Spp. composition = 4.75

(%) Litter accumulation = 20.75

(%) Erosion hazard = 74.50

Total = 100.00

5.2.2 Biomass Production Per Unit Area

As reported by M.M.Suliman (1985) in the baseline survey of Kordofan and Darfur, the production and long-term productivity of the herbaceous biomass have been continuously and constantly decreasing due to over-use and environmental stress. The decline in the herbaceous biomass productivity is illustrated in Table No. 4.

Table No. 4: Some Changes in the Herbaceous Biomass Productivity

Ecological Zone	Productivity (Ton Dm/ha) 1958 Harrison	1974/1975 Range and Pasture	1985/87 M. Suliman
1) Semi-desert			
2) Low Rainfall	0.2	0.1	0.05
Savannah			
2.1 Northern Part	0.24	0.1	0.14
2.2 Central Part	0.33	0.1	0.14
2.3 Southern Part	0.66	1.5	0.2
2.4	0.66	-	0.33
2.5 Baggara	0.99	2.5	0.8

Source: M. Suliman (baseline surveys for Kordofan and Darfur

(1985-1987).

5.3 Range Research Activities

5.3.1 Previous Research Attempts

Research in dryland including range development is always directed to problems concerning food production. There is always a total neglect regarding rangeland and pastoral communities and pastoral ecosystem.

Proper research programmes started with the establishment of the Gazala Gawazat Range and Livestock Research Station during 1960. Aspects of range livestock nutrition were intensively investigated. Other research activities included the following:-

Vegetation trend analysis on the protected range exclosure.

Assessment of carrying capacities and testing of suitable grazing management system.

The establishment of adoptable forage plant species (stylothansis sp) for range improvement.

Range improvement using bush control methods.

Eighteen years later, the government recognized that improvement and development of grass-land agriculture might require a long-term commitment to research. The dramatic result was the creation of the Western Savannah Agricultural Research Project (WSARP) in 1978. The World Bank and the USAID contributed US$30 million to the project, which had as its focus a commitment to research on rangeland and dry-land farming systems. For such purposes four research stations were built, two in Kordofan at Elobied and Kadugly, and two in Darfur at El Fashir and Ghazala Gawazat. Although the project funds were committed, the work in research activities was very slow, and execution of the research programme is now hindered by unavailability of necessary funds.

5.3.2 Rangeland Research Aspects

There are social as well as psychological barriers and technical problems to overcome so as to modernize the management and utilization of the country's grazing resources and develop the livestock production. The Government, in the current 10 Years Plan (1991-2001) is interested to see that livestock production is developed as soon as possible. The modernization of the pasture management system through the introduction of ranching or the application of controlled deferment and rotational grazing systems will be limited due to the lack of basic knowledge of the characteristics of the Range Savannah forage resources.

It must be emphasized that currently there is inadequate information as to the original range forage plant composition, its seasonal changes and growth cycle in relation to the short-term climatic sequences. There is no knowledge of the actual grazing potential or the carrying capacities of the varying range types either from botanical assessment or grazing experiences.

To remedy this deficit of knowledge, the research must be oriented to measure and examine all parameters that maintain and influence range forage composition and production. The seasonal range plant composition changes must be correlated with seasonal climatic sequence as well as with the effect of seasonal burning, and with all other parameters that may influence these compositional changes.

5.4 Rangeland Rehabilitation and Improvement

It is acknowledged that the restoration of degraded rangeland under the current open grazing and in the absence of land use policy is a difficult task. However, the Range and Pasture Administration's previous and current programme is composed of a number of corrective measures involving Rangeland Conservation, Rehabilitation, Rangeland Improvement and Forage Production.

5.4.1 Rangeland Conservation

Rangeland Fire prevention through the construction of fire breaks provides an effective means of protecting the grazing resources. The total length of the fire lines grid executed last year (1994/1995) exceeds 31,932km.

Inspite of the fact that fire-line building using hand tools proves to be effective, although somewhat slow, it is time consuming and relatively expensive. During the late seventies, in the RMPA experiment, the use of herbicide mainly translocated chemicals, such as USTILAN in the opening of the side strips of the fire line. Herbicides were applied at the end of the dry season to prevent grass growth along the side strips during the following rainy season. Thus far, however, the experiment has been inconclusive in regard to the economic benefits to be derived from the use of chemicals which must be purchased with foreign exchange as opposed to paying local labour when using hand tools. Further investigation will therefore be required.

5.4.2 Rangeland Rehabilitation

Using seeding and water harvesting techniques, two approaches were tested to revegetate degraded rangelands. The first approach was absolute protection to allow natural plant succession to take place when causes of degradation were excluded by fencing. This method was found to be expensive and the recovery was very slow.

The second approach was direct reseedling, using adaptable forage plant seeds along with soil treatment and water spreading for soil moisture improvement.

In consideration of the necessity to initiate immediate measures to restore the ecological balance following the drought of 1983, the RMPA combined the two approaches (reservation and seeding) and implemented a series of pilot projects across the savannah belt. Among the most important of these seeding project are Abu Fas, the sand dune fixation projects at Elbashiri, and the management of range resources around permanent water supply at Elodaya in Kordofan State. Other projects are range rehabilitation using water spreading technique, which were implemented in the Gash delta in Kassala province, and ElKoma and El Rakas pilot project in Northern Darfur state.

In 1985 the RMPA, with the assistance of FAO, purchased 12.4 tons of pasture seeds in addition to 180 kg. of inaeulant from Australia and Kenya. These seed species included *Cenchrus ailiaris, Chloris gayana, Cenchrus setigrus, Stylothenses hamata* and *Macroptilium phasolus*.

Six sites of an area ranging between 2 x 2 km to 4 x 4 km were partially fenced and reseeded after soil treatment. Table No. 5 illustrates sites selected and amount of seeds reseeded.

Immediately following first rain showers, 85 seeds were broadcasted and covered by labours using tree ranches. According to the evaluation carried out by the RMPA, the grass cover was successfully regained in most of seeded sites. Unfortunately, this demonstration was not followed through and most of the partial fences were destroyed and the established vegetation cover was overgrazed.

5.4.3 Seed Treatment for Rangeland Revegetation

Laboratory as well as field trials were carried out during 1994 by the author and Dr. Jad Kerim from Western Savannah Research Project on the development of seed pellets for revegetating rangeland on sand soils in the "Girigiekh" area located to the north in North Kordofan. In these trials nine seed species were tested namely:

Pannieum turgidum Cenchrus biflorus

Pennesetum spp. Cenchrus setigerus

Aristida funiculata Chloris vergata

Cenchrus ciliaris Stylothansis hemata

The main objective of this experiment was to select the best technique to be used for seed treatment against dormancy and to choose the best mixture of earth pellet that could be applied to speed up the rate of germination so as to make sound proposal for sand done fixation through the rehabilitation of the vegetation cover in the Bara area. The results of the effect of seedling establishment as effected by pelleting are illustrated in Table No. 6.

Table No. 5: Names of Sites and Amount of Seeds Planted

Species	Amount of Seeds (sag)	Amount of Seeds Planted in Ranch Site (sqs)					
		Kassala	P.Sudan	White Nile	Tendelti	Aburukba	El Gezira
Cenchrus ciliaris	150	14	25	25	25	25	2
Cenchrus setigerus	200	14	25	35	35	35	2
Chloris gayana	47	14	6	6	6	6	2
Stylothenses hamata	60	14	7	8	8	8	1
Macroptilium phasolus	60	14	7	8	8	8	1
Total	517	70	80	82	82	82	8

Source: Sudan Experience in Range-land Rehabilitation, Darag 1985).

Table 6: Seedling Establishment as Effected by Pet Pelleting and Organic Manure

Treatment	Pelletration Clay: Silt	Organic Manure added (%)	KNO3 added (%)	Seedling (%)		
				Cenchrus biflorus	*Paricum turgidum*	*Chloris gayana*
1	3 : 1	-	-	20	60	60
2	3 : 1	1	-	20	80	80
3	3 : 1	1	1	60	80	100

The result of these trials indicated that pelleted seeds with clay and silt (3 : 1) with the addition of 1% organic matter and % of KNO3 improved rate of germination of grass seeds tested. Seed treatment with cold water before pelleting for 24 hours proved to increase percentage germination of *Pannicum surgidum* (80%) and *Conchrus biflorus* (24%).

The highest percentage germination of pelleted species was scored by *Choris gayana* (95%), *Pannicum turgidum* (80%), and *Choris vergata*. These species are recommended to be used for the revegetation of degraded rangeland of north Bara District.

5.5 Other Projects Which are Currently

Under Implementation

These projects include (i) Elodaya Phase II (intigrated rural development for desertification control at Eloday) (ii) Community based carbon sequestration in the North area, and (iii) The dry land husbandry project at El Khowei and Butana Camel Research Centre. All these projects are financed jointly by the Gos and the United Nations Development Programme (UNDP). All these projects are designed as self-help undertakings with substantial inputs by local land users in both planning and implementation stages.

The first project (Elodaya Phase II) covers the entire area of the Elodaya Rural Council encountering 22 village councils (60 villages) and 20,000 land users. The ultimate goal of the project is to establish a self-sustaining continuous local organizational structure to plan for proper management, conservation, and utilization of resources. These objectives will be achieved through the revegetation of denuded rangeland.

The third project is oriented to revegetate the degraded rangeland at the vicinity of Elkhowie village through the mobilization of the land users at the village site.

6. Conclusion and Recommendations

The problem which is confronting agricultural development is not the lack of resources, but perhaps because of the abundancy of these resources, virtually no planning has occurred regarding the use of these resources. The emphasis is currently oriented upon "Project Programming" rather than land use planning.

The land use map and land use policy are essential in regulating different land uses with the actual capabilities and suitabilities of the predominant ecological zones. The absence of these maps and polices have created conflicts upon the use of recourses. Mechanized farmers, for example, have intruded onto lands customarily used by traditional farmers and nomads. Nomadic people and traditional farmers, in turn, have encroached upon forest lands in search of fuel, fodder and new ground to clear and cultivate. These conflicts will continue unless land use plan and policy are prepared.

After rangeland is defined within the proposed land-use map, a vegetation survey must be prepared to project the actual current vegetating composition, forage biomass production and the actual carrying capacity of the grazing land.

It must be confessed that currently there is no information regarding vegetation compositional changes, forage production and rangeland carrying capacity. Research must be oriented towards filling this gap.

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A Synopsis of Research on Pastoralism in Eastern Sudan with Emphasis on Camel Husbandry and Ecology

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1. Introduction

The Camel Research Project was embarked upon in 1983 by a group of researchers from the Faculty of Veterinary Sciences, University of Khartoum. Initial and back-bone funding was secured by the then National Council for Research (Khartoum) with a token support from the Faculty of Veterinary Sciences. Several researchers carried out investigations on various aspects including anatomy, physiology, parasitology, microbiology and reproduction (Anon, 1988).

Ecologic studies on the camels' habitat and rearing conditions were begun in 1984-85 and were triggered by the severe drought which hit all of the camel range. The main question raised during that period was: what were pastoralists, specially camelmen, doing to cope with the drought? These studies were commenced in Butana and the Fringes of the Nubian Desert (Abbas and Musa, 1986) and were later extended to the Red Sea and Gash regions (Abbas and Tilley, 1987; Abbas, 1987; Abbas, et. al., 1992). In this paper, a synopsis of the findings will be presented. The emphasis here will be on the lessons learned from several years of encounters with pastoralists and the pastoralists' advocacy in relation to a better future. Since camels were considered as the index animal for studying pastoralism in the arid and semi-arid zones of the Sudan, most of the information will be on camel ecology and camelmen views of life in this zone. It will be clear, however, that most, if not all, camel keepers also raise variable numbers of other livestock and the discussion of the welfare of camels and camel keepers will necessarily include the study of other livestock in the region.

2. Herding Strategies in the Butana

A survey was conducted in 1987 which covered the whole of the Butana area in addition to the Gash basin and Nile Province. A total of 822 herders were interviewed in the presence of their herds of camels. The survey was based on computerized questionnaire formats which were based on a model previously tested in Niger and Saudi-Arabia ((IEMVT, Maisons - Alfort, France). Multivariate statistics were used to group the 17,650 camels included in the 822 herds into clusters or herding strategy categories on the basis of herd size, feeding strategy, owner's occupation, farming intensity, camel uses and marketing. Four distinct herding strategies were revealed (Abbas, et. al., 1992).

Type 1:

These are herds belonging to a single owner keeping a small number of camels (mean=12 camels) and depend mainly on trees and bushes in the riverine areas of Gash, Atbara River and the Nile, rarely grazing further into the deserts during the rainy season. They depend also on crop residues from cultivation in the schemes of gerfs (river-banks) in addition to supplements of dura. A high percentage of males is kept and is devoted for labour. Most of the owners are seasonal farm employees in the irrigated schemes or towns in the area. The herds in this group invariably include a number of small ruminants.

Type 2:

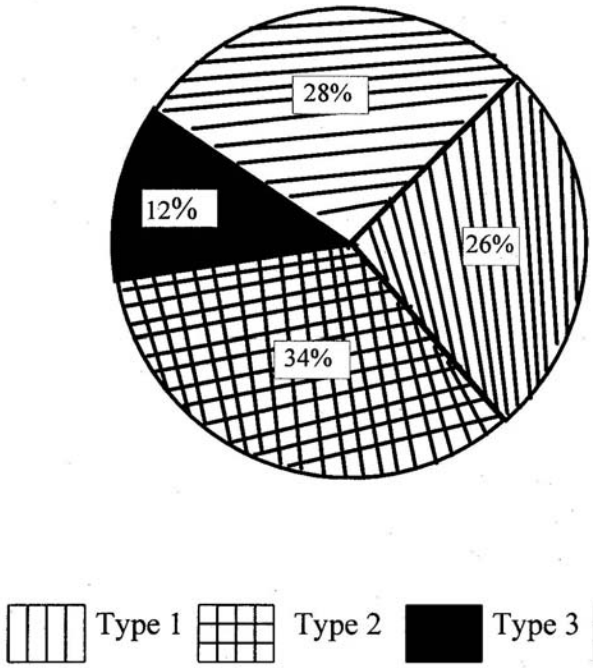
These are herds usually belonging to several owners who, as a group, hire between one and four keepers and rarely raise other animals. The herds move over large areas extending throughout Eastern and Northeastern Sudan but range predominantly in Eastern Butana during the rainy season. The mean number of camels in these herds was 84 and the range was 37 to 156. The representative tribes are the Bawadra and Rashaida with a few Kawahla, Massalamyia and a smaller group of Lahawine. The

predominant occupations of owners are agriculture and commerce, specially border trade (Rashaida) (Maillard, 1992).

Type 3:

These are herds belonging to a single agropastoralist who keeps camels in addition to cattle and small ruminants. During the rainy season, the camels and other stock are always taken to Butana, where a paid keeper is employed. During the dry season camels are fed on crop residues from irrigated schemes, namely New Halfa and Rahad schemes. The owner is a sedentary farmer for most of the year. Herd size range between 9 and 65 camels with a mean of 39 camels. Tribes practising this herding strategy are mainly the Shukryia (86 per cent), the Kawahla, Lahawine, Arakiyeen and Masalamyia.

Fig. 1: Types of Camel Herding Strategies in North Eastern Sudan and a Possible Path of Their Evolution (n=822 herds)



Type 1 : Sedentary - Labour small herds ($\bar{X}$ = 12 camels)
Type 2 : Agropastoralists - Traders large herds ($\bar{X}$ = 84 camels)
Type 3 : Sedentary - Tenant farmers medium herds ($\bar{X}$ = 39 camels)
Type 4 : Transhumant - Medium herds ($\bar{X}$ = 62 camels)

Type 4:

These are herds belonging to a single owner who is a true transhumant pastoralist. They graze only on natural pasture and rarely purchase scheme residues in the Gedaref area for supplementing the dry-season range. The herd size is highly variable (20 to 200 with a mean of 62 camels). Owners always raise small numbers of sheep and goats. Representative tribes are Kawahla, Rashaida, Shukryia, Lahawine, Arakiyeen and a few of the Hedendowa. The herds utilize the Butana, Gedaref and Atbara rivers as homelands while Rashaidis move very extensively and also range into the Gash and Red Seas hills.

3. Herd Nutrition and Management

Camels are mainly browsing animals and utilize browse for most of the year; hence the ideal camel range should always include trees, however sparse their abundance might be. During the rainy season, there is no problem with food for camels. However, as soon as the dry season sets in and wind changes its direction from southern (southwest) to northern, camelmen begin a very uncomfortable season. The quality of life during the dry season is always harsh, but the relativeness of this difficulty depends on the previous rainy season. If that season was good, the following dry season could be spent with relative ease as there was usually plenty of range all over the region. If the previous rainy season was poor or below average, then the dry season was a horrifying and gloomy one, with many decisions of difficult choices to make. These would include:

a) Sale of some animals to buy fodder (as well as an extra amount of grains).

b) Partition the herd into two or more bodies, each of which expected to range in a different area.

c) Migration to a different, often remote habitat (eg. schemes, forests, Red Sea hills etc...).

The strategies adopted by pastoralists to cope with extreme drought conditions were studied in the Summer of 1984, the year that marked the peak of the most recent Sahelian drought (Abbas and Musa, 1986). The following responses were recorded. Small herd (20 animals) were taken to the riverine areas in the Nile, Atbara or Gash vicinity where their owners worked as share croppers or labourers and fed their animals from trees and crop residues. Large herds (50 animals) were taken well out of the study area into the Rahad and Dinder forests, while medium-sized herds roamed the dry desert, foraging in the stream beds and old pastures in expectation of a better rainy season. This group lost most of their animals, specially breeding females and old males.

4. Continuous Survey of Camel Health and Productivity (1990-1994)

The results of former surveys were utilized to design a continuous survey of camel herd productivity and health problems actually obtained in the field. A total of 1036 camels belonging to 20 different herds and representing the major herding types as well as ethnic groups in the area were visited monthly for 4 years. During each visit ear-tagged animals (20-30 per herd) were individually examined and their body measurements taken. New calvings in the herd were recorded as well as mortalities (Agab, 1992; Le Horgne and Abbas, 1992). Data were computerized and analyzed on yearly basis (PIKBEU Computer system, CIRAD, EMVT). It was thus possible to perform reliable epidemiological and reproductive studies on a large number of camels over a rather long period (Tables 1 and 2). Data on body weight gain in relation to rainfall and range condition is still pending.

The first year of study (1990) was characterized by very poor rainfall (76 mm in Kassala and 372 mm in Gedaref) compared to an annual average of 218 mm for Kassala and 581 mm in Gedaref. Thus, an elevated mortality rate was the first consequence (Table 1). It was also confirmed from the analysis that pastoralists who ranged seasonally into the schemes and used crop residues maintained their herds in

better condition. Their herds also attained an earlier sexual maturity, allowing in economic terms more intensive use of the herd. Thus, the sustainability of camel pastoralism in Butana was greatly helped by the availability of huge crop residues and agro-industrial by-products. However, during years of low rainfall Butana must face significant overstocking and range deterioration. It was also notable that the continuous trend of erratic rainfall and the growing use of crop by-products led to a gradual transfer of ownership from traditional pastoralists to rich farmers whose crop cultivation encroached on traditional pastures (Abbas, et. al, 1992; Abbas, Le Horgne and Saint-Mortin, 1992).

5. Outcomes of the Research Project

As a result of several years of work with pastoralists in the study area, experience was gained in many aspects of camel husbandry. However, the secondary outcomes of the project are also noteworthy. First of all, solid and reliable contact was established with numerous pastoralists from all tribes in an area extending from south of Gedaref to the Tokar Delta on the Red Sea Coast. As a result, researchers find excellent cooperation throughout the year whenever they undertake field visits. A field station was established in Showak town, on the cross-road of the main eastern migratory route. The station is equipped with basic laboratory facilities and a rest-house. Since its establishment in 1990-1991 it has become the focal center of diverse activities for researchers from different parts of the world as well as Sudanese researchers (Agab, et. al., 1994 a,b).

Post-graduate studies received the greater part of the projects agenda. Three French graduates and seven Sudanese M.Sc and Ph.D students have used the station in addition to 3 international missions. This station promises to be an international forum for research and development work on pastoralism.

Extension was the back-bone of our interest and our means of coverage of this large and diverse base of beneficiaries. Contact was actively established with herd owners and traditional healers as well as other agencies with similar interests operating in the region (ADS, UNDP, OXFAM, FINNIDA, etc..).

6. Conclusions and Recommendations

Camel husbandry is the main source of living for pastoralists in the semi-arid zone in Eastern Sudan. It is a viable activity and is witnessing transformation mandated by ecological and demographic factors. There is need for research and development activity along several lines, notably the following:

a) Means of survival in the face of drought recurrence: the potential for establishing summer refuges in areas of good potential. This should increase the fodder security of pastoralist herds, specially camels (and sheep) in the deserts of Sudan; fodder banks; range cropping.

b) Incorporation of pastoralists in agricultural development: allocation of land specially for animal farming (mixed-farming) in schemes established in traditional pastoral regions, the potential for establishing communal ranching or, as well as the allocation of adequate acreage for interested pastoralists for establishing individual ranches.

c) Research into ethnoverterinary knowledge to bridge the gap between inhabitants views and concepts on disease aetiology and to tap the local arsenal of medicines from plants (as well as surgical procedures) practised locally.

d) Research into the performance of camels under improved husbandry conditions and the use of breeding technology similar to that practised in the bovine industry.

e) Research into the role of pastoralist women in rural development, their contribution to family income, indigenous knowledge, specially cultural and social stability.

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Annex 1

Table 1: Performance of the Herd (from inquiry data Saint-Martin et. al., 1990 Maillard, 1992)

Reproduction Age at first birth 6.5 years (n=8,847)

Interval between births 2.3 years (n=2,307)

Annual calving rate 35% (n=6,426)

Mortality 0-1 year annual rate 12% (n=4,765)

1 year annual rate 4% (n=2,910)

Offtake overall annual rate 11% (n=5,055)

Table 2: Performance Obtained in 17 Months of ContinuousSurvey (Oct. '90-March '92) (from Le Horgne and Abbas, 1992)

Reproduction Calving rate 32% (n=320)

Mortality 0-1 year rate 51% (n=84)

Offtake Overall rate 7% (n=384)

Indications of Recovery in Biomass Productivity and Soil Organic Matter of Sudan's Sahel Region: A Case Study of Northern Kordofan*

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Abstract: *The region of North Kordofan was taken as a case study representing the vulnerable Sahelian zone in the Sudan. The objectives were centered on the assessment of biomass, soil potential and its capability to build up a rich carbon sink following the good rainy season of 1994. The findings concluded that land degradation and ecological imbalance associated with the combined adverse effects of years of below average rainfall and mismanagement may be favourably reversed if rational management practices are applied in accordance with rainfall patterns. The study revealed major trends of recovery both in biomass productivity and soil organic content.*

1.1 Introduction

Symptoms of land degradation in the Sudan dates back to 1942 when the government established a Soil Conservation Board to report on the soil condition in the Sudan particularly with regard to erosion and desiccation (Soil Conservation Report, 1944). The Board recommended several soil conservation measures that may help in "The recovery of nature's healthy conditions for the most advantageous production of crops, pasture and forests for the well-being of the inhabitants". Nonetheless, serious and intensive human manipulations of land misuse accelerated after World War II, posing considerable degradation of productive arable land. The result of over-exploitation had been devastating signals of land degradation.

Stepping (1953) did not attribute the causes of degradation to a single factor as he stated that "it is not the unchecked practice of shifting agriculture, plus the largely increased numbers of grazing animals and the annual firing of natural vegetation which is responsible for the present position". It is not equally true that the causes of degradation and degeneration of forests into scrub type can be traced to geological, geographical or marked climatic changes. Lamprey (1975) tried to measure the Southward shift of ecological zones. He concluded that the desert's boundary shifted southward by an average of 90-100 km in the last 17 years as observed in Northern Kordofan. Moreover, Lamprey (1975) reported southward drift of sand dunes on a large scale particularly in areas around Bara and Kheiran. These findings were also noted by DECARP (1976). In a report on the anthropogenic causes of desert advance, Ibrahim (1978) drew the conclusions that cultivation north of the agronomic dry boundary will result in loss of arable land i.e., former productive land will be transformed into desert like conditions. Other authors (Bakhiet, 1983; Mohamed, 1983; Suliman and Darag, 1983) suggested that the spread of desert-like conditions were the results of both physical (drought) conditions and human misuse of resources. Misuse of natural resources and expansion of rain-fed farming into marginal lands were among the causes cited as leading to poor land productivity, while frequent droughts accelerate the process of degradation. In fact, most of these studies link the process of desertification and drought as amplifying each other.

Understanding the nature and causes of desertification attracted other researchers. A group of researchers from Lund University started integrated investigations on desertification using advanced equipment for digital image analysis combined with conventional geographical methods, and arrived at more convincing factors leading to the spread of aridity in Northern Kordofan (Hellden, 1978 & 1988; Olsson, 1985; and hlcrona, 1988). Hellden (1978) questioned the conclusions of Lamprey. Through a

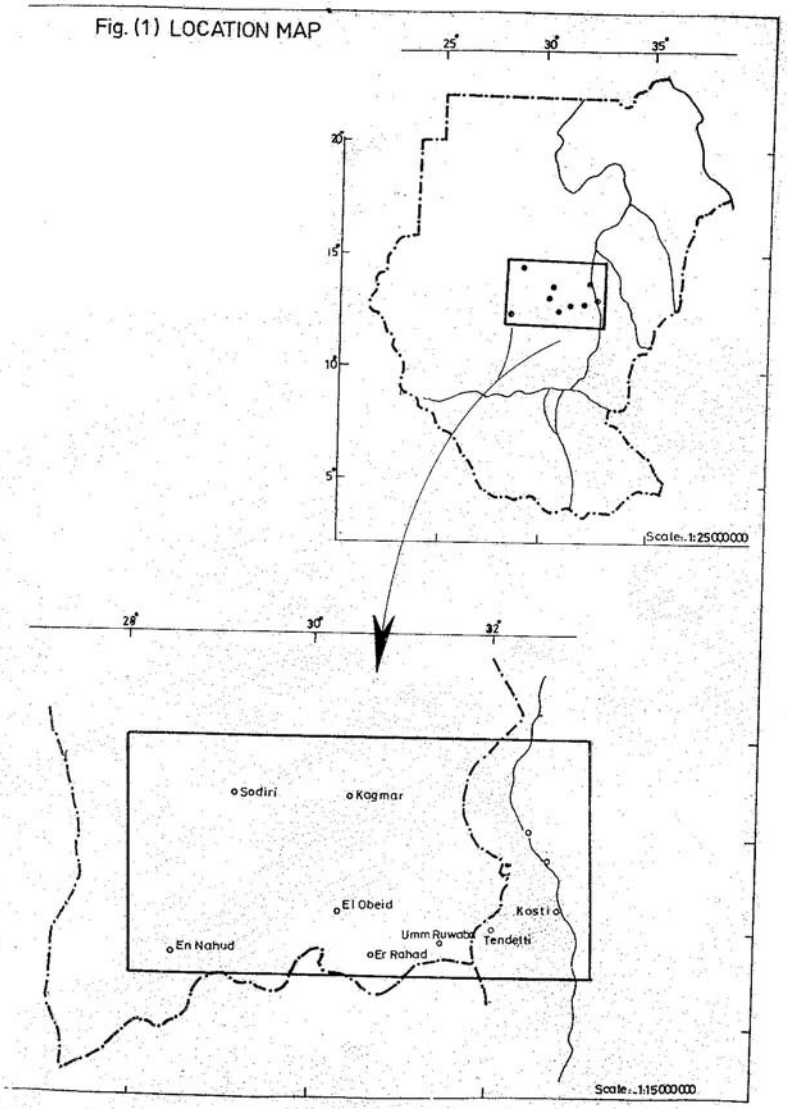
satellite-based study in Northern Kordofan Hellden detected no significant shift of the location of the desert margin between 1972, 1976 and 1979. He found that the desert boundary coincided with the 100mm isohyet at latitude 16ºN which again coincided with the desert boundary mapped by Lamprey (1975). Hellden (1978) found no evidence or signals of an active sand creep between Sahara and Kheiran areas of Northern Kordofan. On the contrary, he observed that the dune complex was of a stabilized nature. Olsson (1985) studied three areas in Northern Kordofan taking Bara area as an example of a region with ample subsurface water that permits rather intensive land use in spite of the generally insufficient rainfall in bad years. He also took Um Ruwaba area as an example of extremely intensive land use, and the third area he investigated covered the region between Um Ruwaba and Bara as an example of low land use intensity. Olsson (1985) suggested that reports on desertification have not been based on scientific approach. Most of the studies were based on comparisons of observations on two occasions: one prior to the Sahelian drought and the other during or shortly after it. He further elaborated these statements by stating that "signs of desertifican can mainly be seen during extremely dry periods when rainfall returns to normal, both natural vegetation and agriculture crops recover". According to these hypotheses it could be concluded that the conditions vary with climatic conditions.

Ahlcrona (1988) drew attention to the decrease in the biological productivity that could be caused by aridity or man-made factors, while land degradation is mainly caused by man. According to the investigations carried in the areas west of the White Nile and in East Kordofan, Ahlcrona (1988) concluded that "The major impact on lands biological productivity has been caused by climatic factors and not by man". Among the various variables tested by the researcher as indicative of man-made land degradation, only the qualitative deterioration of natural vegetation cover was regarded as significant.

In a recent general study in 1995 on the magnitude of desertification in the Sudan, carried out by the National Drought & Desertification Control Programme, Co-ordination and Monitoring Unit (NDDU), the desert margin was defined and quantified using NDVI data. In this way it was possible to modify the known ecological zones leading to the production of risk maps. However, this general study contributes little to the debate on the nature and causes of desertification or to the ability of Sudan's Sahel soils to recover as the result of good rainy seasons. Hence this study had been launched to verify recovery using biomass and organic matter as yardsticks. Aerial photos for 1994 good rainy season offered an excellent opportunity to note recovery and help for future evaluation.

For the purpose of the study, an interdisciplinary team composed of soil scientists, botanists and social scientists carried out fieldwork in carefully selected areas in Northern Kordofan (Fig. 1). The fieldwork enabled the team to collect soil samples, make vegetation transects and apply various methods as reported in appropriate places in the subsequent sections. The field work was situated in the areas between latitudes 13ºN and 14ºN from where samples were taken and observations recorded. This finding was supported by satellite images, climatic data and laboratory analyses as will be indicated later.

Fig. (1) LOCATION MAP



1.2 Precipitation Trends

In arid and semi-arid lands there is a strong correlation between total annual rainfall on the one hand and biomass/organic matter content on the other. Meteorological data obtained from the Sudan Meteorological Department were examined in order to identify the general trends in the annual rainfall pattern in Northern Kordofan during the last two decades for the purpose of defining the relationship between the observed patterns among other factors and the biomass. The main features are summarized in the following:

a) The annual rainfall totals within the area varies from about 170mm in the north to about 350mm in the south.

b) The inter-annual coefficient of variability in the rainfall ranges between 25% to 50% on analysis of readings of various stations.

c) There are periodical changes in the annual rainfall pattern at the stations of the whole area.

d) The average precipitation anomaly index shows that the years 1988, 1993 and 1994 were the wettest, while the years 1984 and 1990 were the driest (Table 1).

Table 1: Total Rainfall in Two Stations in the Study Area

Date	El Obeid (mm)	Umm Ruwaba (mm)
1981	364.9	235.0
1981	310.3	327.0
1982	201.9	278.0
1983	351.8	-
1984	161.7	97.0
1985	218.6	236.0
1986	375.6	N.A.
1987	226.3	233.0
1988	346.0	229.0
1989	267.8	300.0
1990	170.6	163.0
1991	204.4	287.0
1992	513.9	475.0
1993	378.7	319.0
1994	544.7	465.0

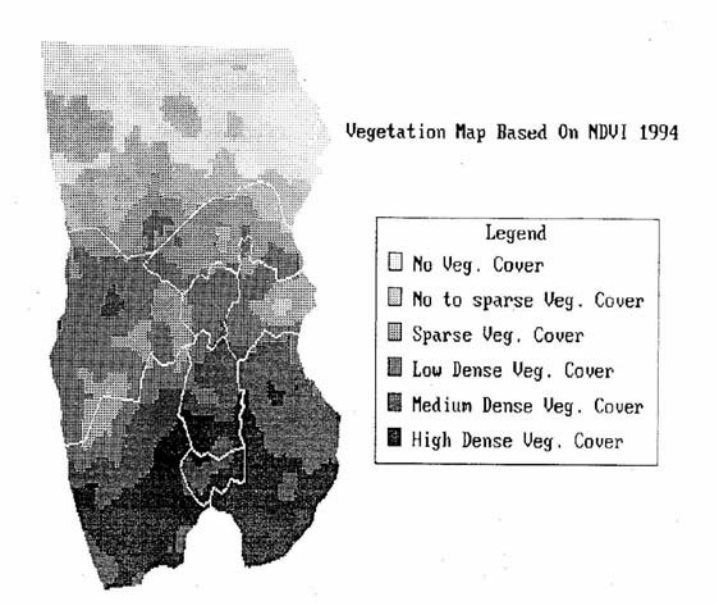


Fig 2 Vegetation Map Based on NDVI 1994

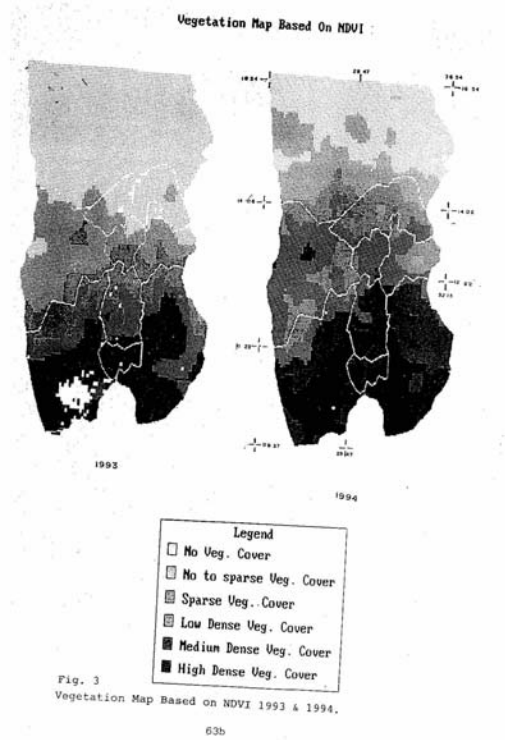


Fig 3 Vegetation Map Based on NDVI 1993 & 1994

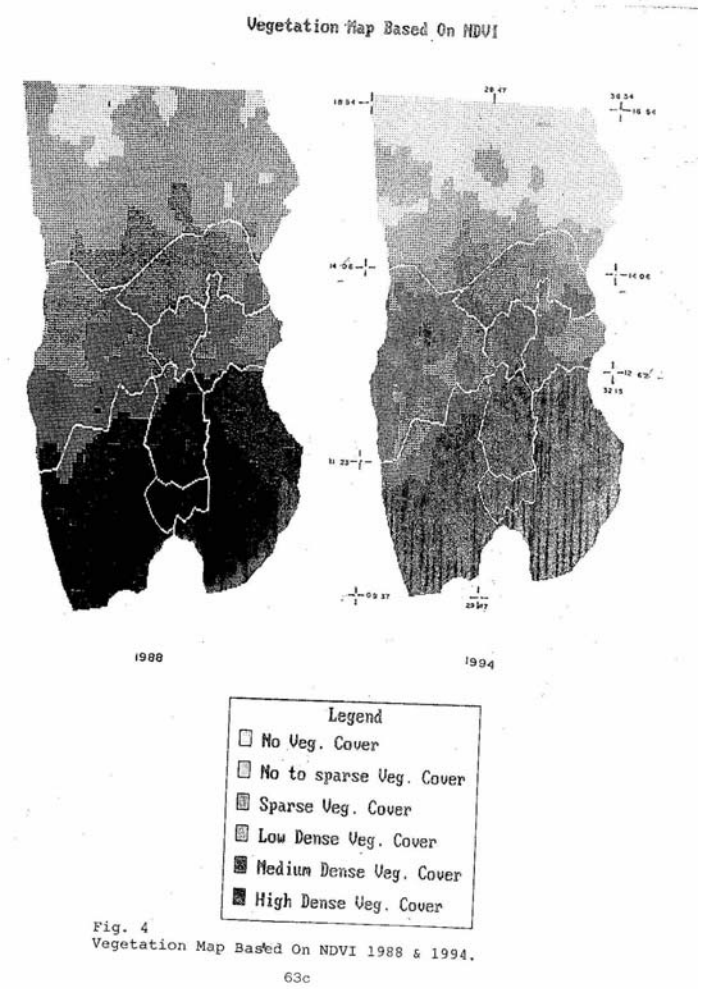


Fig 4 Vegetation Map on NDVI 1988 & 1994

1.3 Vegetation Survey in Northern Kordofan

Data from NOAA Satellite were used to assess the environment of the areas and detect the changes in vegetation cover in 1994, 1993 & 1994; 1988 & 1994 (Figs. 2, 3 & 4). It is clear that the vegetation cover in 1994 is superior to that of 1993. The comparison between cover of 1994 and that of 1988 shows that the northern part of the area was better in the green cover in 1988 than in 1994, while in the area that lies between latitude 14ºN and latitude 13ºN, some zones were found to be good in their vegetation cover in 1994 than in 1988. South of latitude 13ºN the situation was better in 1988.

1.4 Land Use and Human Impact

The economy of Kordofan state is predominantly agro-pastoral. In the sporadic human settlements the two types of economies are normally integrated forms of production. Crop production is mainly traditional. Cereal and cash crops cultivated in fertile soils/stabilized sands during good rainy years include millet as the dominant crop, sorghum and sesame. Millet occupies the largest cropped area accounting for more than 50% of the area under different crops. In areas around Um Ruwaba, Er Rahad and Tendalti sesame occupies substantial area. In recent years, natural fallow periods became less, giving only limited chance to woody herbaceous vegetation to recover.

Acacia senegal plantation is another form of land use. Because of its economic benefits for gum arabic collection, it is the only tree that is planted and protected by the farmers.

Livestock production is primarily based on systems of range location and utilization. There are two types of livestock management: sedentary livestock and nomadic pastoralism. Settled villagers keep goats, sheep and few cattle, while nomads are mainly camel owners who traditionally move with their livestock in north-south axis.

Forestry activities are locally practised mainly for the supply of fuelwood and construction material for local and commercial purposes.

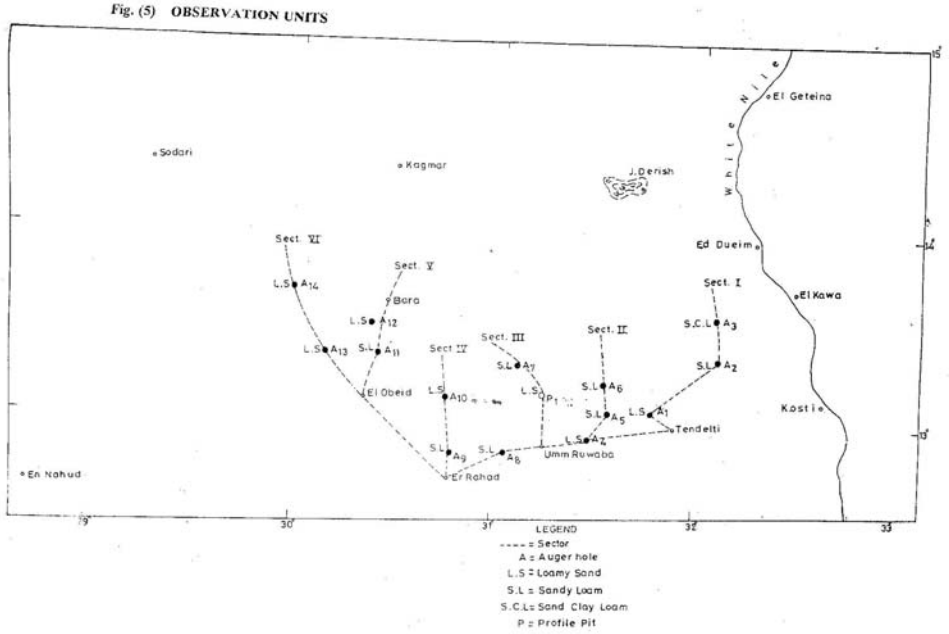
Crop production declined during the years of drought. The low yields were compensated for by increased areas under crops to produce the amounts needed for family consumption. Such practices might cause land degradation. However, the good rainy season of 1994 resulted in a complete change in the ecological conditions. Field observations and NDVI image interpretation have revealed contrast with those described during years of the Sahelian drought. The considerably rapid recovery and improved ecological conditions may be attributed to the following factors, which will be discussed in more detail in the subsequent sections:

a) Throughout the prolonged Sahelian drought large-scale out-migration of the inhabitants and their livestock gave a resting period for degraded areas to recover.

b) The flora and fauna of Northern Kordofan are ecologically resilient and when good conditions prevail, mainly during good rainy seasons, the recovery is rapid and almost guaranteed.

c) Successive years of drought posed human/animal suffering; the inhabitants developed a reasonable degree of awareness of irrational practices and hence became more concerned with careful management of their land and water resources.

Fig. (5) OBSERVATION UNITS



2. Assessment of Biomass Productivity After 1994 Rainy Season

In the study area, the years of drought (1973-1984) manifested disastrous physical and biological consequences. The biological impact had many indicators of stress such as considerable shrinkage in vegetation cover, diminishing specific diversity, a sharp decline in abundance of plants and scarcity of above-ground biomass upon which the local agro-pastoral life depended for subsistence and income generation. Those drought years also resulted in sharp decline in number of herds and in very poor agricultural productivity.

The study on biomass productivity was carried out during April 1995 to assess the signs of recovery in the region after the exceptionally good rainy season of 1994. The vegetation maps based on NDVI for the years, 1988, 1993 and 1994 indicated sharp favourable changes in vegetation cover. This feature coincided with a well-above average total rainfall.

For the purpose of data collection, six carefully selected sites (Sectors I-VI) (Fig. 5) were used. The criteria for sector selection had been: (a) that the sectors collectively represent major habitats along N...S trend of increasing regional rainfall (b) that they express a similar trend on E...W axis and (c) that within each sector there is one or more community types that characterize Northern Kordofan. The sectors included all the major ecologically prominent vegetation sub-units (Table 2).

Table 2: Ecological Data and Biomass Productivity (A)

Sector	Community	% Cover	Density m2	M.H cm	Litter Depth	Dry Wt. gms.
I	Acacia tortilis	15-20	20-50	30	2.5	7.2
	Acacia senegal	20-30	30-50	36	2.5	7.8
	Indigofera oblongifolia	40-50	35-50	40	3.0	6.0
II	Leptadima	35-40	30/50	38	3.25	8.7
	Acacia senegal	50-60	40/50	46	3.7	9.0
III	Acacia senegal	40	40/50	37	3.6	9.1
	Maerua	50	38/50	40	3.9	10.4
	Crassifolia	50	46/50	52	3.6	11.7
	Maeua/boscia					
IV	Acacia senegal	60	35/50	45	4.0	14.0
	Acacia maerua	50	40/50	50	4.5	14.0
	Acacia/Boscia	60	40/50	56	4.2	15.9
V	Acacia tortils	60	35/50	66	5.5	16.6
	Acacia senegal	70	40/50	66	5.5	18.7
	"Maerua/Boscia	40	40/50	70	6.0	20.0
VI	Acacia tortilis	70	40/50	70	7.0	20.6
	Acacia senegal	80	56/50	77	7.0	24.8

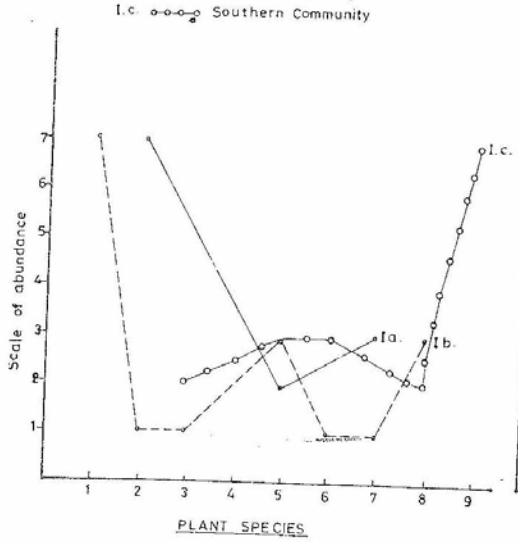
During the field work, an appropriate land survey approach was applied. The eco-taxonomical data have been obtained from sample units located at random in the centre of each community type in the sector. the eco-taxonomical data focused on recording the prominent characteristics of the general landscape, a broad description of the vegetation and the species present. The sampling units which were located in the

centre of each community gave evident expression of the optimal level of biomass components, the highest specific diversity, peak in visible ground cover and maximum indices of abundance of the main species, herbaceous as well as woody perennials. As expected, the richness of high indices noted in the community centre followed a gradual decline on either side of the centre of each, while northerly locations in the community contained plant species of dry affinities, the southerly locations contained species of relatively less dry affinities. Accumulations of litter in each community type was recorded as indicative of relative quantities of litter on the soil surface. The data served the purpose of comparison amongst the different vegetation units (Figs 6 & 7).

Fig. (6) SCALE OF ABUNDANCE OF PLANT SPECIES IN EACH COMMUNITY

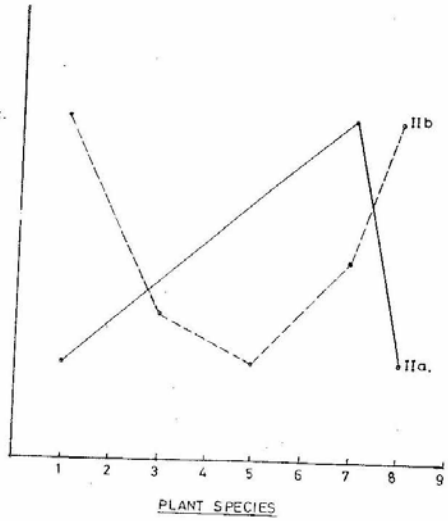
SECTOR I Fig. 6 (a)

I.a. —— Northern Community
I.b. – – – Central Community
I.c. o-o-o Southern Community



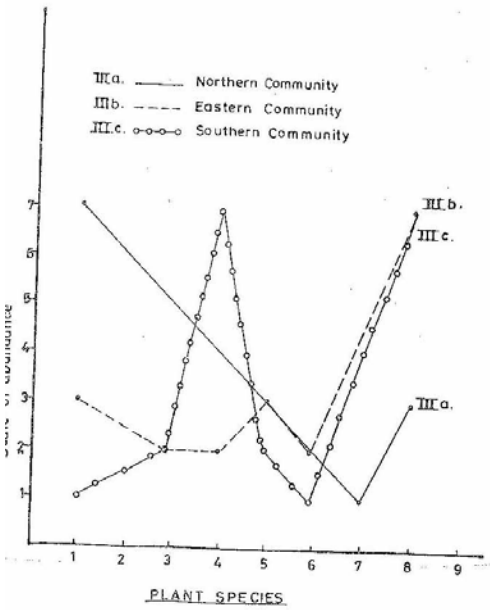
SECTOR II Fig. 6 (b)

II.a. —— Northern Community
II.b. – – – Southern Community



SECTOR III Fig. 6 (c)

III.a. —— Northern Community
III.b. – – – Eastern Community
III.c. o-o-o Southern Community



SECTOR IV Fig. 6 (d)

IV.a. —— Northern Community
IV.b. – – – Central Community
IV.c. o-o-o Southern Community

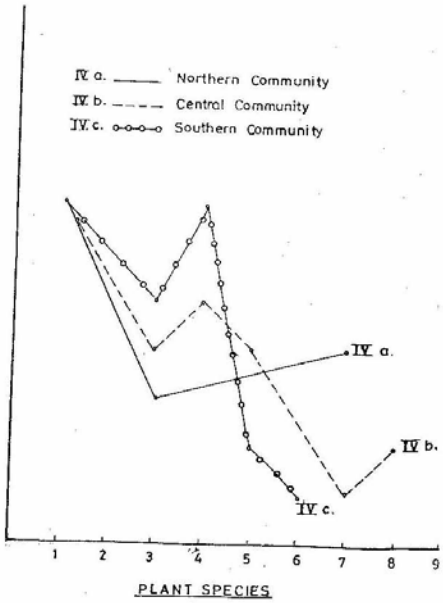
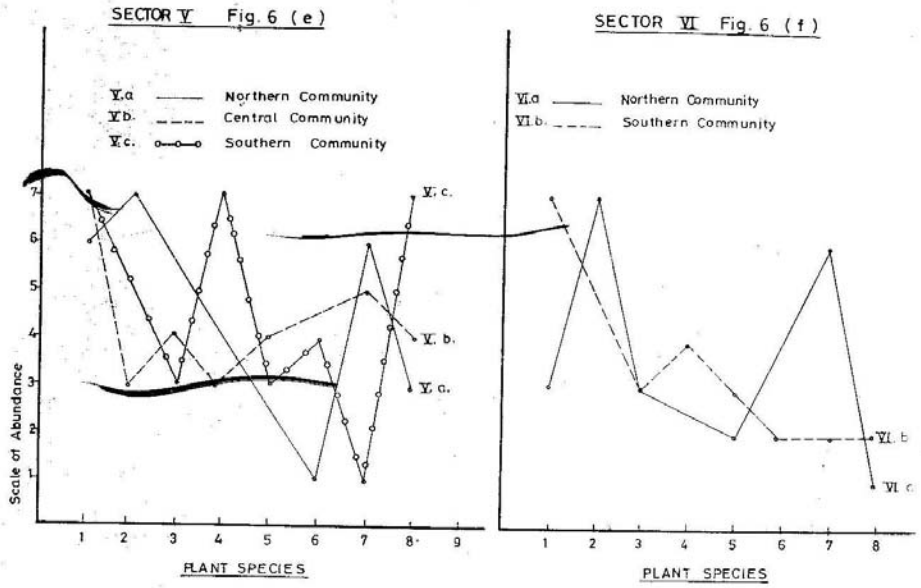


Fig.(6) SCALE OF ABUNDANCE OF PLANT SPECIES IN EACH COMMUNITY



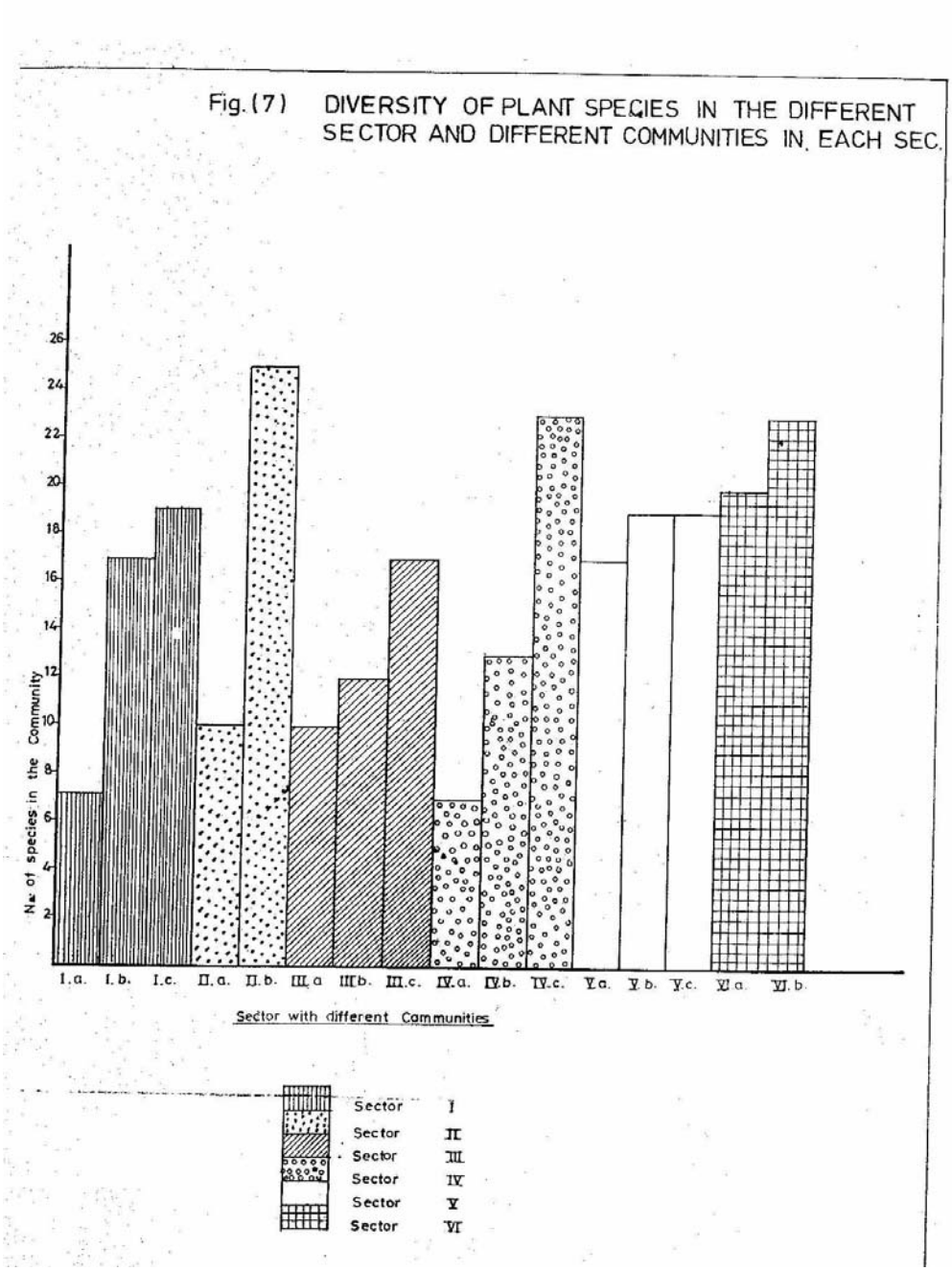
LEGEND

Key Woody Species

1 Acacia senegal
2 A.tortilis scp.raddiana
3 Balanites aegyptiaca
4 Basica senegalensis
5 Calotropis procera
6 Faidherbia albida
7 Leptadenia pytotechnica
8 Maerua crassifolia
9 Indigofera oblongifolia

Scale of Abundance

0.5 = Very rare (V.R)
1 = Rare (R)
2 = Occasional (O)
3 = Frequent (F)
4 = Common (C)
5 = Abundant (A)
6 = Very abundant (V. A)
7 = Dominant (D)



2.1 Vegetation Cover and Biomass Productivity

There is no reliable comprehensive data base for vegetation cover and above ground biomass in the study area. Under such circumstances and because of the short field work duration, the task of determining biomass productivity was limited to using ecological parameters suited to vegetation monitoring over large areas. Each of the two strata of community was treated separately: (a) the biomass of ground cover and (b) small to medium size woody trees. In each, biomass estimates were made by percentage ground cover. While quadrates (400m2) were used for the herbaceous ground vegetation,

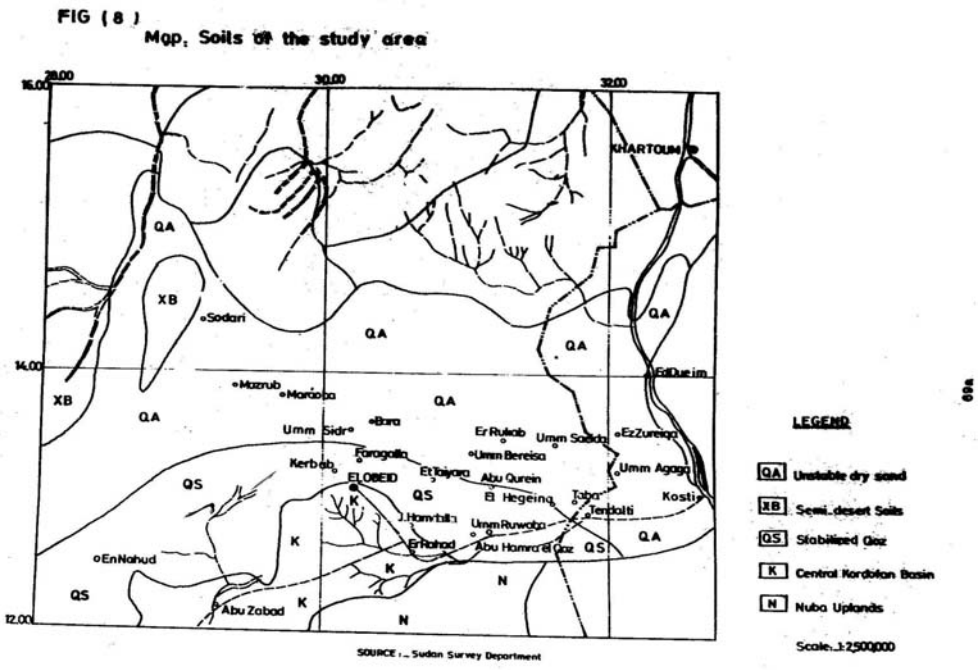
crown diameters were measured to obtain the canopy area of mature common woody trees that characterized the landscape in each study site.

Data for percentage cover and dry weight of herbaceous vegetation represented important attributes of the plant community in each type. The data revealed trends that match (a) availability of optimal soil type (b) species affinities and responses to different levels of impacts and (c) bulk of seed bank that would contribute to the relative magnitude of recovery in good rainy years.

Herbaceous biomass productivity and cover variables were determined in terms of the ground strata community, not according to individual species. Hence the biomass of the association, as represented by litter, rather than individual species, was used to evaluate the productivity. Alongside with specific composition list, a scale of abundance was made to reflect biomass productivity of the vegetation assemblage. Patterns of abundance of prominent species reflected on biomass productivity (Figs 6 & 7).

2.2 Diversity

Diversity of plant species in arid and semi-arid lands was under siege from the combined pressure of recent drought, hence the northerly habitats of Kordofan experienced a serious decline in range desirable species and the prevalence of drought resistant rejected forms. However, species list prepared during the survey, suggested clear trend of improved diversity levels and hence relatively better system stability. The trend coincided with higher soil moisture conditions in accordance with higher means of annual rainfall. The present survey tended to confirm the possibility of recovery when moisture requirements were satisfied in rainy years.



2.3 Transitions and Linkages

Territorial transitions were detected near "hafirs", seasonal streams, village outskirts and edges of agricultural plots where trees had been removed and in well-defined undulations. Hence, the

interpretation of the dynamics of vegetation and the condition of the biomass productivity should be based on soil type/moisture regime on the one hand and grazing/agriculture and human settlement on the other. The latter manifested itself on the progressively fading destructive efforts of villages upon the natural vegetation and biomass productivity. A radial pattern of diminishing ecological imbalance was evident in estimated vegetation cover, litter depth, species diversity and vegetative performance. This was noted in random transects starting from the village centre and extending to the margin of undisturbed natural habitat.

3. Status of Soil Organic Matter

3.1 Soil of the Study Area

Soils of the study area were mostly stabilized sand dunes (Goz) consisting of yellowish red sandy loam and loamy sand soils (Fig.8). The study area was part of the stabilized Goz described by Lebon (1965) as occupying a very large area of west central Sudan forming a belt from the White Nile to the Western borders with Chad. For the purpose of assessing soil organic matter content, the same six sectors described in section 2 (Fig. 5) were used. Along these sectors 43 soil samples were taken from 15 observation points for laboratory analysis. A version of Walkley and Black method of wet oxidation of organic matter percentage for the representative samples was computed and the pressure of roots was also recorded.

3.2 Results

Generally the soil texture was loamy sand to friable sand loam showing high sand percentage ranging from 66-88% for the top soil to 62-92% at subsoil level, indicating slight differences in sand content in a downward direction. Silt percentage was very low (0-9%) while clay varied between 12% and 20%.

Results of the laboratory analysis show that the organic matter percentage ranges from 0.09 to 0.31% with and average of 0.17% for the top soil which is really low compared to similar soils under arid moisture regime elsewhere in the tropics (Table 3). However, the 1994 rainy season contributed forage of grass roots to the soil, but it was so fresh when samples were taken that it could not be easily detected as soil organic carbon. This remarkable addition of roots indicates that under good rainy seasons a considerable volume of Co2 is extracted from the atmosphere by plants, sinks down into the soil and kept there for humification and mineralization processes.

Low organic matter percentage in arid areas is very common. Young (1976) cited that organic matter content of the semi-arid zones is generally low compared to other soils in the tropics. The very low figures obtained could be attributed to the following:

a) The results of the analysis show that the present organic matter had accumulated in the years prior to 1994.

b) Organic matter added during 1994 is undecomposed and could not be easily determined under the present available facilities.

c) Considerable increase in millet cultivation depletes the soil organic matter which had been added during former good rainy years.

d) Frequent dry years limit the organic matter annually added to compensate for losses due to cultivation.

e) Soil micro-organisms are very much affected by moisture availability, hence consecutive dry years- which are very frequent in this area - retard the process of humification.

Despite the low organic matter percentages obtained, there is ample evidence that repeated studies, in years following good rainy seasons will reveal values similar to soils under arid regime in the tropics.

4. Conclusions

The widely prevalent instability of annual rain input in the semi-desert of Northern Kordofan is reflected in low biomass productivity in poor rainy years. Evident indicators in recovery occur in good rainy years. This study assessed the 1994 good rainy year with respect to impacts on biomass productivity and soil organic matter content in these areas. However, due to factors related to the time when field work was carried out the study could only provide trends and qualitative description of the signals of recovery.

Ideally, two visits of land survey must be made: one at approximately 10-12 weeks after the commencement of the rainy season, and the second visit 10-12 weeks after the first visit. The former visit would reflect the peak of the green mantle and vigour, the latter visit signals the beginning of vegetation anti-climax, though it gives information on the magnitude of disturbance and the residual seed bank stored in the soil for future recovery.

Successional changes since the mid 1970s highlighted degradational changes that have been related to progressive decline of rainfall means below the normal average. However, the 1988 rainfall had been exceptional, giving an undoubted recovery (Fig. 4). The subsequent years were of below average means leading to slow recovery as revealed by Fig. 3. The rainfall of 1994 was high and the good recovery was manifested in NOAA Stellite images and confirmed by the present observations based on land surveys (Fig. 2).

Despite the limitations mentioned, the fieldwork revealed major trends in biomass recovery, which are manifested in high species diversity and abundance of plant litter. It was possible to identify and record palatable species thought to have been lost. In fact there was no total loss but the good rainy conditions led to large scale recovery of many species. During years of drought, researchers observed the south-westerly movement of vegetation units as species of (e.g. Adansania "Baobab", Balanites" Higlig", Boscia "Mukheit" Eragrostis "Bano grass", Arilid "Gaw" Acacia tortilis" Seyal" and Acacia nubica "Laot"). The present study found dense cover of these species in areas described by previous researchers as decidedly desertified.

Such results indicate the resilience of the semi-desert areas of North Kordofan and its potential for recovery if good moisture conditions prevail. Hence it is possible to postulate here that the observed trends of recovery are the result of climatic factors. This does not rule out man's impact, through farming and grazing, in creating qualitative deterioration of vegetation in locations near settlements leading to changes in plant cover, usually becoming thinner as observed in areas near Bara. In fact, years of drought are associated with a drastic decline in pastoral potential leading to both population and herd migration to areas of good grazing resources. This feature allows the meagre plants that grow to reach maturity and produce seeds that succeed to germinate when optimum moisture conditions prevail.

Increase in biomass recovery, as reported for 1994 rainy season, has influenced soil organic content. Generally the soil organic matter content of the semi-arid zones such as that in Northern Kordofan is considered to be low. However, when good rains prevail, substantial amount of organic mater will be added to the soil in the form of plant roots and litter. The amount of organic matter during such good rainy years form a good reservoir for future use. Taking into consideration the ecological nature of the study area and for reasons mentioned earlier, the soils showed percentages lower than normal as compared to soils of similar areas. This result does not rule out the fact that the year 1994 added substantial amount of organic matter to the soils because of good biomass productivity adding tons of grass roots to the soil, but it was undecomposed that could not be determined as soil organic matter. However, it will remain in the soil for the humification and mineralization processes. This suggests that under good rainy conditions, a considerable volume of carbon dioxide is absorbed from the atmosphere by plants and sinks down into the soil (Table 3).

Table 3: The Status of Soil Organic Matter

Lab. No.	Profile No.	Depth (cm)	Rooting Depth (cm)	Organic carbon %	Organic Matter
1	A1	0-30	20	0.07	0.12
2		30-60		0.08	0.14
3	A2	0-30	21	0.08	0.14
4		30-60		0.08	0.14
5		60-90		0.07	0.12
6	A3	0-30	15	0.18	0.31
7		30-60		0.11	0.19
8		60-90		0.08	0.14
9	A4	0-30	29	0.05	0.09
10		30-60		0.06	0.10
11		60-90		0.07	0.12
12	A5	0-30	34	0.08	0.14
13		30-60		0.08	0.14
14		60-90		0.08	0.14
15	A6	0-30	24	0.11	0.19
16		30-60		0.07	0.12
17		60-90		0.05	0.09
18	A17	0-30	26	0.12	0.21
19		30-60		0.07	0.12
20		30-60		0.04	0.17
21	A8	0-30	37	0.09	0.15
22		30-60		0.05	0.09
23		60-90		0.05	0.09
24	A4	0-30	28	0.07	0.12
25		30-60		0.07	0.12
26		60-90		0.08	0.14
27	A10	0-30	48	0.11	0.19
28		30-60		0.03	0.05
29		60-90		0.05	0.09
30	A11	0-30	29	0.09	0.15
31		30-60		0.07	0.12
32		60-90		0.07	0.12
33	A12	0-30	62	0.11	0.19
34		30-60		0.07	0.12
35		60-90		0.07	0.12
36	A13	0-30	26	0.11	0.18
37		30-60		0.08	0.14
38		60-90		0.07	0.12

39	A14	0-30	-	0.13	0.22
40		30-60		0.07	0.12
41		60-90		0.05	0.09
42	P1	0-28	56	0.07	0.12
43		28-120		0.02	0.03

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Annex I

Workshop on Dryland Husbandry in the Sudan

Sharja Hall 29-30, November 1995

Programme

First day 29 November 1995

Opening Session 8:30 - 10:30

Chairman: **Prof. Ahmed Ali Ginaf**

Minister of Agriculture, Natural Resources and Animal Wealth.

Convenor: **Prof. Yousif Babiker Abu Gideri**

Director, Institute of Environmental

Studies.

Opening Address: **Prof. Hashim Mohamed El Hadi**

Vice-Chancellor, University of Khartoum and Chairman of the Steering Committee.

Address: **Prof. Ahmed Ali Ginaf**

Minister of Agriculture, Natural Resources

and Animal Wealth.

Break 10:00 - 10:30

Second Session

Chairman: **Mr. Mohamed Abdalla Ali**

Secretary General, Higher Council for Environment and Natural Resources.

Convenor: **Dr. El Tigani Mohamed Salih**

National Coordinator, Desertification Coordination Unit.

Papers

1. *Natural Resources Management in the Arid Areas of the Sudan* by **Dr. Mutasim Beshir Nimir**, Sudanese, Environmental Conservation Society.

2. *The Dry Rangelands in the Sudan* by **Mr. Ali Darag and El Sadig Yousif**, Range and Pasture Administration.

3. *Dryland Husbandry in the Sudan with emphasis on the Semi-desert Zone* by **Dr. Mustafa M. Baasher**, Former Assistant Under Secretary (Range).

Second Day: 30 November 1995

First Session: 8:30-10:00

Chairman: **Dr. Hassan Mohamed Salih**

Secretary General, Council for Higher Education.

Convenor: **Mr. El Sadig Yousif**

Director, Range and Pasture

Administration

Papers

1. *Indicators of Recovery in Biomass and Soil Organic Matter of Sudan's Sahel Region: A Case Study of Northern Kordofan* by **Dr. Yagoub Abdalla Mohamed, Dr. Babiker Fadalla and Mr. Mohamed El Amin Abdel Rahman,** Institute of Environmental Studies.

2. *A Synopsis of Researches on Pastoralism in Eastern Sudan with Emphasis on Camel Husbandry and Ecology* by **Prof. Babiker Abbas**, Faculty of Veterinary Science.

3. *Socio-economic Studies of Pastoralism in Arid and Semi-arid Lands of the Sudan* by **Prof. Mohamed El Abusin**, Department of Geography, University of Khartoum.

Break 10:00-10:30

Second Session 10:30-1:00p.m.

Chairman: **Prof. Yousif Babiker Abu Gideri**

Director, Institute of Environmental Studies

Convenor: **Dr. Yagoub Abdalla Mohamed**

Institute of Environmental Studies

Discussion on:

- Future Programme for Research and Development of Dryland Areas in the Sudan.

Discussion

Recommendations

Annex II

Institutions that Attended the Workshop

1. Faculty of Veterinary Science
2. Camel Research Centre
3. Faculty of Animal Production
4. Institute of Environmental Studies
5. Range and Pasture Administration
6. Faculty of Agriculture, University of Khartoum
7. National Desertification Coordination Unit
8. Higher Council for Environmental and Natural Resources
9. Sudanese Environmental Conservation Society
10. Environmentalists Society
11. Oxfam
12. Wildlife Research Centre
13. Wildlife Forces
14. Animal Resources Directorate
15. National Forestry Corporation
16. Gum Arabic Company
17. Department of Geography, University of Khartoum
18. Institute of Environmental Research
19. IGAD Focal Point
20. UNDP Khartoum
21. FAO Khartoum
22. Arab Organization for Agricultural Development
23. Ministry of Finance (Planning)

24. Pastoralists' Association

25. All Newspapers

26. Sudan Radio

27. Ministry of Foreign Affairs (Africa Section)

28. Agency for the Development of Areas South of the Sahara

29. Ina'am Company

30. Range and Pasture Administration (El Obeid)

31. Range and Pasture Administration (El Gedarif)