PN-AAW-791 62
ISN 19405

ENERGY RESEARCH COUNCIL - USAID

SUDAN RENEWABLE ENERGY PROJECT

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SUDAN - THE ECONOMICS OF WOOD ENERGY PRODUCTION ON MECHANISED FARMS

by

DEREK E. EARL

April 1985

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ENERGY / DEVELOPMENT INTERNATIONAL

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with contributions by : Mohamed Hanafi Obeid

DISCLAIMER

This report is one of a series of reports being prepared by the Sudan Renewable Energy Project to bring the current results of its activities to the attention of all those concerned with work on renewable energy in Sudan. The views expressed and the recommendations made are those considered appropriate at the time of preparation and are the sole responsibility of the consultant. Endorsement by the Sudan Renewable Energy Project is not necessarily implied.

ACKNOWLEDGMENTS

Among those names appearing in the list of people contacted (APPENDIX 3) I would like to thank those for help which was especially invaluable to this mission and the production of the report. Dr El Tanir Ismail Harbi for an excellent briefing to the background of the Mechanised Farming Corporation. Dr El Tag Seif El Din of the Arab Sudanese Blue Nile Agricultural Company, Hamid Mohed Mahmoud of the Damazin Agriculture and Animal Production Company and Salah El Din El Khalifa of the Sudanese Egyptian Agriculture Integration Company for so willingly helping my mission with hospitality, information and special assistance in Khartoum and on our brief but valuable visits to their farms. Abu El Gassim and Abdel Marouf A/Rahman of the Forest Administration for generous assistance and hospitality in Sennar and Damazin. J B Ball and A Wink of the FAO, Fuelwood For Energy Development Project for their advice and constructive criticism on the draft report and F Thompson of the Department of Forestry, Oxford for information on shelterbelts in the tropics. I owe much gratitude to Dr El Tahib Idris Eisa of SREP for his excellent organising ability and cheerfulness.

In addition to the names above, I have many people to thank but for lack of space I cannot mention each person by name. I acknowledge, therefore, with much gratitude the help given by the following. The Chairman and Managing Director of the Mechanised Farming Corporation and his staff; The Director of Forest Administration and staff; the Minister of Agriculture and Natural Resources and Director of National Resources at Wad Medani; the Commissioner and Deputy Provincial Commissioner for Blue Nile Province; The executive Manager and staff of the ASBNACo; the Executive Manager and staff of DAAPCo; The General Manager and staff of SEIACo; the Project Director and staff of the Damazin Blue Nile Integrated Agricultural Development Project; the Project Manager and staff of the CARE Project, Gedaref; the Agricultural Manager and staff of the Rahad Agricultural Corporation; the Director of Natural Resources of Eastern Region, Kassala; the Regional Forestry Advisor of USAID-Energy Initiatives for Africa, Nairobi; the Director General and staff of the National Energy Administration; staff of the USAID, UNHCR, the FAO, Energy Development International and Georgia Institute of Technology, and the Department of Forestry, Oxford.

Finally, nothing would have been possible without the backing and support of Don Peterson - Chief of Party, and staff of the SREP, to all of them I wish to record my deep appreciation for their friendliness and willing help.

Derek E Earl April 1985

LIST OF CONTENTS

		page
DISCLAIMER		2
ACKNOWLEDGMENTS		3
GLOSSARY OF TERMS, ABBREVIATIONS AND CONVERSION FACTORS.		6
1	SUMMARY	13
2	CONCLUSION AND RECOMMENDATION	15
3	INTRODUCTION	19
4	MECHANISED FARMING IN SUDAN	22
5	DESCRIPTION OF THE FARMS SELECTED FOR A CASE STUDY OF WOOD ENERGY PRODUCTION	29
6	THE ECONOMICS OF CHARCOAL-MAKING IN LAND PREPARATION	34
7	THE ECONOMICS OF FORESTRY AND SHELTERBELTS ON MECHANISED FARMS	45

APPENDICES

1	Consultancy Mechanised Farming - Terms of Reference - (revised February 1985)	59
2	Itinerary	61
3	People contacted	64
4	Sample plot data for calculation of potential charcoal production from forest clearance operations	68
5	Diagrammatic plan of farm roads and shelterbelts	83
6	Rainfall distribution at Agadi (ASBNACo) 1980-84	86
7	Soil profile description (DAAPCo)	87
8	Scope of SREP assistance for mechanised farming and Forest Administration activities	89
9	Agricultural companies with farms approved by the General Administration of Agricultural Investment Ministry of Agriculture	98

page

10 Charcoal transport costs in LS 99

11 NEA team's report on fuel supply for refugees in the Eastern Region of Sudan, March 1985 . . . 100

12 Bibliography 116

MAPS

EASTERN SUDAN (showing locations of farms leased by ASBNACo, DAAPCo and SEAICo) 7

MECHANISED FARMS IN THE BLUE NILE PROVINCE . . 84

BLUE NILE FORESTS AND GAME RESERVES . . . 85

EASTERN SUDAN (showing centres of refugee camp areas) 105

PHOTOGRAPHS . . . . . 8 - 12

DIAGRAMS

EFFECT OF SHELTERBELT ON WIND SPEED . . . 47

PLAN OF SHELTERBELT 48

SECTION THROUGH SHELTERBELT 49

EFFECT OF SHELTERBELT ON CROP YIELD . . . 50

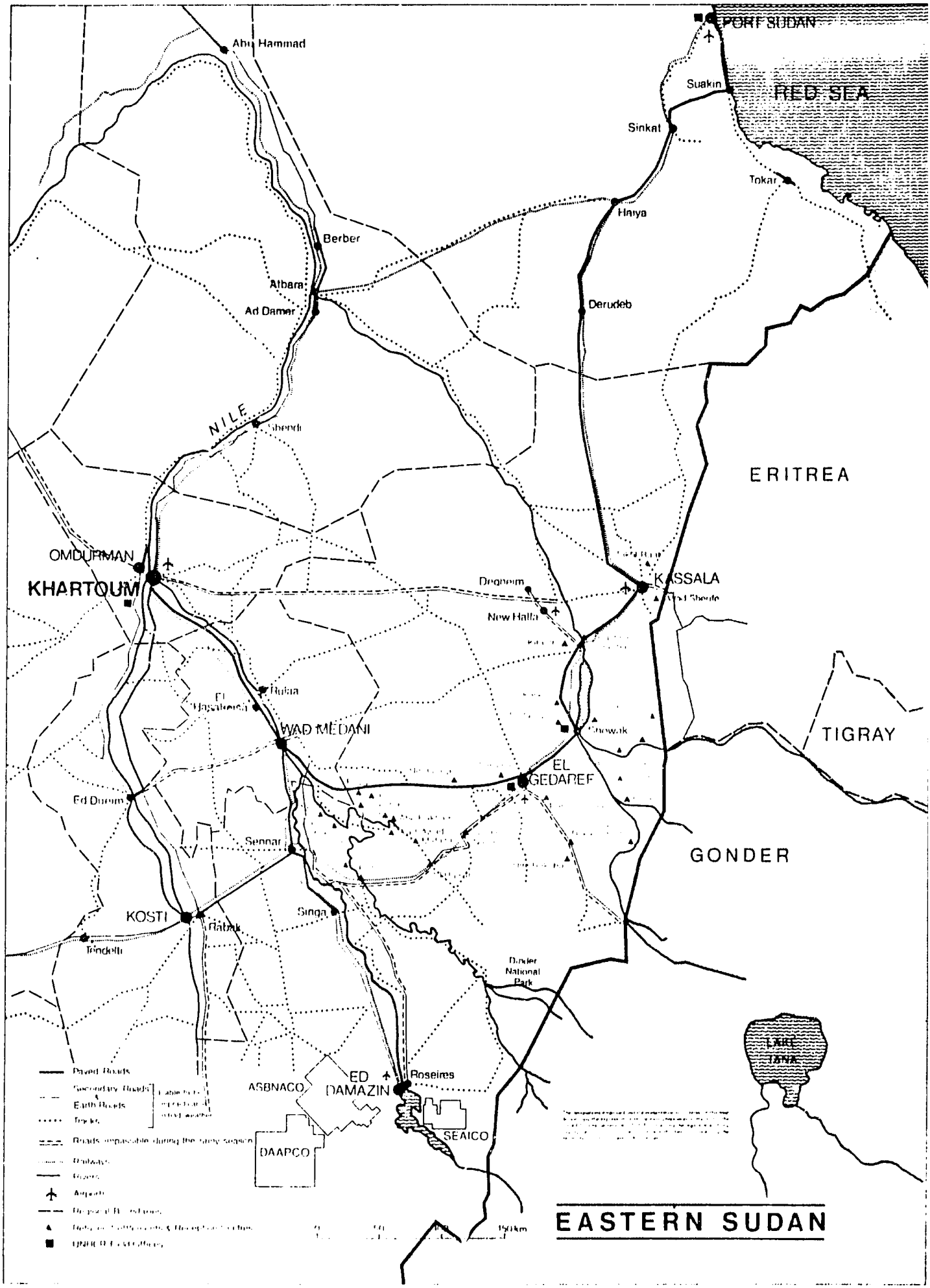
PLAN OF FARM ROADS AND SHELTERBELTS - DAAPCo . 83

GLOSSARY OF TERMS, ABBREVIATIONS AND CONVERSION FACTORS

BA	basal area	The sectional area of the trunk of a tree at 1.3 m above ground
c	circumference	
cm	centimetre	
fd	feddan	
H	height	
ha	hectare	
kg	kilogram	
km	kilometre	
LS	Sudanese pound	2.5 US$
m	metre	

ASBNACo	Arab Sudanese Blue Nile Agricultural Co. Ltd.
CARE	Care and Rehabilitation Everywhere
COR	Commissioner of Refugees
DAAPCo	Damazin Agricultural and Animal Production Co. Ltd.
EDI	Energy Development International
ERC	Energy Research Council
FAO	Food and Agriculture Organisation of the United Nations
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association
MFC	Mechanised Farming Corporation
NEA	National Energy Administration
SEAICo	Sudanese Egyptian Agricultural Integration Co. Ltd.
SREP	Sudan Renewable Energy Project
UNHCR	United Nations High Commission for Refugees
USAID	United States Agency for International Development

m3 stacked	-	A cubic metre of fuelwood stacked one way
stacking factor	-	The ratio between the wood content of a stacked cubic metre and a solid cubic metre of wood
weight of bag of charcoal including bag	-	39 kg
1 ton charcoal	=	26 bags
Number of bags of charcoal per m3 stacked	-	2 to 2.5
m3 stacked per ton of charcoal	-	10 to 13


PORT SUDAN
Abu Hammad
Suakin
RED SEA
Sinkat
Tokar
Haiya
Berber
Atbara
Ad Damer
Derudeb
NILE
Shendi
ERITREA
OMDURMAN
KHARTOUM
Degheim
KASSALA
New Halfa
Rubia
El Hasaheisa
WAD MEDANI
Chewa.ik
TIGRAY
EL GEDAREF
Ed Duein
Sennar
GONDER
KOSTI
Rabak
Singa
Tindelti
Dinder National Park
LAKE TANA
Paved Roads
Secondary Roads
Earth Roads
Tracks
Roads impassable during the rainy season
Railways
Rivers
Airports
ASBNACO
ED DAMAZIN
Roseires
SEAICO
DAAPCO
150km
EASTERN SUDAN

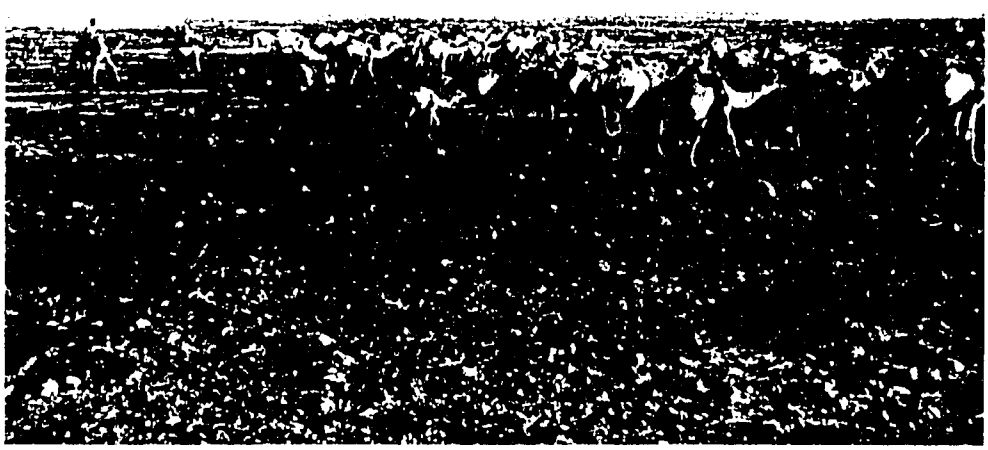
Tree cover on land about to be cleared
Sample plot, Blue Nile, February 1985

Stacked wood ideal for charcoal
Sample plot, Blue Nile, February 1985

Land clearing by fire (1)
Blue Nile, January 1985

Land clearing by fire
Blue Nile, January 1985

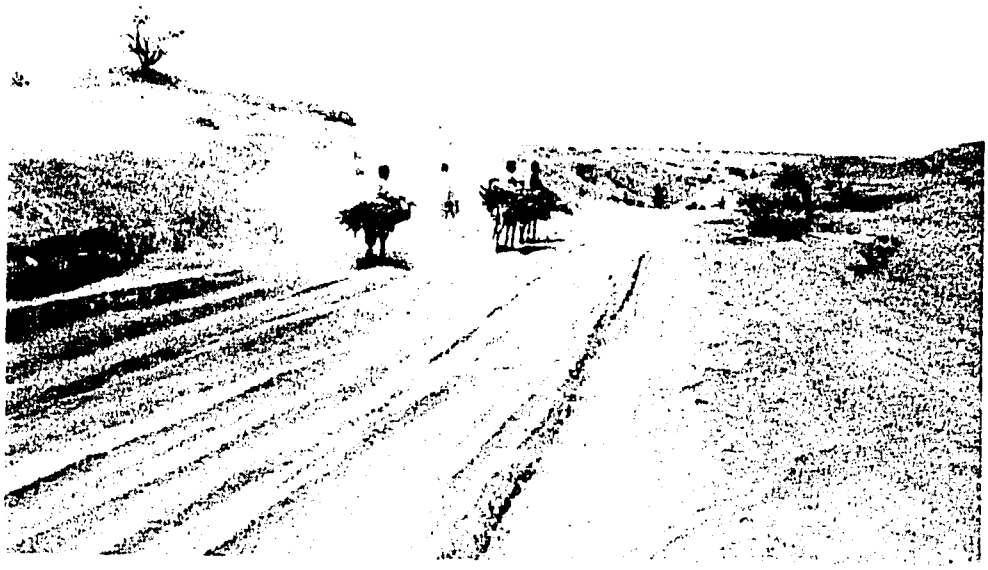
Fields after harvesting
Blue Nile, February 1985



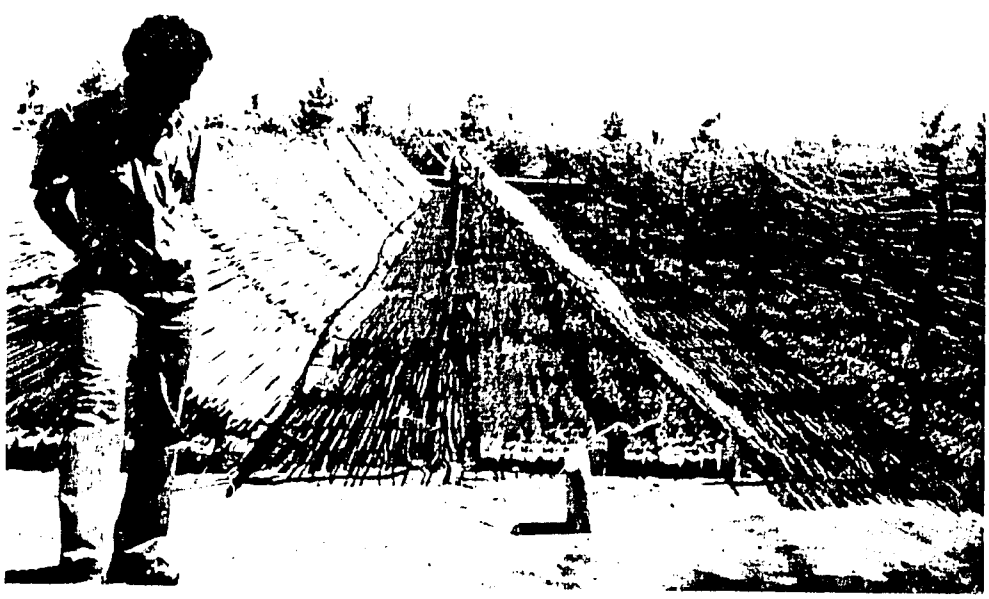
Former farm land, Kassala
January 1985

Charcoal from undemaracated farm land
Blue Nile, Fabruary 1985

Wood being stacked for charcoal kiln
Khartoum North, March 1985



Fuelwood for sale cut near refugee camp
Showak, near Kassala



C.A.R.E. nursery raising trees for shelterbelts
Showak, near Kassala, March 1985

1 - SUMMARY

On the initiative of the Sudan Renewable Energy Project, a consultant was engaged to (a) formulate a study to evaluate the economic costs and benefits of agro-forestry integration on land designated for clearing under a large, mechanised farming scheme; and (b) to evaluate the results of the study and produce recommendations for forestry and energy activities within Sudan.

Discussions with appropriate experts, a review of the literature, and reconnaissance of the Central and Eastern Regions to look at the results of both past and present mechanised farming activities was made, followed by the selection and a closer examination of three large farms with a combined gross area of 969,000 feddans (407,000 ha) in the Blue Nile Province near Damazin.

An examination of current practice at each farm was followed by an assessment of the potential for producing and marketing charcoal from the remaining forest resource and an estimate of how much natural forest was required to ensure adequate future fuel supplies, shade and shelter.

Computation of the results from the three mechanised farms chosen for study have indicated, that with good planning and organization, more than 2,500,000 bags of charcoal could be obtained from land to be cleared in the 1985/6 season which would result in a considerable reduction in farming costs. No major marketing problems should arise because of a newly identified refugee demand, even if all available raw material were to be carbonised.

If most of the wood available from ground-clearing operations were to be carbonised on all mechanised farming schemes in the Blue Nile Province, a surplus of 7,500,000 bags of charcoal would be produced annually during the next 5-6 years which should help solve some of the immediate planning problems of the National Energy Administration. This energy bonus would give the opportunity for Government to: (a) introduce legislation to drastically reduce the amount of charcoal being made on marginal lands without affecting domestic charcoal supplies; (b) allocate approximately 2,000,000 bags of charcoal annually to the Commissioner of Refugees to help alleviate the energy problem arising from the recent influx of 400,000 extra people from Ethiopia; (c) approve an export quota of approximately 5,000,000 bags of charcoal per year for the national benefit.

A survey of current agricultural practice on the three mechanised farms indicated that although some natural forest was left along rivers and on low-lying land, little attempt was being made to provide adequate shelterbelts. This report considers that shelterbelts should be laid out on all farms at time of land

clearing with some new species of trees introduced to increase fuel production, to improve crop yields and for the general protection of the environment. Practical criteria have been formulated for leaving natural forest within the farms, to be augmented, where necessary, by seedlings to be raised in regional nurseries or on the farms. A request from the farms for assistance from the SREP and the Forest Administration to carry out a pilot programme has been received.

Major recommendations in this report are: (a) the institutions concerned should ensure that leases for farm land are granted only if it is agreed that trees removed during land clearing will be utilised; (b) the Mechanised Farming Corporation and the Forests Administration should take a more active role in all allocations of land for farming; (c) another 1,000,000 feddans (420,000 ha) of land in the Blue Nile Province should be demarcated as forest reserve to serve as an essential environmental buffer zone between farming areas and to be managed as a principal potential source of fuel.

Although this report has been based upon studies made in the Central and Eastern Regions only, its main recommendations, with minor modifications, are likely to apply to most of Sudan. Early action is needed to prevent further wastage of a valuable energy resource and to leave enough trees to safeguard fuel supplies for the future.

2 - CONCLUSION AND RECOMMENDATIONS

Conclusion

Mechanised farming, which started forty years ago as a wartime expedient to increase food supplies to the army, has led to a vast expansion in total crop production, and is now the largest component of the agricultural sector in Sudan.

Concern has been expressed that the rapid horizontal expansion of mechanised farming in the rain-fed sector has been at the expense of natural resources and soil fertility, and has increased the danger of soil erosion (EL NOUR [1983]). It has been noted that insufficient areas of land are being left under forest as buffer zones between farms for nomad/stock routes and to ensure that adequate local fuel supplies and other benefits (especially protective) will be available when land clearance comes to an end. The reasons usually given for this apparent disregard for the benefits available from trees are attributable to institutional factors (including antiquated laws and lack of control or direction by the relevant authorities) and the failure of market forces to take into account the requirements of long-term development.

A vast resource of wood is being destroyed annually in land clearance for mechanised farming and this potential source of energy, for domestic use, or for export, is not being recovered to benefit the Sudanese economy. Very little attention is being given to the protective function of trees. Although some trees are being left on poor soil sites and low lying areas liable to flood, insufficient trees are being left as barriers against wind erosion. Where shelterbelts of trees are left in situ as protection, they are frequently too narrow and thinly stocked to provide anything other than a nuisance value to the farms.

The main conclusion of this report is that mechanisation assists the farmer to produce crops cheaper and faster than by hand but this can be sustained without environmental deterioration and loss of present and future fuel resources only if the rules for good land husbandry are observed.

The recommendations which follow are intended to assist farmers to obtain a reduction in the costs of clearing land and an increase in the range of benefits available from well-managed trees and shelterbelts on the farms. Additional benefits will be an improvement in the environment and a useful if modest contribution to the solution of the energy needs of Sudan.

Recommendations

Modern farming is normally highly mechanised and all farmers use machinery to a greater or lesser extent, therefore:

THE WORK OF THE MECHANISED FARMING CORPORATION SHOULD ENCOMPASS THE GENERAL PLANNING OF ALL FARMING IN THE RAIN-FED SECTOR; IN LINE WITH THIS BROADER BASE ITS NAME SHOULD BE CHANGED TO: THE SUDANESE FARMING CORPORATION.

Lack of control and direction of large-scale farming activities is leading to the destruction of much potential wood energy and the loss of forest which could provide for strategic supplies of charcoal and environmental protection in the future. The authorities which should be most concerned with these features of farming are the Forestry Administration and the Mechanised Farming Corporation, therefore:

THE TERMS OF REFERENCE OF BOTH THE SUDANESE FARMING CORPORATION AND THE FOREST ADMINISTRATION WILL INCLUDE RESPONSIBILITY FOR THE PLANNING OF FARMING AND FORESTRY ON ALL LAND IN THE RAIN-FED SECTOR.

Information on areas allocated to farming and areas demarcated as forest reserves is available but dispersed, therefore:

A LAND-USE MASTER MAP SHOULD BE PREPARED AS SOON AS POSSIBLE FOR SUDAN AND COPIES DISTRIBUTED TO ALL THE AUTHORITIES CONCERNED WITH LAND ALLOCATION.

There is little real scientific information on the long-term effects of mechanised farming on the environment, although there is evidence of loss of soil fertility in those areas with low rainfall (below 450 mm/year) and it is in these areas where tree cover should always be left for environmental protection, therefore:

RESEARCH INTO THE EFFECTS OF REPEATED CROPPING ON SOIL FERTILITY SHOULD BE STRENGTHENED. COMMERCIAL CHARCOAL-MAKING ON RAIN-FED LAND NORTH OF 13 DEGREES LATITUDE SHOULD BE FORBIDDEN AND THE LEASES OF MECHANISED FARMS NORTH OF THIS LATITUDE SHOULD BE CANCELLED OR TRANSFERRED AND THE LAND DEMARCATED AS FOREST RESERVE FOR AFFORESTATION.

It is paradoxical that although Sudan is facing a crisis in the supply of fuel, large-scale burning down of forests is allowed. This is a cost to the nation which should be avoided, therefore:

FARMERS CONTINUING TO CLEAR THE LAND WITHOUT UTILISING THE WOOD AS PRODUCE OR FUEL SHOULD PAY A MINIMUM CHARGE OF LS 90 PER FEDDAN AS A RESOURCE COST.

It is estimated that 2,000,000 bags of charcoal to meet the needs of refugees and 5,000,000 bags for export, extra to domestic needs, could be obtained annually for the next 5 to 6 years from properly planned and executed charcoal-making operations in the mechanised farms, therefore:

PLANNING FOR THE TASK OF PRODUCING AN ESTIMATED 7,500,000 BAGS OF CHARCOAL FROM WOOD, WHICH WOULD OTHERWISE BE WASTED, SHOULD BEGIN AS SOON AS POSSIBLE FOR PRODUCTION TO START AT THE BEGINNING OF THE DRY SEASON IN OCTOBER 1985.

On some mechanised farming schemes so much cover is being removed as to pose a threat to the environment. Although many farmers are leaving some trees, they know little about the advantages of managing shelterbelts for soil protection, increased crop yields, and future fuel supplies, therefore:

CRITERIA FOR LEAVING TREES ON FARMS HAVE BEEN LAID DOWN (SEE CHAPTER 7) WHICH SHOULD FORM PART OF EVERY LEASING AGREEMENT AND BE OBSERVED BY ALL FARMS IN THE RAIN-FED SECTOR. THE SUDANESE FARMING CORPORATION SHOULD INITIATE A STUDY ON THE EFFECTS OF SHELTERBELTS ON CROP YIELDS.

The three farms studied in the Blue Nile Province will serve as models for replication elsewhere. Fast-growing trees are needed to establish new shelterbelts both on those farms which have removed all trees, and for enriching existing shelterbelts. Some seedlings will be available at nurseries established at Damazin and Roseires but ultimately, it will be much cheaper and more convenient to raise seedlings on the farms. For this purpose, they will need some technical assistance, therefore:

THE GRANT PROPOSALS FOR THE THREE FARMS, AS INDICATED IN APPENDIX 6, SHOULD BE ORGANISED BY SREP WITH THE HELP OF THE FOREST ADMINISTRATION, AS SOON AS POSSIBLE.

This report has highlighted the fact that Sudan is in the fortunate position of having large reserves of raw material suitable for charcoal, on land which is scheduled for conversion to agricultural use. The estimated amount of extra charcoal will be available only:

a) for a limited period of probably 5-6 years, and

b) provided that immediate action is taken to change the present destructive pattern of land conversion.

There is no room for complacency if the supplies for the future are to be secured. It has been calculated (EL FAKI [1985]) that an additional 390,000 hectares of forest will be required over and above the existing demarcated reserves to maintain fuel supplies to Khartoum and other urban areas from the Blue Nile Province beyond 1992. This consultant agrees broadly with this calculation, therefore:

IMMEDIATE STEPS SHOULD BE TAKEN TO RESERVE ABOUT 1,000,000 FEDDANS (420,000 HA) OF FOREST LAND IN THE BLUE NILE PROVINCE TO PROVIDE FOR FUTURE CHARCOAL SUPPLIES FOR URBAN AREAS IN THE CENTRAL REGION, ENVIRONMENTAL PROTECTION AND TO ACT AS BUFFER ZONES BETWEEN THE EXISTING AND PROPOSED LARGE FARMING AREAS/SCHEMES.

3 - INTRODUCTION

The Sudan Renewable Energy Project

The Sudan Renewable Energy Project (SREP) is part of the bilateral assistance programme of the Government of Sudan and the US Agency for International Development (USAID).

The Project is implemented by the Energy Research Council (ERC) Sudan, and the Georgia Institute of Technology, United States. The Project began in October 1982, and will continue until the end of June 1987. The SREP seeks to encourage the commercial development of renewable energy technologies in Sudan, and to develop the capacity of the ERC and the Renewable Energy Research Institute to evaluate and disseminate these technologies. The SREP focusses on the following five technology areas:

fuelwood production
charcoal production
wood-burning stoves
charcoal-burning stoves
small-scale applications of photovoltaic power.

Work on these five areas is supported by SREP funds and by a special Renewable Energy Development Grants fund, designed to encourage government and private sector institutions, co-operatives, and other groups to initiate renewable energy enterprises.

Charcoal production

In January 1984 a consultant was recruited by Energy Development International (EDI), for SREP, to prepare a report on charcoal production. Among his recommendations were some referring to the potential contribution that fuelwood and charcoal, from the forestry and mechanised farming sectors, could make towards the solution of Sudan's energy problem. The summarised recommendations appearing in Report 002 on charcoal production were:,

a) ensuring that all wood cleared from rain-fed mechanised farming schemes is utilised and not burnt on site;

b) insisting that 10-15% of such land is left under tree cover as had long been recommended;

c) planning for land to be allowed to grow fuel (including, in some cases, *Acacia senegal* (gum arabic) during the fallow period;

d) the management of some forest reserves in fuel-deficient

areas for fuel production on a sustained basis;

e) the gazetting of 1.7 million hectares as forest reserve to bring the total area of forest estate to 3 million hectares.

In January 1985, the same consultant was recruited by EDI for SREP: the objectives of this consultancy (see Terms of Reference, APPENDIX 1) developed from recommendations made in Report 002, these were:

1) to formulate a study to evaluate the economic costs and benefits of agriculture/forestry integration on land designated for clearing under a large mechanised farming scheme;

2) to evaluate the results of the study and produce recommendations for forestry and energy activities within the Sudan Mechanised Farming Sector.

It was decided that the most promising area of mechanised farming activity to investigate was in the Damazin area of the Blue Nile Province, Central region, where some well organised, efficient, agricultural companies with adequate resources of capital, labour and machinery were operating. The reasoning behind this decision was that if extra inputs of expertise, capital or machinery were needed to gain commercial advantage from producing charcoal and lowering clearing costs, and leaving trees to safeguard their future supplies of fuel; then these companies were likely to react quickly and provide a rational demonstration for replication elsewhere.

To obtain a balanced view, it was decided to study the economics of wood energy production on four farms owned by agricultural companies. Because one farm was already receiving assistance from a development agency, more detailed analysis was confined to three farms only.

Methodology

1. Discuss background to the study with officials of Mechanised Farming Corporation, Forest Administration and read relevant literature.

2. Prepare work programme, discuss logistics and obtain approval of SREP.

3. Reconnoitre from the air and on the ground the main areas of past and present mechanised farming activities in Central and Eastern Regions.

4. Select farms considered to be suitable for study and interview farm managers willing to co-operate.

5. Make a field survey of each farm followed by the selection of areas of natural forest considered by the local manager to contain an average stocking of trees.

6. Measure both standing and felled trees in sample plots in those selected areas in order to obtain an estimate of charcoal potential.

7. Estimate the effective and potential demands for charcoal and relate these to transport costs from the supply zones to the market centres.

8. Discuss with the farm managers to discover what they think are the advantages and disadvantages of leaving trees on the farms and obtain a consensus of their views to discuss with the General Managers in Khartoum before deciding what criteria could be laid down to produce optimum results.

9. Analyse results and prepare report.

It was originally planned that the consultant would come to Sudan for a month in January 1985 to devise a 4 month study and to return to Sudan in June/July 1985 to complete the final report. In the course of discussions with the SREP executive, it was agreed that because of the urgent need to produce recommendations for guidance of the various organizations of Government dealing with land clearance and conservation in Mechanised Farming Schemes, the consultant would come to Sudan in January 1985 and spend as much time as possible in the field collecting data and present a draft report for comment before leaving Sudan in March 1985. The final report which, would incorporate all artwork and photography and agreed amendments, would be completed in Oxford in April 1985.

4 - MECHANISED FARMING IN SUDAN

General background

a) Geography

The population of Sudan is estimated at about 22 million of which 15 million are rural, 4.5 million live in the towns and 2.5 million are nomadic. The yearly increase in population is estimated to be 2.5% without taking into account the recent large influxes of refugees.

Sudan has an area of 2.5 million square kilometres of which about 50% is desert or semi-desert and 40% of the remainder is savanna woodland, much of it converted or under conversion to agricultural use. Most of the country is flat but there are a few mountains over 3,000 m above sea level. Soils are predominantly sandy in the North and heavy cracking clays in the central, easterly plain.

The most interesting and economically important natural asset is the River Nile, and its two branches, the Blue Nile and White Nile which join at Khartoum. The Blue Nile and its tributaries arise in the highlands of Ethiopia and the White Nile, starts from Lake Victoria Nyanza in Uganda. Nile water provides much of the domestic water and electricity supply for most of the population of Khartoum and the large towns of the Central Region, and also the means to irrigate very large areas of rich flood plain.

Rainfall varies from zero in the Northern desert to more than 1,500 mm per annum in the South. Rainfall in the Damazin area varies from 500-800 mm per annum, see APPENDIX 6, with the rainy season starting in May and finishing in October (July and August being the wettest months).

b) Energy

Sudan has been badly affected by the high price of oil currently taking about 80% of the foreign exchange earned from exports.

Less than 20% of total energy consumption is from imported oil and from hydropower, the remainder is from biomas (fuelwood, charcoal, agricultural residues and dung).

About 46% of current charcoal demand is being supplied from the Blue Nile Province in Central region of Sudan. The source of supply in the Eastern region is almost completely exhausted and further removal of vegetation is likely to hasten the process of soil deterioration already noticeable around Gedaref and Kassala.

c) Forestry

The forest reserve area in Sudan is just over 3,000,000 feddans (1.3 million ha) which is only 1.2 % of Sudan's total land area. Forests outside the reserved areas are rapidly being destroyed and the land converted to other use. The paucity of reserved forests in the Blue Nile Province has been referred to by EL FAKI (1985). The locations of these reserves can be ascertained by reference to the map in APPENDIX 5.

The most important activity in forestry is the production of gum arabic (a product of Acacia senegal), about 100,000 feddans (42,000 ha) of this species has been established within the forest reserves. Other major activities of forestry are those concerned with desertification control and fuelwood plantation development. These latter activities are well supported by various aid agencies but because there is little co-operation between the projects and work on a pilot scale usually commences only after the forest has been removed, the impact is minimal when viewed alongside the rapidly increasing rate of forest destruction.

d) Agriculture

Agriculture employs about 80% of the population of Sudan and contributes approximately 40% to the gross domestic product. Principal exports are: cotton, vegetable oils, gum, oil cake, livestock, hides and skins, and sorghum.

It is estimated that there are about 44,000,000 animals in Sudan (camels, cows, goats and sheep) which tend to graze at a very low density, if settled, or rather intensively along stock routes if owned by nomads. The migration of nomads in the Blue Nile Province is roughly SSE-NNW in June-July, and NNW-SSE from October-December.

There are three main types of arable farming.

(a) Traditional farming which extends to over 12,000,000 feddans (5,000,000 ha), with most crops grown under rain-fed conditions.

(b) Irrigated schemes totalling nearly 3.5 million feddans (1.5 million ha), e.g. Gezira and Rahad, which are intensive, well organised, and supplied with water from the Blue Nile dam at Sennar.

(c) Mechanised farming which with about 7.4 million feddans (3.1 million ha) at present under cultivation in the rain-fed sector, is undergoing rapid horizontal expansion with the help of international agencies and foreign private business interests.

Historical background

Mechanised farming in Sudan started in 1944 at Gadambaliya near Gedaref in the Central Region as an attempt to produce the extra sorghum needed to feed the troops fighting in Ethiopia and Eritrea. This area was chosen, despite its low rainfall (c. 400-500 mm/year) and poor soils, because vegetation was light and easy to clear as compared with the more productive areas nearer to the Blue Nile in the South with richer soils and higher rainfall (600 mm/year) but covered by much denser, tree growth. Cultivation began with two large tractors borrowed from the army and was so successful that additional equipment was purchased, and the area extended to 12,000 feddans (5040 ha) by 1946. Small parcels of land (28-240 fd [12-100 ha]) were leased for 8 years to farmers who were able to hire the tractors and ploughs, as required, from the Government. Because of fluctuating yields (which were directly correlated with the amount of rain which fell in the season) the area under cultivation reached a maximum of 31,000 feddans (13,000 ha) in 1951 and dropped to 19,000 feddans (8,000 ha) in 1953 when, as a result of the recommendations of a Government committee, a new administrative structure for mechanised farming was introduced.

From 1953 the Mechanised Crop Production Scheme (a new department of the Ministry of Agriculture),apart from establishing pilot farms to study specific problems and distributing the land to farmers was to concentrate on planning and supplying infrastructural services. Although all land was supposed to be distributed to the private sector, by the Mechanised Crop Production Scheme, the big profits obtained from 1954-9 encouraged a huge, illegal, horizontal expansion of land under cultivation which was often poorly planned with no provision of services. It was estimated by the Mechanised Farming Corporation (MFC) (1972) that the area cultivated without the knowledge and control of the Government during this period was more than the area under Government control and supervision. The expansion slowed down from 1951-8 because by 1968 it had been noted that:

> 'Continuous monoculture of dura (sorghum) resulted in soil depletion leading to low yields, especially in the more marginal area of the North'.

and

> 'Most of the open grass and sparse tree vegetation lands in the North which could be easily and cheaply developed had already been put under cultivation. Further development in the higher rainfall area of the southern region <u>would entail heavy costs of tree clearance</u>.' (MFC [1972])

In 1968, the Mechanised Farming Corporation was established as the agency responsible for the development of the mechanised rain-fed sector in Sudan. In the same year IBRD approved a loan of US$ 5,000,000 for the development of 140 farms of 1,000 feddans (420 ha) each at Simsim. Further credit was obtained from IDA in 1973.

The responsibilities of the MFC were defined by its constitution (1975) as follows:

i Survey land which is allocated to it by the Government and demarcate schemes and distribute them to farmers for mechanised rain-fed crop production and provide the necessary services, according to a comprehensive plan for optimum land use, which will promote production and realise settlement in these areas.

ii Assist the private investors and direct their attention to the best agricultural techniques. Provide improved seeds, extension services and crop protection services in co-ordination with concerned institutions and departments.

iii Promote agricultural research.

iv Provide credit for farmers on reasonable terms, for the finance of farm operations and other agricultural aspects which are seen appropriate.

v Operate state farms.

vi Provide social services.

'It has been noticed that the emphasis during the past years has been primarily on survey, demarcation and distribution of schemes and on operations of state farms. There has been little activity in the other aspects of responsibility.' (MFC [1984a])

The new objectives and policies of the MFC are based on a letter from the Minister of Agriculture Food and Natural Resources (1983).

'The overall strategy for the rain-fed sector will be to increase productivity in existing schemes, horizontal expansion would be gradual and within modest limits.'

'The new policy would be for the MFC to concentrate on extension work, demonstration crop trials and adaptive research.'

'State farm activities to be phased out, the assets sold and only a small area, 5-10 thousand feddans retained for meeting policy requirements.'

The present position of mechanised farming

State farming has virtually ceased and mechanised farming activity is almost entirely taking place in the private sector. The total area presently cultivated in the mechanised rain-fed sector is estimated as 7.4 million feddans (3.1 million ha) and

the area being converted from forest to farm is increasing rapidly, prompted by the good profits available from escalating sorghum prices.

In the Central and Eastern Regions the chief crops grown are sorghum, cotton and sesame. Land is cleared between October and April (usually most work is done after January). Cultivation takes place with disc ploughs in May/June followed by seed sowing. Spraying with herbicides and insecticides is usually done once or twice before harvesting in September-December. Most operations are mechanised except for cotton picking and occasional hand reaping of sorghum and sesame.

Land clearing is very labour intensive: the trees are usually burnt down with fire, cut up with axes, heaped and burnt. Roots are dug up by means of hoes and axes. The MFC has rules for leaving 20 m wide strips of trees at 500 m intervals to act as shelterbelts but these rules are rarely complied with. There is no requirement to leave an area of the farm fallow long enough both to restore fertility and provide a crop of fuel. Farm managers felt that they could not afford to leave fields fallow for more than 2-3 years as they were specifically required to maximise food crop production, and that the Forest Administration should be providing for fuel for the future from forest reserves. There are no rules concerning trees or shelterbelts for farmers obtaining leases for land from local authorities or for companies with leases on land approved by the General Administration of Agricultural Investment.

At present 44% of the area of all mechanised farming schemes is in the Eastern Region and 34% in the Central Region. The total area of farmland leased to approved companies in the Blue Nile Province amounts to 2,576,000 feddans (1,082,000 ha) of which 498,000 feddans (209,000 ha) has been cleared (by 1984).

Demarcated schemes

About 4 million feddans (1.7 million ha) of farms are cultivated under demarcated schemes. Demarcated schemes are those approved by the Ministry of Agriculture through the General Administration of Agricultural Investment and the MFC. The criteria for approval by the MFC include:

(a) rainfall sufficiency
(b) adequate soil fertility
(c) observance of Forest Reserves as buffer zones
(d) recognition of the rights of nomads to move along stock routes.

The schemes are demarcated and then subdivided into 1,000, 1,500 or 2,000 feddans (420, 630 or 840 ha). The MFC provides services, e.g. improved roads, potable water supply and supervisory and advisory technical support. The farmers are

given a 25 year lease at a ground rent of LS 1.00 per feddan. This land revenue forms the main source of finance for the MFC to function.

Agricultural companies over 2,000 feddans (840 ha)in size are granted their leases and controlled by the General Administration of Agricultural Investment, Ministry of Agriculture. This is in accordance with the provision of The encouragement of Investment Act (1980). About 0.3 million feddans (0.126 million ha) of land is at present under cultivation by agricultural companies and a large increase in the rate of conversion is under way.

In order to establish these large farms, feasibility studies are prepared which must be approved by the General Administration of Agriculture Investment. Approval ensures tax freedom for 5 years, custom-free entry for essential machinery and parts, and repatriation of profits. No reference to the MFC, the Forests Administration or Regional Government is required.

The most important of these companies are listed below (a full list is given in APPENDIX 9).

Name of Company	Gross area fd	Gross area ha
The Blue Nile Livestock and Crop Production Co. Ltd	1,000,000	420,000
The Damazin Agricultural and Animal Production Co. Ltd.	500,000	210,000
The Sudanese Egyptian Agricultural Integration Co. Ltd.	250,000	105,000
The Arab Sudanese Blue Nile Agricultural Co. Ltd.	219,000	91,980
The Green Valley Agricultural Co. Ltd.	100,000	42,000
Abu Sabika Agricultural and Animal Production Co. Ltd.	56,000	23,520
The African Plantation Co. Ltd.	44,000	18,480
TOTAL	2,169,000	910,000

Most of these companies have taken up concessions in the Damazin area of the Blue Nile Province which is an area relatively rich in tree cover. Operations on all farms have commenced with the exception of the Blue Nile Livestock and Crop Production Co. Ltd.

The general managers of three of these companies (The Arab Sudanese Blue Nile Co. Ltd [ASBNACo], The Damazin Agricultural and Animal Production Co. Ltd. [DAAPCo], and The Sudanese

Egyptian Agricultural Integration Co. Ltd. [SEAICo]) were interviewed and agreed to co-operate fully with the consultant in seeking a practical alternative to the present system of clearing land for cultivation and to provide for energy supplies, both now and in the future, from the natural endowment of trees.

Undemarcated schemes

About 3.4 million feddans of mechanical farming activity (1.4 million ha) is not under the control of the MFC or of the General Administration of Agricultural Investment, and is said to be 'undemarcated'. Farms in this category do not receive Government support and no technical or other important factors have been considered in their establishment. This has resulted in some farmers: locating their farms in areas of inadequate rainfall; applying unaccepted agricultural practices; ignoring the presence of forest reserves, nomad/stock routes and other areas which should not be cultivated (MFC [1972]).

A recent report by the MFC Task Force (1984a) has pointed out that:

> 'Uncontrolled expansion of mechanised farming during the past years has devastated the forestry and pasture wealth of the country particularly in marginal rainfall areas in which mechanised farming extended without authorisation from concerned Government institutions. Undemarcated mechanised schemes have spread into grazing areas, blocked traditional stock routes and contributed to desertification.'
>
> 'However, it is expected that in future years the trend towards expansion in the sector would be increased and therefore the hazards to land use and to environment are expected to be even greater. Therefore, MFC should be given the responsibility of planning for the development and expansion of the sector and should be the sole Government agency which authorises new expansion in mechanised agriculture.'

It is apparent that the MFC has been very frank in pointing out the deficiencies in mechanised farming and of its own weaknesses. It is fair to say that some very good work has been done by the MFC, particularly in assisting farmers to get started and in pioneering work on its own farms. Undoubtedly, given a well defined role and sufficient power, it could be of great service to Sudanese agriculture and at the same time play a crucial part in ensuring that the environment is fully protected.

5 - DESCRIPTION OF THE FARMS SELECTED FOR A CASE STUDY OF WOOD ENERGY PRODUCTION

Background

About 2.5 million feddans (1 million ha) of land in the Damazin area of the Blue Nile Province has been allocated and leased to agricultural companies by the General Administration of Agricultural Investment (see APPENDIX 9). About 20% (500,000 feddans [210,000 ha]) of forest had been cleared and was under cultivation at the end of 1984. Because of the scale of the operations and the speed with which they are being carried out, it was considered to be of the utmost importance to try to present a reasonable case for saving the fuel from being lost, and to produce criteria for leaving some land within the farms under tree cover, before the 1985/6 clearing season begins.

Reasons for selection

The three mechanised farms selected for study were chosen because they have already established systems for clearing forest and cultivation, and are comparatively close to each other. They are representative of a number of well-organised, efficient farm companies who would be likely to appreciate any practical suggestion offered to them to increase profitability and would be in a position to implement such acceptable suggestions very quickly.

Brief details of the farms

The combined gross area of the three farms is 969,000 feddans (406,980 ha) which is about 38% of the total area of land allocated by the General Administration of Agricultural Investment.

The soils are all alluvial and range from very fertile cracking clays and loams with a pH of about 8.5 to less fertile sands with a pH of approximately 6.0.

Rainfall varies from 500-700 mm/year occurring during May-October with a dry period from November-April.

The natural vegetation consists of a ground layer of grasses and herbs over-shadowed by a light covering of savanna trees, principally Acacia species: the percentage of Acacia seyal varies from 50-60% on the acid sandy soils to 79-80% on to the more alkaline clays.

The layout on the three farms is in chequer-board fashion with 2 km square fields separated by North-South and East-West roads,

i.e. each field is 952 feddan (400 ha) (see APPENDIX 5).

Initial clearance is done with manual labour, sometimes by direct hire, but usually by means of contractors. Grass and small wood fires are made at the bases of individual trees until they fall when they are cut into pieces small enough to be manhandled, heaped and burnt. The cost of this operation, including removal of any unburnt roots, varies from between LS 25-45 per feddan (LS 60-107 per ha), with an average cost of LS 40 per feddan (LS 95 per ha).

Areas left uncleared are river banks, low lying land liable to flood, very sandy sites, nomad/stock routes and shelterbelts. The criteria used for determining the amounts left vary considerably between farms and in different areas of the same farm. The criteria used for deciding on what to leave as shelterbelts are perhaps the most varied. The tendency, at best, has been to leave narrow strips at 500 m intervals, or at worst, to leave out the belts altogether.

Cultivation is normally by multiple disc ploughs pulled by very large, wheeled tractors.

Crops grown are principally sorghum, sesame and cotton on a rotation system.

Fertiliser additions are few to nil, phosphorus being the main requirement with nitrogen needed after a few years.

Herbicides are applied quite intensively on all crops, often by aerial spraying.

Harvesting of sesame, cotton and the older, long-stalked varieties of sorghum is usually done by hand. Harvesting of the new short-stalked varieties of sorghum is normally done with combine harvesters.

Yields are low by world standards for similar conditions but give a good return on capital because of the relatively low inputs required, very low land rent and no account taken of resource costs (i.e. value of the forest removed). The main crop grown is sorghum which produces 330-430 kg per feddan (786-1023 kg per ha) at the present time.

Brief details of the individual farms

Arab Sudanese Blue Nile Agricultural Co. Ltd. (ASBNACo)

Area	Feddans	Hectares
Gross	219,000	91,980
Cleared to end 1983-4	148,000	62,160
Planned to clear 1984-5	11,000	4,620
Planned to clear 1985-6	35,000	14,700

Damazin Agricultural and Animal Production Co. Ltd (DAAPCo)

Area	Feddans	Hectares
Gross	500,000	210,000
Cleared to end 1983-4	60,000	25,200
Planned to clear 1984-5	22,000	9,240
Planned to clear 1985-6	30,000	12,600

Sudanese Egyptian Agricultural Integration Co. Ltd (SEAICo)

Area	Feddans	Hectares
Gross	250,000	105,000
Cleared to end 1983-4	90,000	37,800
Planned to clear 1984-5	20,000	8,400
Planned to clear 1985-6	20,000	8,400

ASBNACo

This farm of 219,000 feddans (91,980 ha) with field Headquarters at Agadi (about 35 km from Damazin), was established as a state farm in 1971 with 12,000 feddans (5,040 ha). As a result of a change in policy, the farm was sold to the present company of Sudan Government and Arab interests in 1983. Crops of sorghum, cotton and sesame continue to be the main products as before.

The farm has been laid out with 2 x 2 km fields with roads between fields running approximately NNW-SSE and ENE-WSW. A 2 km wide strip of natural forest 20 km long running through the centre of the farm (NNW-SSE) has been left as a nomad/stock route. Shelterbelts varying in width from 10-30 m have been left on both sides of most of the East-West roads and additional strips of approximately 10 m width have been left within the fields at 500 m intervals. Most of the shelterbelts are in a rather open condition with very few young trees present. It was thought that this might be brought about by the policy of late burning (November-December) in the belts to eliminate weeds. Land-clearing is by direct labour estimated to cost LS 25 per feddan (LS 105 per ha). This figure does not take into account the costs of transporting workers, the provision of water and overheads.

DAAPCo

This farm with field Headquarters at Abu Dom, about 90 km from Damazin, started pilot operations in 1978 with the assistance of Dalgety Agricultural Development International Ltd. It was proposed to utilise 290,000 feddans (121,800 ha) of the more acid, sandy soils for livestock (cattle ranching) and the remaining 210,000 feddans (88,200 ha) of calcareous, black cracking clay soils for the production of cotton, sesame and sorghum. After 2-3 years of trials, it was decided to abandon livestock production because of the high mortality rate of introduced cattle and the difficulties of providing food and water during the long dry season. The company is now privately owned by Saudi Arabian and Sudanese interests.

The River Khor al Dolieb, which is the centre of a nomad/stock route running North West to South East towards the southern part of the cultivatable land, floods in late May and holds water and provides fresh grazing until December when the nomads start to leave for the South. On the initiative of the Regional Commissioner, a 5 km wide strip on each side of the river has been excluded from the lease and reserved for the use of the nomads. Some people with animals have dug wells and appear to be settling in the strip and are reluctant to move.

Forest is left on all low-lying land which is liable to flood, and the vegetation (in variable amounts) has been left each side of several other seasonal rivers passing through the farm.

Trees were not retained on any other parts of the farm but after discussions with the Executive Manager in Khartoum, on what should be the criteria for leaving trees, instructions were given to the Field Manager to leave 40 m wide belts on the South side of each East-West road and around the farm perimeter (see map, APPENDIX 5).

The farm is planning to clear 22,000 feddans (9,240 ha), 10,000 feddans (4,200 ha) with direct labour and 12,000 feddans (5040 ha) by contract. It is not known what the clearing costs with direct labour will be, but clearing and burning forest by contractors currently costs about LS 40 per feddan (LS 95 per ha), this may well have to increase in order to persuade more contractors to undertake the work if the 12,000 feddan programme (5,040 ha) is to be completed before ploughing commences in June.

SEAICo

The Sudanese Egyptian Farm is on the South East side of the Blue Nile at Damazin, with field Headquarters 65 km from Damazin. The farm was established in 1976 when 217,000 feddans (91,140) were demarcated. Clearing operations started in 1977-8 and by 1984 130,000 feddans (54,600 ha) were under cultivation. About LS 6,000,000 has been invested in infrastructure including roads,

camps, workshops and houses; and there is at present sufficient agricultural equipment on site to handle all operations on the area under cultivation. Crops of sorghum, cotton and sesame are rotated within 2 x 2 km fields surrounded on both North-South and East-West sides by roads. Soils are black cracking clays (less calcareous than those on the West of the Nile) and sandy loams. The black clays are the more fertile.

There is no major problem with nomad/stock routes or rivers and tree cover is left on the less fertile sites. Formerly, Balanites aegyptiaca trees were left in the fields (in accordance with local custom) but since 1983, they have been removed and no trees were being left behind in all new clearings. Until 1983 shelterbelts 20 m wide were left each side of the roadways, usually on the East-West roads but occasionally on the North-South roads too. In February 1985 after discussions, the General Manager decided that clearing old shelterbelts should cease and that some forest should be left as shelterbelts along the East-West roads on newly cleared land.

Clearing is all done by 3-4 large contractors at the cost of about LS 40 per feddan (LS 95 per ha).

6 - THE ECONOMICS OF CHARCOAL-MAKING IN LAND PREPARATION

Main objective

The purpose of this chapter is to demonstrate that preparation costs for mechanised farming could be drastically reduced if charcoal were to be profitably manufactured and marketed from trees normally burnt during land-clearing. Three mechanised farms have been selected, in the Blue Nile Province, as models for economic analysis as their problems are common to many other mechanised farms in that area (and have probable relevance to other parts of Sudan). The issues raised, however, are too complex and important for the market alone to tackle and institutional changes will be needed if society as a whole and the farms in particular are going to maximise all the benefits from a natural resource which will be freely available in relative abundance for only a few more years.

Land-clearing techniques

The three mechanised farms selected for study are providing essential crops of grain and exportable cash crops from previously under-utilized land resources. These farms are well-organized and efficient, but they are finding it increasingly difficult to meet the high costs of land-clearing. The costs of clearing forest can be set against profits but as part of the profits are obtained from the export of cotton, some of the high land-clearing costs represent a net loss of foreign exchange.

Clearing forest for cultivation on the three farms is a labour-intensive operation. The work is usually contracted- out but is also undertaken by direct hire. Small grass and wood fires are made at the bases of individual trees until they fall, when they are cut into pieces small enough to be manhandled, heaped and burnt. The cost of this operation, including the removal of any unburnt roots, varies from between LS 25-45 per feddan (LS 60-107 per ha) with an average cost of LS 40 per feddan (LS 95 per ha). maintained.

Fuelwood would not be practicable to produce for sale on the three farms studied because of its rapid deterioration and high transport costs per unit of available energy. There are no practical or technical reasons why charcoal, a stable fuel with low transport costs per unit of available energy, should not be made from all the available wood. Charcoal-makers, working on a relatively small scale outside the farm areas, tend to cut down most trees about 30 cm above ground. This was commonly given as a reason for not encouraging charcoal-making on the farms. If charcoal-makers were offered suitable incentives and their activities were controlled by very clear directives, there appears to be no technical reason why the land should not be

cleared to the high standard required for cultivation and at a fraction of the cost of cutting and burning.

Charcoal-makers do not normally cut down Balanites aegyptiaca (Heglig), although its wood is suitable for charcoal, because it produces edible fruits, good timber and keeps its leaves throughout the dry season when shade is most needed. In times of famine, its branches can be cut off for livestock fodder. It was formerly, by law, a protected tree and many country people would like to see that law reintroduced.

Availability of wood resource

The natural vegetation on the three mechanised farms is dominated by savanna trees especially :

Acacia seyal (over 60%)
A. fistula
A. senegal
Combretum hartmannianum
Anogeissus leiocarpus
Balanites aegyptiaca

A. seyal wood is suitable for fuel if used within 2 months of felling: if kept longer, it rapidly decomposes because of insect borers: if converted to charcoal, it can be stored almost indefinitely. The charcoal produced is of excellent quality and this tree is the preferred choice of charcoal-makers. Charcoal made from some trees, including other Acacia species, is not as high a quality as that produced from Acacia seyal but is acceptable, especially as it will nearly always be mixed in with harder charcoal. The other trees occurring in the farm areas can also be used as fuelwood or charcoal and some of them, e.g. Balanites aegyptiaca, can also produce very good construction timber.

Data obtained from trees in sample plots (APPENDIX 4), measured both standing and felled in average stands, due to be cleared in 1985, show higher stacked volume to basal area ratios for A. seyal than for the trees in the plots as a whole which indicates that the proportion of wood utilizable as charcoal from A. seyal is significantly higher than that obtainable from other savanna trees. (See TABLE 6.A)

TABLE 6.A

Comparison per feddan of the total volume/basal area of mixed savanna trees with the volume/basal area of *Acacia seyal* (A.s.)

Farm	Total BA m2	BA A.s. m2	% BA A.s.	Total stacked vol. m3	Stacked Vol. A.s. m3	% vol. A.s.
ASBNACo	1.016	0.542	53	13.5	9.9	73
DAAPCo	1.173	0.913	78	16.5	14.1	85
SEAICo	1.396	0.848	61	15.7	10.2	65

From the sample plots it was ascertained that the resource at the three farms is eminently suitable for conversion into charcoal and that the potential average amount of charcoal obtainable per feddan is likely to be not less than 30 bags of 39 kg weight (see TABLE 6.B)

TABLE 6.B

Sensitivity analysis of estimated production of charcoal per feddan from areas being cleared for cultivation

Farm	lowest No. bags	Medium (1) No. bags	Medium (2) No. bags	Highest No. bags
ASBNACo	24.2	28.2	30.3	35.3
DAAPCo	32.4	33.8	40.5	42.3
SEAICo	31.6	32.4	39.5	40.5

Lowest - lower vol m3 wood x lower conversion (2 bags/m3)
Medium (1) - higher vol m3 wood x lower conversion (2 bags/m3)
Medium (2) - lower vol m3 wood x higher conversion (2.5 bags/m3)
Highest - higher vol m3 wood x higher conversion (2.5 bags/m3)

The costs and benefits of charcoal production in land-clearing

Not far from the Sudanese Egyptian Farm an enterprising farmer has encouraged charcoal-makers to prepare the ground as it would normally be prepared by the clearing contractors. This farmer paid LS 42.00 per feddan (LS 100 per ha) for the land cleared to the standard required for cultivation: supplied bags and water and additionally paid a bonus of LS 1.50 for each bag of charcoal produced. As there is a ready market for charcoal at LS 3.50 per bag at roadside, the cash obtained for the charcoal helped to pay the cost of ground clearing.

It has been noted that clearing costs can be reduced or eliminated by offsetting these against sales of charcoal. Provided that a bag of charcoal, made from wood produced during clearing operations, can be sold for more than its cost of production, the cost per feddan of clearing land will be reduced by this difference times the estimated number of bags of charcoal per feddan. The manufacture of charcoal can thereby benefit the company, by reducing clearing costs and perform an overall service to the national economy by saving foreign exchange.

let (a) equal the value of a bag of charcoal (the selling price of a bag of charcoal at site)

(b) equal the cost of production of a bag of charcoal at site

(c) equal the estimated number of bags of charcoal per feddan

(d) equal the value per feddan of having cleared land

(e) equal the cost per feddan of clearing land

$$\text{The Benefit/Cost ratio} = \frac{(a) \times (c) + (d)}{(b) \times (c) + (e)}$$

The Benefit/Cost ratios for the three farms examined have been calculated for the 1985 programme using an estimated average charcoal yield of 30 bags per feddan (TABLE 6.B), and a recently negotiated price of LS 3.00 per bag (sack extra) with the COR, and the assumption that clearing costs will be incurred at LS 5 per feddan less than the costs for land cleared without charcoal being made. (There is room here for a further reduction in costs).

1. Arab Sudanese Blue Nile Agricultural Co. Ltd.

Area to clear 1985	=	11,000 fd
(a) The selling price of a bag of charcoal at site (value of a bag of charcoal)	=	LS 3.00
(b) Production cost of a bag of charcoal including licence (LS 0.25)	=	LS 2.50
(c) Estimated number of bags of charcoal per feddan	=	30
(d) Value of cleared land	=	LS 25/fd
(e) Cost of clearing land	=	LS 20/fd

$$\text{B/C ratio} = \frac{3.00 \times 30 + 25}{2.50 \times 30 + 20} = \frac{115}{95} = 1.21$$

The farm will save 80% of its clearing costs by introducing charcoal-making, i.e. a saving of LS 220,000.

2. Damazin Agricultural and Animal Production Co. Ltd.

Area to clear 1985	=	22,000 fd
(a) The selling price of a bag of charcoal at site (value of a bag of charcoal)	=	LS 3 0
(b) Cost of production of a bag of charcoal including licence (LS 0.25)	=	LS 2.50
(c) Estimated number of bags of charcoal per feddan	=	30
(d) Value of cleared land	=	LS 40/fd
(e) Cost of clearing land	=	LS 35/fd

$$\text{B/C ratio} = \frac{3.00 \times 30 + 40}{2.50 \times 30 + 35} = \frac{130}{110} = 1.18$$

The farm will save 50% of its clearing costs by introducing charcoal-making. The total cost will be LS 440,000 instead of LS 880,000, a saving of LS 440,000.

3. The Sudanese Egyptian Agricultural Integration Co. Ltd.

Area to clear 1985		=	20,000 fd
(a)	The selling price of a bag of charcoal at site (value of a bag of charcoal)	=	LS 3.00
(b)	Cost of production of a bag of charcoal including licence (LS 0.25)	=	LS 2.50
(c)	Estimated number of bags of charcoal per feddan (see APPENDIX 4)	=	30
(d)	Value of cleared land	=	LS 40/fd
(e)	Costs of clearing land	=	LS 35/fd

$$\text{B/C ratio} = \frac{3.00 \times 30 + 40}{2.50 \times 30 + 35} = \frac{130}{110} = 1.18$$

The farm will save 50% of its clearing costs by introducing charcoal-making. The total cost of clearing 20,000 feddans will be LS 400,000 instead of LS 800,000, a saving of LS 400,000.

The constraints to charcoal production

The question to be asked is: why is so little charcoal made from the trees cleared from the land on the three farms? The land has been leased with no value given to the tree resource, therefore, the forest is regarded as consisting of useless material which costs money to remove. EL FAKI (1985) has calculated that the replacement costs of wood for charcoal using a 10% discount rate is LS 3.72 per bag for establishing a forest with a potential yield of 60 bags of charcoal per feddan. It is suggested that the present low royalty fee of LS 0.25 per bag should continue to be paid for bags of charcoal produced, but a much higher fee of at least LS 3.0 per bag or LS 90 per feddan should be imposed on those farmers or agricultural companies burning trees down in land-clearing operations after a target date has been set. At present the farms have built-in accounts for clearing purposes and the Field Managers normally apply to Head Office for the funds required to pay the labourers or contractors for the costs of clearing the next year's target area. In other words, for a long time clearing land has been an 'institutionalised' factor cost which is expected to be incurred and is allowed for fully in the farm budget.

If payment of resource costs are to be avoided and a reduction of land- clearing costs achieved, four practical considerations will have to be taken into account and settled in order that the manufacture of charcoal can be introduced on the farms as a viable commercial undertaking. These are:

1. **Timing** - the production managers need the land cleared of trees before the start of the intensive discing and sowing operations in June.

2. **Transport** - this may be costly and difficult to obtain.

3. **Liquidity** - The manufacture, and quite often the storage, of charcoal costs money which is not fully recovered until several months after it has been paid out.

4 **Markets** - extra charcoal on the market might fail to find buyers or cause the price to drop to an uneconomic level.

1. Timing Although having land cleared ready by June for seed-sowing is so critical to the farms, top management personnel who keep a tight rein on the accounts, often do not give the field managers the programme needed to start clearing operations until January or February (which is far too late to arrange for a well planned charcoal-making operation). The practical basis for making charcoal from the trees being cleared and burnt would be established if the production managers in the field were to obtain a firm, early decision from their Headquarters as to how much land they should clear in order that charcoal operations can starts in October at the beginning of the dry season. All the charcoal could be sold or taken to storage depots in Damazin before the rainy season commences in June and the roads between the farms and Damazin become impassable. Charcoal-making as part of the land- clearing exercise will undoubtedly involve more time and managerial skill than the organisation of a straightforward cut and burn operation. These facts should be recognised by top management and it would probably be worthwhile paying a bonus to field staff prepared to maximise charcoal production and thus lower farm costs.

2. Transport There is sometimes a difficulty in obtaining transport because of fuel shortages, but generally transport can be hired at very reasonable rates provided that enough time is given to the carrier to arrange return loads. A survey of the available means of transport for charcoal (APPENDIX 10) indicates that the most practical, though not the cheapest) transport for journeys between the farms and Damazin is by lorry containing approximately 200 bags. The most economical and practical means of transport from the farms direct to Khartoum is by truck and trailer containing approximately 650 bags. The most economical and practical means of transporting charcoal to Port Sudan for export is by rail from Damazin. There is a special lower rate for entire train loads of 16 trucks to Port Sudan which would be well worth arranging if an overseas order for charcoal becomes available.

3. Liquidity The problem of finding the money with which to pay charcoal-makers in advance for their production and to allow for the interest lost on the value of charcoal stored before sale is a fairly simple one if the companies make charcoal with direct

labour. The expected savings, at least 50%, on land clearing costs, will convince any good accountant that even with the present high prevailing interest rates, they should release enough money early enough in the season (October) to allow the managers to clear the land most cost-effectively. One of the agricultural companies has decided to start charcoal-making and clearing a demonstration area of 1,000 feddans (420 ha) on their farm with direct labour to obtain accurate costings for its own use in budgeting. The problem of finding sufficient funds is not quite so easy where the companies rely exclusively on contractors to clear their land for them as the amount of liquidity required for clearing and charcoal-making is about 50% higher than that required for clearing and burning. A number of contractors interviewed said that they would make charcoal if they could get their contract at the start of the dry season and find sufficient capital to get the land-clearing/charcoal-making operation under way for the first two months, when outlay is highest and returns are at a minimum. The amount of money required in advance for operations covering 5,000-10,000 feddans (2,100-4,200 ha) would not need to be more than LS 20,000 to give the necessary stimulus to the contractor. It would be enough for the agricultural companies to issue a letter to the contractor's bank manager showing that a contract had been awarded to him for a stipulated sum of money, to be paid in instalments, as the work was completed.

The companies preferring to get the clearing and charcoal-making done with contractors would not be able to make as much savings on costs as those using direct labour but they would find it comparatively easy to negotiate a lower price for clearing and at the very least they should be able to save the expected increase in the next year's costs by holding the figure down to its present level.

4. Markets EL FAKI (1985) has shown that charcoal is easy to sell at high prices during February-March and then prices fall rapidly during April-May as the charcoal operators try to unload their charcoal before the rainy season gets under way. Prices start to rise again from July onwards as supplies of stored charcoal become scarcer, and do not fall until the start of the new season in October-November. Serious consideration must be given to the possibility that extra charcoal finding its way on to the market might fail to find buyers or might cause the price to drop to uneconomic levels. Ibid. (1985) in a study of the supply/demand balance for the Central Region, i.e. Blue Nile, Gezira and Khartoum Provinces, to the year 2000 has calculated that the Blue Nile Province in 1983 supplied a recorded 46% of the demand for charcoal, i.e. 3,150,966 bags. If this percentage of projected effective demand were maintained until the year 2000, the supply of charcoal from the Blue Nile Province would need to be raised as follows:

Year	No. bags of charcoal needed to retain market share
1985	3,403,000
1990	4,189,000
1995	5,167,000
2000	6,387,000

If the supplies of charcoal from outside the Blue Nile Province were to be retained at their present level (which is extremely doubtful) and the 1983 supply of 3,150,966 bags from the Blue Nile Province were maintained, there will be an increasing deficit in supply to the Central Region which is shown in TABLE 6.C.

TABLE 6.C

Charcoal demand (Central Region)
Charcoal supply from existing sources as % of demand
and charcoal deficit

Year	Central Region consumption bags	Supply as % demand	Deficit bags charcoal
1983	6,812,264	100	
1985	7,397,745	92	585,481
1986	7,718,265	88	906,000
1990	9,105,719	75	2,293,455
1995	11,232,526	61	4,420,262
2000	13,884,560	49	7,072,296

Adapted from EL FAKI (1985)

The three farms surveyed are highly unlikely to find any difficulty in selling charcoal on the existing market in 1985 as there is an estimated projected shortfall in supply from the Blue Nile Province of over 585,000 bags (see TABLE 6.D). The estimated potential production from the three farms is 1,590,000 bags but at the time of writing cutting and burning the forest is already in full swing and the amount of charcoal that can be made from the remaining resource in the time available is consequently limited. There is unlikely to be a marketing problem in 1986 as a forecasted decrease in supply from the Eastern Region and new markets envisaged for refugees could be taken up by supplies from the Blue Nile Province.

TABLE 6.D

The potential for charcoal production and marketing prospects from the planned programme of forest clearance from the three farms in 1984/5 and 1985/6

Year	Planned Area to clear fd	Potential* bags charcoal available	Estimated market deficit bags	Estimated production excess bags
1984/5	53,000	1,590,000	585,000	1,060,500
1985/6	85,000	2,550,000	906,000	1,644,000

* Based on sample plot data (see APPENDIX 4)

The refugees need for charcoal

Whilst this report was being written refugees were entering the Eastern Sudan in large numbers from Ethiopia and the NEA were asked by the UNHCR to suggest ways of providing fuel for the camps. COUGH (1985) looked at various sources of fuel and estimated the requirements of 400,000 refugees in Eastern Sudan as around 1,600,000 bags of charcoal per year. The consultant was asked to investigate the possibilities of obtaining this extra supply of charcoal without upsetting the existing market (full details in APPENDIX 11). It was apparent that it would be in the national interest for the charcoal to be produced from the farms. The managers of the agricultural companies were consulted to find out whether they were able to stop the land-clearing by cut and burn and commence charcoal making immediately. All three managers readily agreed to help implement a plan to try to rescue as much charcoal as possible from the 1984/5 land-clearing programme and to arrange to maximise charcoal production from all future clearing operations.

The potential demand for charcoal

The immediate marketing problem for the three farms has apparently been solved but problems will arise if, as recommended, clearing forest for approved farms by charcoal-makers becomes so commercially attractive that other farmers adopt the practice. It is not known how much land in total will be cleared annually in the Province from June 1986 - 1990, but it is likely to be not less than 250,000 feddans (105,000 ha) which could produce approximately 7,500,000 bags of charcoal. Allowing for an increased domestic market share for farms in the Blue Nile Province of approximately 900,000 bags for Khartoum and the urban areas of the Central Region and the estimated requirements of 400,000 refugees in the Eastern Region

of 1,600,000 bags, this would leave an estimated surplus in excess of demand of 5,000,000 bags which could be available for export.

Provided that the recommendations of this report are followed, a great deal of extra charcoal will be manufactured (from trees on land destined to be cleared and burnt over the next 5-6 years) in excess of the estimated demand and which would be in the interests of the economy to offer for export. There has been insufficient time on this consultancy to study all the implications of such a radical step, but the indications are that an export outlet for charcoal, carefully controlled to ensure it came only from designated areas, should be permitted. Charcoal exports would produce profits for the agricultural industry, revenue (from charcoal licences) for the Regional Administration and what is most important, valuable foreign exchange for the economy as a whole. It is estimated that if 5,000,000 bags (192,000 tons) of charcoal were exported annually to the Near East from 1986 - 1990, it would be worth not less than 100 million dollars US in foreign exchange.

The future supply of charcoal

To ensure that charcoal supplies will be available in the future (beyond 1990) early action needs to be taken to reserve some more forest land as a resource base. It is apparent that if the market could be supplied with charcoal (at present lost) from essential land-clearing operations, this would leave more time for planning for enough forest reserves to take over future charcoal production. It is reasonable to assume that the decline in charcoal production from the Eastern Region will continue because of resource depletion. This decline should be encouraged in order to give time for the forests in the more arid zones of that Region to recover. In addition, some of the old mechanised schemes, in the low rainfall areas (less than 500 mm/year) above the 13th parallel, should be taken out of farming, disced and sown with suitable tree seeds and made into forest reserves.

7 - THE ECONOMICS OF FORESTRY AND SHELTERBELTS ON MECHANISED FARMS

Meeting the future energy needs of the farms

This chapter will be concerned with: where, and how much, natural forest should be left to meet the future energy needs of the farms and what management, if any, is required. It is apparent that the farms will eventually run short of fuelwood and charcoal for their own use unless provision is made, at the time of clearance, for supplies to become available once all clearing has ceased. The responsibility of providing the raw material for maintaining supplies of charcoal to the urban market will eventually have to pass to those controlling land mainly dedicated to growing trees, e.g. forest reserves managed by the Forest Administration or Regional Governments. The suggested policy to be adopted by the farms should be that they will ensure that sufficient fuelwood, charcoal and building poles will be available for the needs of their management and labour in the future.

Trees are needed on the farms to provide fuel and also shade for labour whilst working in the field. It would appear to be reasonable to encourage the growth of natural evergreen trees in belts, e.g. Balanites aegyptiaca, and to enrich further with fast-growing trees including exotic species, e.g. Albizia lebbek, Azadirachta indica, Cassia siamea to provide a renewable fuel supply and possible additional income for the future. With the present and likely future shortage of diesel fuel for generators, it might be prudent to plan for the provision of wood or charcoal to fuel producer gas units for generating electricity for the staff quarters and workshops at the different project sites. The most interesting and contentious suggestion is that belts of trees should be left at regular intervals within the farms to protect the soil against wind erosion, to increase crop production as well as to provide fuel for the future.

The advantages of shelterbelts

It is in discussion of the advantages and disadvantages to the farms of leaving shelterbelts that contention occurs because of the difficulty in forecasting the actual costs and benefits expected from any particular course of action. The costs incurred are for the initial survey and subsequent management of the shelterbelts, plus production foregone because of the presence of the shelterbelts. The benefits are the increased crop production (incremental because of shelter) and the value of poles and charcoal from the shelterbelts under a managed forestry system. EL NOUR (1985) has estimated that the average increment of Acacia seyal in the Blue Nile Province is 1 m3 of stacked wood /feddan /year (2.4 m3 of stacked wood/ha/year). This is equivalent to an

estimated production of 2 to 2.5 bags of charcoal/year (5 to 6 bags of charcoal/ha/year). It is felt that with enrichment planting of fast-growing species under standard shade trees, these increments for charcoal could be maintained on a 10 year rotation. Obviously, it is difficult to equate in money terms the annual net benefits from the sale of 2 to 2.5 (5 to 6) bags of charcoal with the cash received from 4 (10) sacks of sorghum. It is, however, when all benefits, including the other less easily quantifiable and/or non-marketable benefits, are considered that the case for retaining shelterbelts becomes very strong. For example, if there were no shade trees for the workers, then management would have to provide grass huts for them to rest or eat their food in, or be faced with a very disgruntled work force. Shade is essential for those working in the fields and shelterbelts could provide for this need in a most cost-effective way.

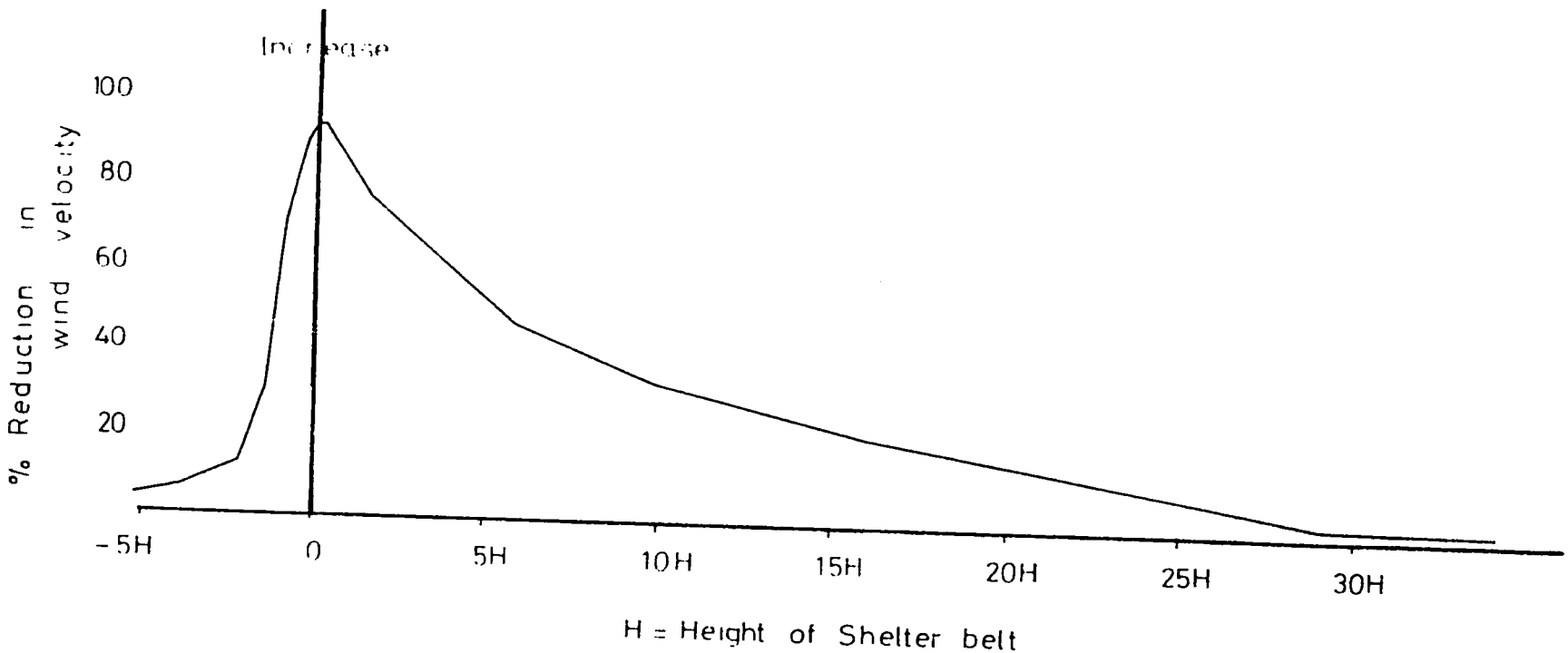
(a) The effect of shelterbelts on wind erosion

Experiments in other countries have clearly demonstrated that shelterbelts aid erosion control by decreasing surface wind shear stresses and by trapping moving soil. The most important variables to control are the porosity, the height and the length of the shelterbelts. When surfaces are highly erodable and wind speeds above the threshold velocity necessary to initiate particle movement, the erosion rate is proportional to the cube of the wind speed. Thus even modest reductions in wind speed can cause major reductions in erosion. Porous shelterbelts are better than solid barriers. Shelterbelts with 50% porosity have significant influences on wind velocity to 20-25H with only a slight reduction in degree (see DIAGRAM 1). The winds over the flat lands of the Blue Nile Province blow mainly from the South but occasionally from the North from whence they carry dust and are strongly desiccating. A series of shelterbelts, bordering existing and planned East/West roads at 2 km intervals, would offer protection, both North and South extending to 20 times the height (H) of the trees, to field crops.

Probably the most effective shelterbelts in the farms would be provided by a coppice with standards system. The standards would consist of trees capable of reaching sufficient height and age to form an over-storey to a faster growing under-storey of trees and bushes which could be cut on a regular short rotation (coppiced) for fuel and/or used for the production of gum arabic (see DIAGRAMS 2 and 3).

DIAGRAM 1.

EFFECT ON WIND SPEED



PLAN OF SHELTER BELT

DIAGRAM 2

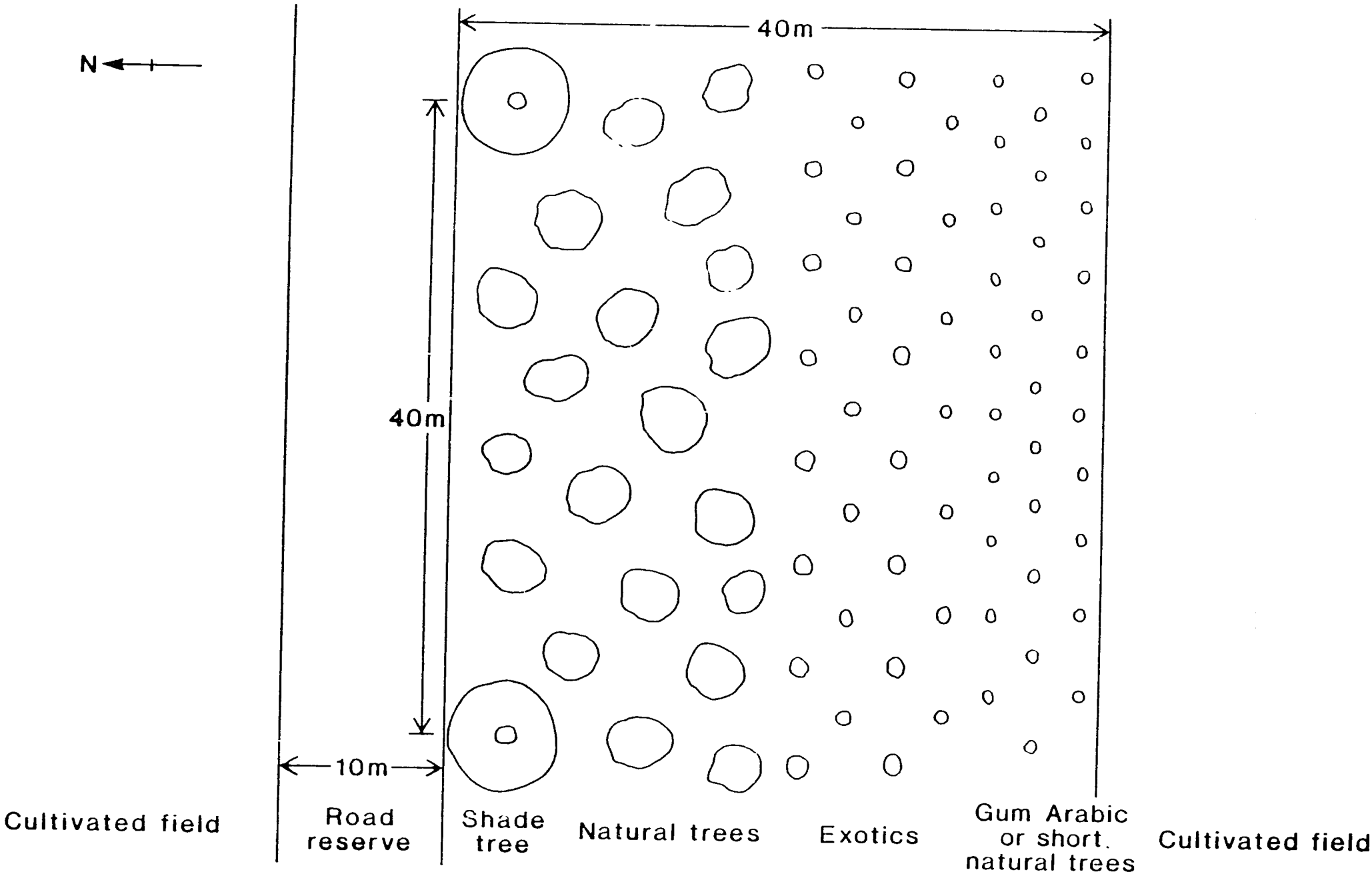


DIAGRAM 3

SECTION THROUGH SHELTER BELT

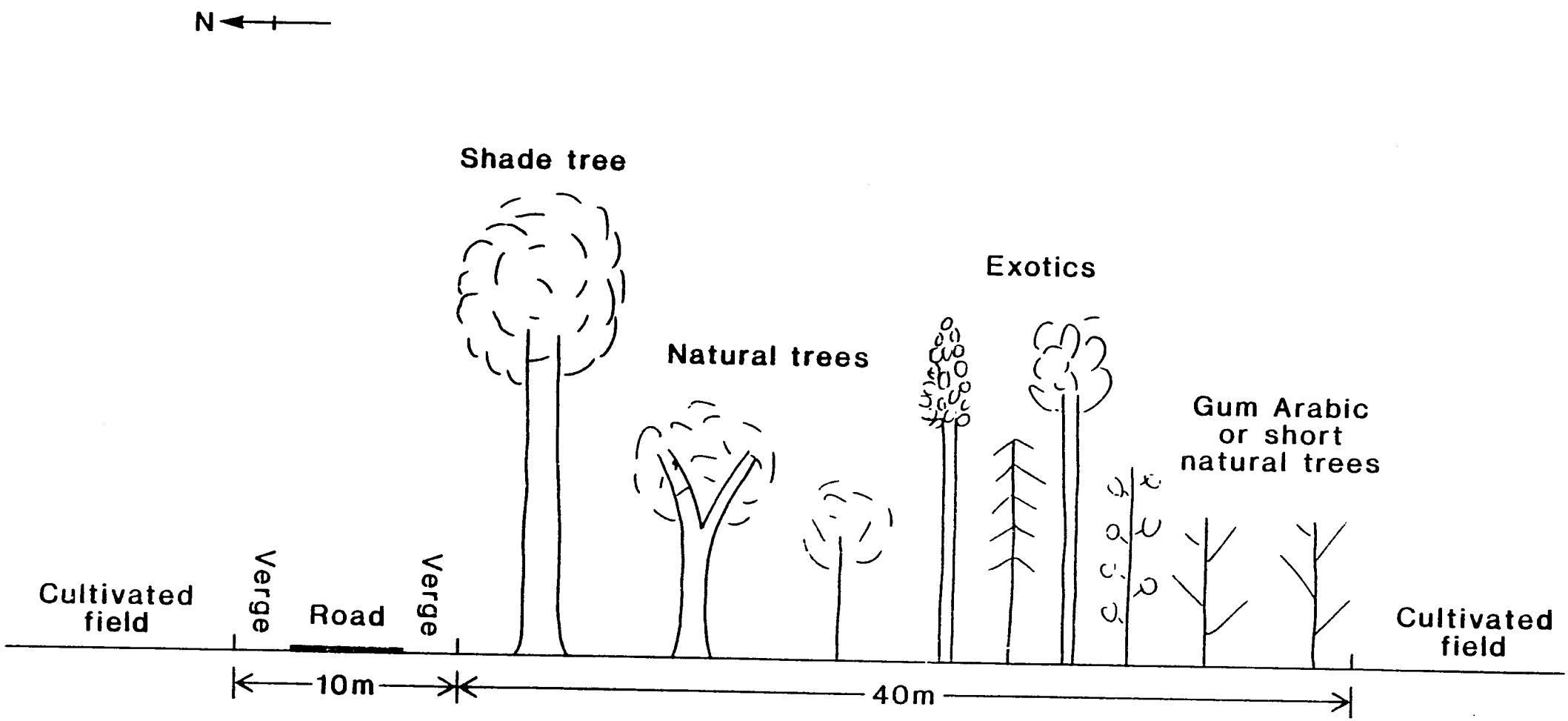
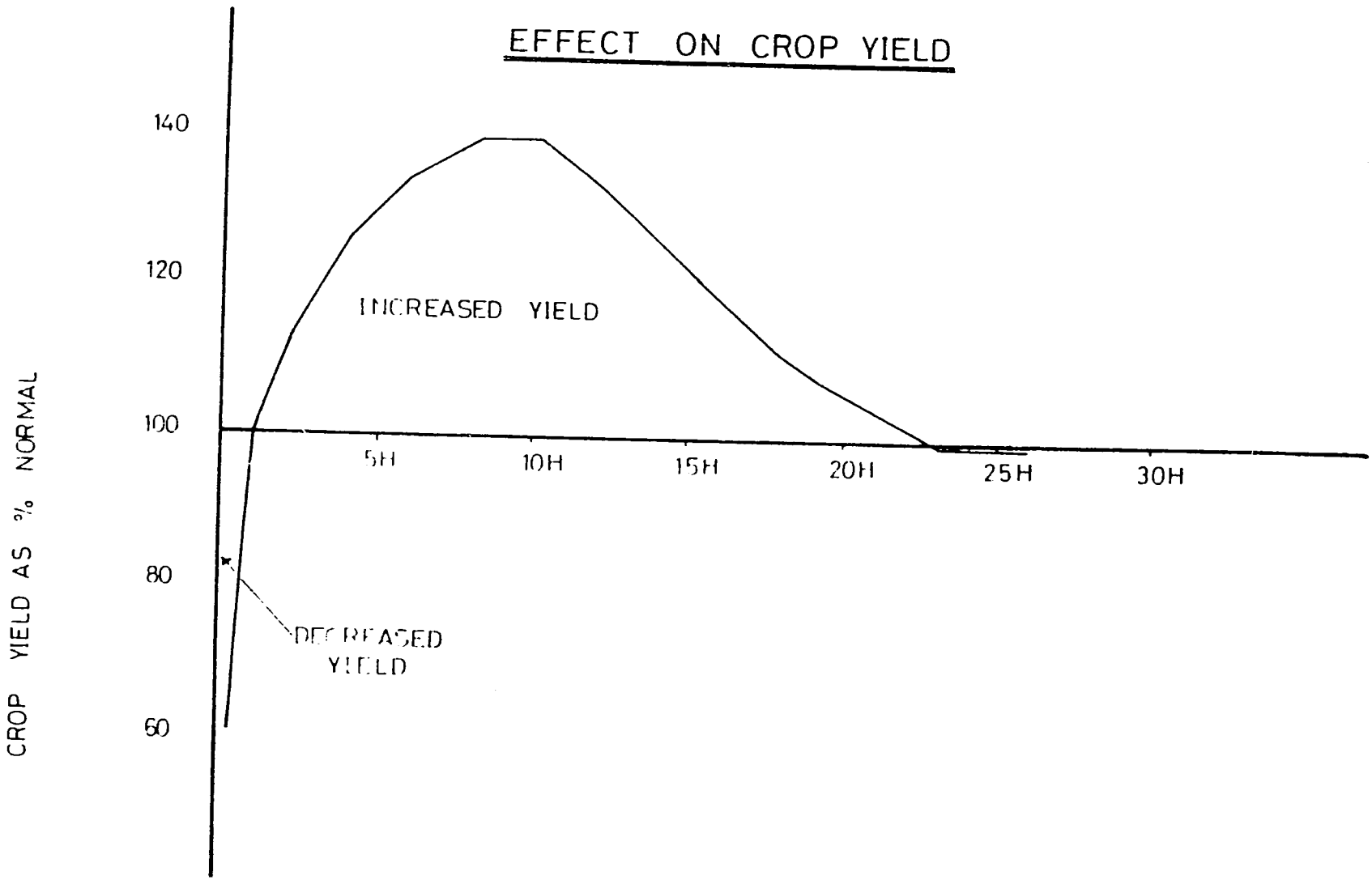


DIAGRAM 4


EFFECT ON CROP YIELD
CROP YIELD AS % NORMAL
140
120
100
80
60
INCREASED YIELD
DECREASED YIELD
5H
10H
15H
20H
25H
30H

(b) The effects of shelterbelts on crop production

The beneficial and other effects of shelter on crop production are usually attributable to a reduction in the rate of evapo-transpiration from the leaves of plants, caused by reduced wind speeds and turbulence and a consequent higher humidity. Plant growth and yields are usually greater in sheltered areas indicating that the net assimilation of carbon dioxide has increased. Depending upon climate, increases in crop yields of more than 20% have been commonly recorded in continental sheltered zones (see DIAGRAM 4).

SKIDMORE (1976) makes the point that as growth and yield within 1-2 shelterbelt height (H) is reduced because of competition for light, water and nutrients, and the land itself is unavailable for crop production, the net effect on yields may often be quite small or negligible unless the timber production is also included, in which case there is little doubt that yields are greater.

Not much information is available on the effects of shelterbelts on crop production in rainfed agricultural schemes in the tropics. An experiment carried out at Yambawa in Northern Nigeria (rainfall 550 mm/year), between November 1980 and April 1981 indicated that millet grain yields of 123.6% were obtained from crops planted between Eucalyptus camaldulensis shelterbelts 8 m tall by 3 m apart (AZRS [1981])

A similar experiment carried out in Niger between 1975 and 1979 produced yields of 129% of millet grown between Azadirachta indica (Neem) planted in 100 m rows at 4 m x 4 m. The beneficial effects were noticeable to 16H down-wind. [BOGNETTEAU-VERLINDEN (1980)]

The financial benefits attributable to shelterbelts on the farms can be calculated theoretically using the following assumed parameters.

H	=	height of shelterbelt	10 m
L	=	length " "	2,000 m
W	=	width " "	40 m
A	=	area of field L x L	400 ha
a	=	area of shelterbelt L x W	8 ha
p	=	protected area L x 20H x 2	80 ha
y	=	yield/sorghum unprotected/ha	10 bags
z	=	yield/sorghum protected area/ha	10 to 12 bags
c	=	yield of charcoal/ha	5 to 6 bags

Price of sorghum	LS 100 per bag
Price of charcoal	LS 10 per bag

Calculation of increased annual production per 400 hectare field from having shelterbelts on each East/West road.

Worst case:

No increase in crop yield from presence of shelterbelts

Yield of sorghum with shelterbelt	3,920 bags
Yield of charcoal from shelterbelt	40 bags
(Yield of sorghum without shelterbelt)	4,000 bags
Loss of gross income = LS 8,800 - 400	(LS 7,600)

Best case

20% increase in crop yield from presence of shelterbelts

Yield of sorghum with shelterbelt 312 ha @ 10	3,120 bags
80 ha @ 12	960 bags
Yield of charcoal from shelterbelt 8 ha @ 5	40 bags
(Yield of sorghum without shelterbelt)	(4,000 bags)
Gain in gross income: LS 8,000 sorghum	
LS 400 charcoal	LS 8,400

Medium case

10% increase in crop yield from presence of shelterbelts

Yield of sorghum with shelterbelt 312 ha @ 10	3,120 bags
80 ha @ 11	880 bags
Yield of charcoal from shelterbelt 8 ha @ 5	40 bags
(Yield of sorghum without shelterbelt)	(4,000 bags)
Gain in gross income (charcoal only)	LS 400

If the medium case is taken as most likely, the value of sorghum lost from the area of ground occupied by 8 hectares of shelterbelt is exactly balanced by the increased crop production from 80 hectares of protected land, and the annual increment of fuel is a bonus.

The theoretical benefits of charcoal which will be available from shelterbelts planned for the DAAPCo farm (see CHAPTER 5 and APPENDIX 5) have been calculated as follows:

total area of shelterbelts 40 m wide on South side of East/West roads	= 584 ha
total area of shelterbelts 40 m wide on all boundaries not covered by the above	= 248 ha
TOTAL	= 832 ha

832 ha of shelterbelts would, if enriched, produce 2.4 m3 of

wood/ha/year, equivalent to 4,000 to 5,000 bags of charcoal worth LS 40,000 to 50,000. This production does not include an estimated 9,000 bags of charcoal worth LS 90,000 which could be produced from estimated 1,400 ha of land along rivers and other non-cultivated areas if managed on a 10 year rotation.

The disadvantages of shelterbelts

The disadvantages of shelterbelts are that they:

(a) provide nesting sites and roosting places for birds which might devour the grain;

(b) hinder aerial spraying of herbicides and insecticides;

(c) harbour harmful weeds;

(d) hinder the movement of heavy mechanical equipment into the fields and prevent the farm managers seeing from the roads what is happening in the fields.

(e) may increase the ground temperatures to the leeward side of the shelterbelts.

The argument that shelterbelts encourage birds who devour grain does not stand in the farms in question, as of the two main seed-eating birds causing damage in Sudan, the first, the Sudan Dioch, (*Quelea quelea*) does not occur in the farms in any significant numbers; and the second, a dove (*Streptopelia* spp.) is causing damage only at the Sudanese Egyptian Farm on the eastern side of the Nile. There is no evidence at all that the absence of belts will stop depredations of the doves because they fly in from their nesting/roosting sites on the banks of the Nile and they do not nest or roost on the farms. At present, the dove population is controlled by the Ministry of Agriculture's Crop Protection Service which sprays known roosting areas along the banks of the river with Wiltox. This is an effective but potentially dangerous method of control as all birds coming into contact with the chemical are killed and local people are selecting some of them to eat. It might be better to arrange for the birds to be shot or trapped as they could then be used safely for food.

There is reason to suppose that closely spaced shelterbelts would hinder aerial spraying, but that belts left or planted at wide enough intervals would minimise any danger or difficulty.

The weeds that cause most trouble to the farms are the late-maturing species which do not occur in the natural forest and tend to be associated with cultivated land. Shelterbelts harbour herbaceous plants but these are mostly of species which grow in the natural forest and tend to be early maturing, and any spread to the crops is of little consequence as they can be dealt with

easily by normal cultural operations. Many of the shelterbelts seen were too narrow and too open to provide enough shade to effectively control weeds. The reason for their light stocking was partly late burning (November - December) in the belts to control weeds. This practice effectively controls young tree growth too.

Shelterbelts left at each side of a road hinder the movement of heavy mechanical equipment into the fields and make it difficult for the managerial staff to see the crops from the roads. Leaving shelterbelts to one side of the road only, would reduce the practical difficulties of this problem.

A reduction of wind speed might have the effect of increasing temperatures but because relative humidity will also be higher under sheltered conditions, transpiration will be slowed down and growth rates enhanced.

The agreed overall benefits from shelterbelts

All the points for and against shelterbelts have been discussed with the management personnel who have agreed that although the case against shelterbelts is weak, the points made hitherto for retaining shelterbelts have not been particularly convincing from the commercial standpoint. In the absence of hard facts about the advantages of shelterbelts, and with the lack of appropriate clauses in the leases to provide for them, it is not surprising that the belts have been regarded as a nuisance from some managerial positions.

There was no support for leaving thinly stocked shelterbelts of natural trees as protection for crops *per se*, it was however agreed that well-stocked, thicker shelterbelts would be an improvement on those that exist at present, by producing fuel for the future and might well serve to increase crop production: additional benefits from shelterbelts would be that they would assist in preventing erosion, particularly on sandy loam soils, and would improve the general environment and appearance of the farms, especially if some evergreen and fruiting varieties of trees were to be introduced. The overall consensus was that the advantages of having well-managed shelterbelts definitely outweigh their disadvantages.

Improving the effectiveness of shelterbelts

The indigenous trees are well adapted to the conditions but apart from *Balanites aegyptiaca* they are normally deciduous during the dry season. The trees are thus able to withstand the long dry period but do not produce effective shade at the time it is most needed. It is suggested that the shelterbelts should be augmented with species which would provide shade for comfort and also help to suppress ground vegetation. This might well be done

by the adoption of a multi-storey shelterbelt system with Balanites and other selected evergreen standard trees growing above other trees which could be grown for poles, fuel or gum (see DIAGRAMS 2 & 3). The standard trees would maintain shade and help to ensure the continuing survival of the shelterbelt by mothering new seedlings to augment the regrowth of coppice. It is suggested that the under-storey could be cut on a 10 year plan together with most of the naturally occurring trees, e.g. Acacia seyal, A. fistula and Combretum hartmannianum. A discussion with local foresters has identified some trees which could well be tried with success.

Standards to be planted at 40 m intervals in shelterbelts and along perimeters

Cassia siamea	This can grow as a standard but coppices extremely well to provide very good charcoal. It is found in the Damazin area and produces plenty of seed.
C. sieberiana	This produces spectacular flowers and would, therefore, be a good marker tree.
Albizia lebbek	This also grows well in the Damazin area and produces good timber (plenty of seed is available
Tamarindus indica	Appears to grow well on sandy soils in in the Blue Nile area.
Balanites aegyptiaca	This should be produced in the nursery for planting in the shelterbelts and perimeters where none exists at present. It is practically certain that this tree will do well as timber in addition to fuel.
Azadirachta indica	This can be grown as coppice. It produces very good poles and fuel and is almost immune to termite attack.

Other species which should be tried out on a small-scale are:

Casuarina)	
)	Selected species only
Eucalyptus)	

Under-storey trees to be cut on a 10 year rotation for fuel or utilised for gum production

Acacia mellifera	Grows well and produces very good charcoal. It is particularly recommended to augment the under-storey trees on the perimeter belts.
A. senegal (gum arabic)	This could be grown in the shelterbelts (next to the roads). 10 m width of the belt could be devoted to this species. One farm is particularly keen on growing this tree for gum, in this case the trees could be felled and replanted on a 20 year rotation.
Albizia amara	This evergreen tree can be used for firewood, charcoal and building poles, additionally, the bark is used for tanning.
Azadirachta indica	Coppices well and is good for poles and charcoal.
Bauhinia rufescens	Useful for both firewood and charcoal.
Cassia siamea	Coppices well, is good for fuelwood and charcoal.

The criteria for retaining and planting trees on the farms

It is felt that a multi-use concept is the most appropriate one to apply to all areas of land to be left under trees. For example, trees managed for fuel and possibly other products such as gum and fruits, could, at the same time, provide soil protection, increased crop production and shade for people and animals. The advantages attributable to trees left in the farmlands were discussed with the management of the three farms and acceptably practical criteria formulated for deciding where natural forest should be left and enriched where necessary. These are as follows:

	Location		Min. width m
1.	Rivers, each side	-	40
2.	Nomad/stock routes	-	400
3.	Farm perimeters	-	40
4.	Areas of low agricultural productivity, low-lying land, etc.	-	as found
5.	Shelterbelts at the South side of every road running East-West	-	40
6.	Shade trees at every work camp and living quarter area	-	where necessary

1. It was agreed that trees helped to bind the soil along river banks and that in areas where great fluctuation in water levels occur, much wider strips (than 40 m) of forest would be left because of the danger of erosion during the rainy season.

2. The Nomad/stock routes should form part of a pattern throughout the region and must be properly planned on a national scale. The minimum width of 400 metres should be interspersed with wider areas approximately 1 km square at about 20 km intervals along the designated routes. These resting spots should be at reasonable watering places for the cattle. Where a nomad/stock route follows a water source, 400 m each side of the river should be left.

3. 40 metre wide shelterbelts of forest should be left around all farm perimeters. Within these belts large shade trees (marker trees) should be planted, unless already existing, at 40 m intervals.

4. It is difficult to quantify the amount of land of low productivity which should be left as it will vary from farm to farm. It is suggested that suitable marker trees should be planted at 40 m intervals along the margins and that these areas could be reserved for wildlife and amenity.

5. The main problems with the existing shelterbelts are that they are usually too poorly stocked to serve as windbreaks or as sources of fuel, and serve only to obstruct farm operations. One reason for the poor stocking was that the farmers sometimes burn the shelterbelts in November/December to destroy weeds but this practice also destroys the young trees that germinated from seeds during the rains with the result that no regeneration is possible. It is suggested that burning during the early part of the rainy season in May/June would be almost as effective and not so likely to damage young trees. Shelterbelts at the South side of each East-West road would amount to 2% of the farm area but would be much less disturbing to farm operations than is the present practice in some farms of leaving narrow shelterbelts at every 500 m and on each side of the roads. In particular, aerial spraying would not be affected and access to and vision of fields would be obtainable from all roads (including East-West roads one side only).

It is extremely difficult to calculate the full financial worth of a programme of leaving trees in the farms because many of the costs and benefits are unquantifiable and unmarketable. It is considered that having trees along rivers, on poor low-lying land, around nomad/stock routes and to provide shade in the camps are as necessary for the farms as their seed and water supplies.

It was gratifying to note that in advance of any specific recommendations in this report, one company has started to leave shelterbelts this year, and another has stopped the removal of shelterbelts and has instructed the farm managers that belts

should be left in all future clearing operations. There are very good immediate practical reasons for leaving trees on land being cleared for farming, and reasonable expectations of obtaining better returns of fuelwood and crop production in the future if shelterbelts are sited and managed well. It is hoped that with support from SREP and the Forest Administration, these more productive practices will be maintained on the farms and eventually spread to most of the mechanised rain-fed farming sector.

APPENDIX 1

CONSULTANCY MECHANISED FARMING
TERMS OF REFERENCE - (revised February 1985)

1. OBJECTIVES

   a) Formulate study to evaluate the economic costs and benefits of agriculture/forestry integration on land designated for clearing under a large mechanised farming scheme.

   b) Evaluate results of study and produce recommendations for forestry and energy activities within the Sudan Mechanised Farming Sector.

2. ACTIVITIES/TASKS

   1) Meet with counterparts and representatives of the Mechanised Farming Corporation to identify a planned large agricultural scheme to be studied (minimum 100,000 feddans).

   2) Tour the scheme area to assess general physical and administrative conditions, spending 5 weeks in the field collecting data.

   3) Analyse various strategies of selective land clearing which would provide for the sustained presence of woodlots, shelterbelts, shade plantings and other forest forms beneficial to agricultural production.

   4) Assess the options available for the utilization of the forest resource to be cut, to ascertain the most efficient modes for its sustained utilization (poles, fuelwood, charcoal from earth kilns, charcoal from other kilns, other pyrolysis products).

   5) Visit other mechanised farming schemes to collect comparative data on crop yields, soil changes over time and other factors required for the appraisal of costs and benefits of agriculture/forestry integration in the surveyed area.

   6) Evaluate field studies and produce final report.

3. OUTPUT

a) Scope of work and implementation plan for study (with timetable).

b) Final report based on study results, with specific recommendations for technically and economically feasible methods of agriculture/forestry integration within mechanised farming schemes.

c) Public presentation of results.

4. TIMETABLE

a) January-February 1985 - field work.

b) March-April 1985 - complete final report.

5. COUNTERPART

Hanafi El Obeid.

APPENDIX 2

ITINERARY

January 1985

9 Left Oxford arrived Khartoum

10 Meeting with SREP staff

11 Planning the work programme

12 Forestry Administration & Green Belt

13 Meeting Mechanised Farming Corporation Head of Engineering Administration

14 Meeting with Executives of Agriculture Companies

15 Meeting Managing Director Mechanised Farming Corporation

16 Meeting German Embassy & US Embassy staff

17 Left Khartoum arrived Damazin by air. Meeting Executive Agricultural Companies

18 Left Damazin arrived Abu Dom HQ of Damazin Agricultural & Animal Production Co. Ltd. (DAAPCo)

19 Left Abu Dom arrived Damazin

20 Visited Sudanese Egyptian Agricultural Integration Co. Ltd (SEAICo)

21 Left Damazin arrived Abugomai

22 Left Abugomai arrived Damazin - left Damazin arrived Khartoum by air - Visited Blue Nile Agricultural Co-operative Project

23 Discussion SREP Chief of Party and Forestry Administration

24 Meeting Executive Manager DAAPCo

25 Visited Khartoum Green Belt

26 Left Khartoum arrived Fau Rahad Corporation - Discussion with Minister of Natural Resources at Wad Medani

27 Left Fau arrived Gedaref CARE Project

28 Left Gedaref arrived Kassala - discussion with Director of Natural Resources

29 Left Kassala arrived Gedaref visited Rawashda Forest Reserve

30 Left Gedaref arrived Fau visited CARE and Finnish projects

31 Left Fau arrived Khartoum

February 1985

1 Khartoum

2 Meeting Director Forestry Administration

3 Meeting USAID and Ministry of Agriculture

4 Meeting General Manager Arab Sudanese Blue Nile Agriculture Co. Ltd. (ASBNACO)

5 Meeting with relevant bodies

6 Meeting with relevant bodies

7 Khartoum meeting with relevant bodies

8 Khartoum meeting with relevant bodies

9 Left Khartoum arrived Sennar

10 Left Sennar arrived Damazin

11 Left Damazin arrived Agadi field HQ of ASBNACo. - established sample plots

12 Left Agadi arrived Abu Dom field HQ of DAAPCo

13 Established sample plots

14 Left Abu Dom arrived Agadi

15 Left Agadi arrived Damazin

16 Left Damazin arrived field HQ of SEAICo

17 Left SEAICo arrived Damazin - established sample plots

18 Writing draft report & collecting data

19 Visited nurseries Roseires and Damazin

20 Writing draft report & collecting data

21 Writing draft report & collecting data

22 SREP Chief of Party arrived

23 Visited SEAICo field HQ

24 Left Damazin arrived Abu Dom

25 Left Abu Dom arrived Damazin - SREP Chief of Party left for Khartoum by air

26 Writing draft report & collecting data

27 " " " " " "

28 " " " " " "

March 1985

1 Left Damazin arrived Dinder

2 Left Dinder arrived Sennar

3 Left Sennar arrived Khartoum

4 Khartoum meeting & report

5 Khartoum meeting & report

6 Seminar for SREP, USAID & NEA staff

7 Khartoum meeting & report

8 " " " "

9 " " " "

10 " " " "

11 " " " "

12 " " " "

13 " " & finish.

APPENDIX 3

PEOPLE CONTACTED
(Not in order of precedence)

Dr El Tahir Ismail Harbi	Head of Engineering Administration, M.F.C., Khartoum
Dr Richard T Marks	'Fuelwood development for energy' FAO, Khartoum
Osman Abdalla Arifi	Green Belt, Forestry Administration, Khartoum
Haider Mustafa	Green Belt Western Section, Forestry Administration, Khartoum
Dr El Tayeb Idris Eisa	Co-ordinator SREP & Director, Energy Research, Khartoum
Gaffar El Faki Ali	Assistant Co-ordinator SREP, Head of Technology Development and Dissemination Division RERI, Khartoum
Dr Ahmed Hassan Hood	Renewable Energy Research Institute, Project Leader Charcoal Production, Khartoum
Hamid Mohed Mahmoud	Executive Manager, Damazin Agriculture & Animal Production Co. Ltd., (DAAPCo) Khartoum
Dr Ekkehart Gabelmann	First Secretary (Development Co-operation) Embassy of the Federal Republic of Germany
Mohammed Abbass Abu Hassabu	Regional Director of Mechanised Farming Corporation, Damazin
Ibrahim Mustafa	Deputy General Manager & Agricultural Manager, Sudanese Egyptian Agricultural Integration Co. Ltd., (SEAICo) Damazin
Fadil Ahmen	Production Manager, SEAICo, Damazin
Abdel Marouf A/Rahman	Conservator of Forests, Southern Blue Nile, Damazin
Kamal Mohd. Abdulla	Deputy Provincial Commissioner, Damazin, Blue Nile Province

Omer Mohd. A/Rahman	Site Manager, DAAPCo, Abu Dom
Mohamed El Zanati	Manager of Auditing and Costing, SEAICo, Khartoum
Omer Mohd. Ismail	Commissioner, Blue Nile Province, Damazin
Hassan Abu Haraz	Deputy Director, Damazin Blue Nile Integrated Agricultural Project, Damazin
Awad Ghomein Mohamed	Production Manager, Arab Sudanese Blue Nile Agriculture Co. Ltd (ASBNACo), Agadi & Damazin
Tawfig Hashim Ahmed	Chairman and Managing Director, Mechanised Farming Corporation, Khartoum
Mohamed Yousif Mabrouk	Head, Planning Section, Blue Nile Integrated Agricultural Project, Damazin
Dr Osman Khalifa	Minister, Agriculture & Natural Resources, Central Region, Wad Medani
Yahia I M Bushara	Director, Natural Resources, Central Region, Wad Medani
Tag El Sir H Ahd.	Senior Agricultural Inspector, The Administration of Agriculture Investment, Khartoum
Siddig Abdin Mohd.	Agricultural Manager, Rahad Agriculture Corporation, El Fau
Ahmed El Gouni	Social Officer, Rahad Agriculture Corporation, El Fau
Bader El Din	Forester, I/C Rahad Agriculture Corporation Administration, El Fau
El Tayeb Abed Alla	Conservator of Forests, Gedaref
S Tahir Qadri	Project Manager, CARE, Gedaref
Adam Mohd. Babiker	Assistant Conservator of Forests, CARE, Gedaref
J B Ball	Project Manager, FAO, Khartoum
A Wink	Management Officer, FAO, Khartoum

El Abedrahman Ghorashi	Director, Natural Resources, Eastern Region, Kassala
Roger J Hodgson	Forester, VSO, CARE Project, Abu Rakham
Pekka Parvianen	Project Manager, Forest Technician, Sudan/Finland Forestry Programme, El Fau
Abu Bakhr A Kamil	Director, Forestry Administration, Khartoum
James R Seyler	Regional Forestry Advisor, REDSO/ESA, Nairobi
C Anthony Pryor	Regional Energy Advisor, REDSO/ESA, Nairobi
Dr El Tag Seif El Din	Executive Manager, ASBNACo, Khartoum
Dr El Sheikh El Magzoub	Wood Fuels Combustion, Faculty of Engineering & Arch. University of Khartoum (Lecturer Mechanical Engineering Department)
Dr Bart Lucarelli	Consultant, Energy & Economic Planning, NEA, Khartoum
Salah El Din El Khalifa	General Manager, Sudanese Egyptian Agricultural Integration Co, Khartoum
Moh. Osman Candour	ASBNACo, Agadi
C W N Tapp	CARE, USAID, Khartoum
Hamza Hamoudi	Forester, SREP, Khartoum
Dr Abdel Rahman Shulli	Director General, NEA Khartoum
Dr Abdel Rahim A Belal	NEA, EDI, Khartoum
Marc Daudon	Resident Advisor, NEA, EDI, Khartoum
R Mackian	USAID, Khartoum
Elizabeth S F Martella	Ag. Economist, USAID, Khartoum
Dr Heinz Stephan Rade	Co-ordinator, SEP, Khartoum
Christopher Thorne	Programme Officer UNHCR, Khartoum

Omar Bakhet	Dep. Chief Emergency Unit, UNHCR, Geneva
Hassan Attia	Deputy Commissioner of Refugees, Khartoum
Hassan Ahmed Osman	Eastern Region Commissioner of Refugees, Showak
Fred Cuny	Advisor to Eastern Region COR, Showak
Hassan Mohamed Obaid	Accountant, DAAPCo, Abu Dom
Abu El Gassim	Senior Conservator of Forests, Blue Nile Province, Sennar
Kamal Abdel Moneim	Entrepreneur, Khartoum
R A Plumptre	Department of Forestry, Oxford
F Thompson	Department of Forestry, Oxford
P S Savill	Department of Forestry, Oxford
J Howes	Department of Forestry, Oxford

APPENDIX 4

SAMPLE PLOT DATA FOR CALCULATION OF POTENTIAL CHARCOAL PRODUCTION FROM FOREST CLEARANCE OPERATIONS

1. Arab Sudanese Blue Nile Agricultural Co. Ltd. (ASBNACo)

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 1	60 x 30 m			
Acacia seyal	35	1	0.0097	
	39	1	0.0121	
	75	1	0.0448	
	105	1	0.0887	
		-	------	----
TOTAL *Acacia seyal*		4	0.1543	4.17
		=	======	====
Acacia fistula	46	1	0.0168	
Balanites aegyptiaca	13	1	0.0013	
	27	1	0.0058	
Combretum hartmannianum	10	2	0.0016	
	12	1	0.0013	
	17	1	0.0023	
	18	1	0.0026	
	22	1	0.0039	
	23	1	0.0042	
	29	1	0.0067	
	32	1	0.0081	
	33	1	0.0087	
	35	2	0.0194	
	39	1	0.0121	
	43	1	0.0147	
	44	1	0.0154	
	45	1	0.0161	
	51	1	0.0207	
	54	1	0.0232	
	57	1	0.0259	
	70	1	0.0390	
Lasiosyphon kraussianus	35	1	0.0097	
		--	------	----
TOTAL other spp.		24	0.2593	1.89
		==	======	====
TOTAL PLOT		28	0.4138	6.06
		==	======	====

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 2 30 x 30 m				
Acacia seyal	55	1	0.0241	
	94	1	0.0703	
	112	1	0.0998	
		-	------	----
TOTAL Acacia seyal		3	0.1942	2.20
		=	======	====
Combretum hartmannianum	10	2	0.0016	
	16	3	0.0061	
	24	2	0.0092	
	30	1	0.0072	
	32	3	0.0244	
		--	------	----
TOTAL other sp.		11	0.0485	0.40
		==	======	====
TOTAL PLOT		14	0.2427	2.60
		==	======	====

Stacked volume by Acacia seyal and other species

Stacked dimensions m	Stacked vol. m3	Species	%	Species sta vol. m3
	Plot 1	60 x 30 m		
1.30 x 1.20 x 1.00	1.56	A. seyal	100	1.56
1.20 x 1.10 x 1.30	1.72	"	100	1.72
1.30 x 0.50 x 0.90	0.59	"	100	0.59
1.00 x 1.00 x 1.00	1.00	"	30	0.30
		Others	70	0.70
0.90 x 1.10 x 1.20	1.19	"	100	1.19
	---			---
TOTAL	6.06	A. seyal		4.17
	====	Others*		1.89
				====
	Plot 2	30 x 30 m		
1.10 x 0.80 x 1.00	0.88	A. seyal	100	0.88
1.00 x 1.00 x 1.10	1.10	"	100	1.10
0.70 x 1.10 x 0.80	0.62	"	35	0.22
		Other	65	0.40
	---			---
TOTAL	2.60	A. seyal		2.20
	====	Other**		0.40
				====

* *A. fistula*, *Balanites aegyptiaca*, *Combretum hartmannianum*, *Lasiosyphon kraussianus*

** *Combretum hartmannianum*

Summary of sample plot data per feddan (and hectare)

	Plot 1*		Plot 2		Combined plots	
	fd	ha	fd	ha	fd	ha
Total number of trees	65	(156)	65	(156)	65	(156)
BA of trees m2	0.97	(2.30)	1.13	(2.70)	1.02	(2.43)
BA of Acacia seyal	0.36	(0.86)	0.91	(2.16)	0.54	(1.29)
Stacked vol. wood m3	14.1	(33.7)	12.1	(28.9)	13.5	(32.1)
Stacked vol. A. seyal	9.7	(23.2)	10.3	(24.4)	9.9	(23.6)

* This sample plot originally consisted of two adjacent 30 x 30 m plots. The data were combined as one plot when a check in the office, followed by a field visit indicated that it was highly likely that some wood from one of them had been transferred by the woodmen to the other plot where it was included with the wood on that plot and measured.

2. Damazin Agricultural and Animal Production Co. Ltd

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 1 50 x 50 m				
Acacia seyal	37	1	0.0109	
	44	2	0.0308	
	45	1	0.0161	
	49	1	0.0191	
	51	1	0.0207	
	52	2	0.0430	
	55	2	0.0481	
	58	2	0.0536	
	63	1	0.0316	
	64	1	0.0326	
	66	1	0.0347	
	67	1	0.0357	
	68	1	0.0368	
		--	------	----
TOTAL Acacia seyal		17	0.4136	7.27
		==	======	====
Balanites aegyptiaca	53	1	0.0224	
	78	1	0.0484	
	83	1	0.0548	
	93	1	0.0688	
		--	------	----
TOTAL B. aegyptiaca		4	0.1944	2.37
		==	======	====
TOTAL PLOT		21	0.6080	9.64
		==	======	====

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 2	50 x 50 m			
Acacia seyal	10	2	0.0016	
	12	4	0.0046	
	13	4	0.0054	
	14	3	0.0047	
	15	4	0.0072	
	16	3	0.0061	
	17	5	0.0115	
	18	3	0.0077	
	19	1	0.0029	
	20	4	0.0127	
	21	4	0.0140	
	22	8	0.0308	
	23	3	0.0126	
	24	4	0.0183	
	25	9	0.0448	
	26	6	0.0323	
	27	3	0.0174	
	28	6	0.0374	
	29	3	0.0201	
	30	6	0.0430	
	31	3	0.0229	
	32	1	0.0081	
	33	1	0.0087	
	34	2	0.0184	
	35	5	0.0487	
	36	2	0.0206	
	37	1	0.0109	
	38	1	0.0115	
	39	1	0.0121	
	40	2	0.0255	
	41	1	0.0134	
	42	1	0.0140	
	44	1	0.0154	
	45	2	0.0322	
	46	2	0.0337	
	51	1	0.0207	
	52	1	0.0215	
		---	------	----
TOTAL Acacia seyal		110	0.6734	9.60
		===	======	====

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 2 continued				
A. mellifera	10	2	0.0016	
	12	1	0.0011	
	13	1	0.0013	
	15	2	0.0036	
	16	1	0.0020	
	18	1	0.0026	
	20	1	0.0032	
A. senegal	10	2	0.0016	
	12	2	0.0023	
	13	1	0.0013	
	15	1	0.0018	
	17	1	0.0023	
	20	1	0.0032	
	21	1	0.0035	
	23	2	0.0084	
	24	2	0.0092	
	27	1	0.0058	
	28	2	0.0125	
	31	1	0.0076	
	37	1	0.0109	
Balanites aegyptiaca	10	2	0.0016	
	60	1	0.0286	
		---	------	-----
TOTAL other spp.		30	0.1160	0.45
		===	======	=====
TOTAL PLOT		143	0.7894	10.05
		===	======	=====

Stacked volume by Acacia seyal and other species

Stacked dimensions m	Stacked vol. m3	Species	%	Species stacked vol. m3
	Plot 1	50 x 50 m		
1.10 x 1.00 x 1.40	1.54	A. seyal	100	1.54
1.43 x 1.00 x 1.20	1.72	"	100	1.72
1.36 x 1.00 x 1.10	1.50	"	90	1.35
		Other	10	0.15
1.20 x 1.10 x 1.05	1.39	A. seyal	40	0.56
		Other	60	0.83
1.40 x 1.00 x 1.10	1.54	A. seyal	10	0.15
		Other	90	1.39
1.10 x 1.30 x 1.00	1.43	A. seyal	100	1.43
1.20 x 0.70 x 0.62	0.52	"	100	0.52
	---			---
TOTAL	9.64	A. seyal		7.27
	====	Other*		2.37
				====
	Plot 2	50 x 50 m		
1.00 x 0.85 x 1.05	0.89	A. seyal	100	0.89
1.00 x 0.93 x 0.77	0.72	"	100	0.72
0.90 x 0.95 x 1.20	1.03	"	100	1.03
1.00 x 1.10 x 0.82	0.90	"	90	0.81
		Others	10	0.09
1.00 x 1.15 x 0.90	1.04	A. seyal	100	1.04
0.90 x 1 10 x 1 10	1.09	"	100	1.09
0.90 x 1.15 x 0.83	0.86	"	100	0.86
1.04 x 0.99 x 0.90	0.93	"	100	0.93
1.15 x 1.15 x 0.95	1.27	"	90	1.14
		Others	10	0.13
0.99 x 1.20 x 0.95	1.13	A. seyal	80	0.90
		Others	20	0.23
1.05 x 0.90 x 0.20	0.19	A. seyal	100	0.19
	-----			----
TOTAL	10.05	A. seyal		9.60
	=====	Others**		0.45
				====

* *Balanites aegyptiaca*

** *Acacia mellifera*, *A. senegal*, *B. aegyptiaca*

Summary of sample plot data per feddan (and hectare)

	Plot 1		Plot 2		Combined plots	
	fd	ha	fd	ha	fd	ha
Total number of trees	35	(84)	240	(572)	138	(328)
BA of trees m2	1.02	(2.43)	1.33	(3.16)	1.17	(2.79)
BA of Acacia seyal m2	0.69	(1.65)	1.13	(2.69)	0.91	(2.17)
Stacked vol. wood m3	16.2	(38.6)	16.9	(38.4)	16.5	(39.4)
Stacked vol. A. seyal m3	12.2	(29.1)	16.1	(38.4)	14.2	(33.7)

3. Sudanese Egyptian Agricultural Integration Co. Ltd

Species	C cm	No. trees	BA m2	Stacked wood m3
	Plot 1	50 x 50 m		
Acacia seyal	10	3	0.0024	
	11	1	0.0010	
	13	1	0.0013	
	14	2	0.0031	
	15	5	0.0090	
	16	1	0.0020	
	17	2	0.0046	
	18	2	0.0052	
	19	1	0.0029	
	20	2	0.0064	
	21	2	0.0070	
	22	1	0.0039	
	23	2	0.0084	
	24	1	0.0046	
	25	1	0.0050	
	26	1	0.0054	
	27	2	0.0116	
	28	2	0.0125	
	29	1	0.0067	
	30	3	0.0215	
	32	2	0.0163	
	34	1	0.0092	
	35	1	0.0097	
	36	1	0.0103	
	38	1	0.0115	
	40	3	0.0382	
	41	2	0.0268	
	43	1	0.0147	
	45	1	0.0161	
	47	1	0.0176	
	49	1	0.0191	
	51	1	0.0207	
	56	1	0.025[illegible]	
	59	1	0.0277	
		--	------	----
TOTAL A. seyal		54	0.3874	4.81
		==	======	====
A. senegal	20	1	0.0032	
	33	1	0.0087	
Combretum hartmannianum	10	4	0.0032	
	14	1	0.0016	
	15	1	0.0018	
	16	1	0.0020	

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 1 continued				
	17	1	0.0023	
	19	1	0.0029	
	20	1	0.0032	
	22	1	0.0039	
	23	1	0.0042	
	27	1	0.0058	
	29	1	0.0067	
	30	1	0.0072	
	31	1	0.0076	
	32	1	0.0081	
	33	3	0.0260	
	35	1	0.0097	
	36	1	0.0103	
	46	1	0.0168	
	57	1	0.0259	
	63	1	0.0316	
	68	1	0.0368	
	77	1	0.0472	
Lannea spp.	10	1	0.0008	
	16	1	0.0020	
	17	1	0.0023	
	18	1	0.0026	
	27	2	0.0116	
	28	1	0.0062	
	30	2	0.0143	
	33	1	0.0087	
	38	1	0.0115	
	39	1	0.0121	
	44	1	0.0154	
	47	1	0.0176	
	52	1	0.0215	
		--	------	----
TOTAL other spp.		44	0.4033	4.81
		==	======	====
TOTAL PLOT		98	0.7907	9.62
		==	======	====

Species	C cm	No. trees	BA m2	Stacked wood m3
	Plot 2 50 x 50 m			
Acacia seyal	10	1	0.0008	
	18	1	0.0026	
	19	1	0.0029	
	20	3	0.0095	
	22	4	0.0154	
	23	1	0.0042	
	24	1	0.0046	
	25	1	0.0050	
	26	1	0.0054	
	27	1	0.0058	
	28	5	0.0312	
	29	3	0.0201	
	30	3	0.0215	
	[illegible]	1	0.0076	
	[illegible]	3	0.0244	
	33	3	0.0260	
	35	1	0.0097	
	36	2	0.0206	
	37	2	0.0218	
	38	1	0.0115	
	39	1	0.0121	
	40	5	0.0637	
	41	4	0.0535	
	42	2	0.0281	
	43	3	0.0441	
	48	1	0.0183	
	51	1	0.0207	
	53	1	0.0224	
	55	1	0.0241	
	58	2	0.0535	
	62	1	0.0306	
		--	------	----
TOTAL A. seyal		61	0.6217	7.39
		==	======	====

Species	C cm	No. trees	BA m2	Stacked wood m3
Plot 2 continued				
Anogeissus leiocarpus	10	1	0.0008	
	16	1	0.0020	
	24	1	0.0046	
	26	1	0.0054	
	38	1	0.0115	
	42	1	0.0147	
	44	1	0.0154	
	53	1	0.0224	
	76	1	0.0460	
Combretum hartmannianum	10	3	0.0024	
	13	1	0.0013	
	14	2	0.0031	
	15	2	0.0036	
	22	1	0.0039	
	23	1	0.0042	
	28	1	0.0062	
	40	1	0.0127	
	57	1	0.0259	
Lannea spp.	13	1	0.0013	
	14	1	0.0016	
	18	1	0.0026	
	19	1	0.0029	
	43	2	0.0294	
	48	1	0.0183	
Lasiosyphon kraussianus	30	1	0.0072	
		--	------	----
TOTAL other spp.		30	0.2492	1.74
		==	======	====
TOTAL PLOT		91	0.8711	9.13
		==	======	====

Stacked volume by Acacia seyal and other species

Stacked dimensions m	Stacked vol. m3	Species	%	Species Stacked vol. m3
	Plot 1	50 x 50 m		
1.20 x 1.20 x 0.75	1.08	A. seyal	60	0.65
		Others	40	0.43
1.33 x 1.22 x 1.06	1.72	A. seyal	50	0.86
		Others	50	0.86
1.14 x 1.20 x 0.85	1.16	A. seyal	60	0.70
		Others	40	0.46
1.33 x 1.33 x 0.88	1.56	A. seyal	30	0.47
		Others	70	1.09
1.30 x 1.08 x 1.00	1.40	A. seyal	20	0.28
		Others	80	1.12
0.85 x 0.50 x 0.65	0.28	A. seyal	60	0.17
		Others	40	0.11
1.19 x 1.30 x 0.84	1.30	A. seyal	60	0.78
		Others	40	0.52
1.25 x 1.05 x 0.85	1.12	A. seyal	80	0.90
		Others	20	0.22
	----			----
TOTAL	9.62	A. seyal		4.81
	====	Others*		4.81
				====

* *Acacia senegal*, *Combretum hartmannianum*, *Lannea* spp.

Stacked dimensions m	Stacked vol. m3	Species	%	Species stacked vol. m3
	Plot 2	50 x 50 m		
1.12 x 1.20 x 1.00	1.34	A. seyal	100	1.34
1.20 x 1.10 x 0.90	1.19	"	100	1.19
1.05 x 1.20 x 0.85	1.07	"	100	1.07
1.10 x 1.12 x 0.92	1.21	"	50	0.60
		Others	50	0.61
1.20 x 1.15 x 0.90	1.24	A. seyal	75	0.93
		Others	25	0.31
1.10 x 1.00 x 0.95	1.05	A. seyal	80	0.84
		Others	20	0.21
0.85 x 1.00 x 0.80	0.68	A. seyal	90	0.61
		Others	10	0.07
1.15 x 1.17 x 1.00	1.35	A. seyal	60	0.81
		Others	40	0.54
	---			---
TOTAL	9.13	A. seyal		7.39
	====	Others**		1.74
				====

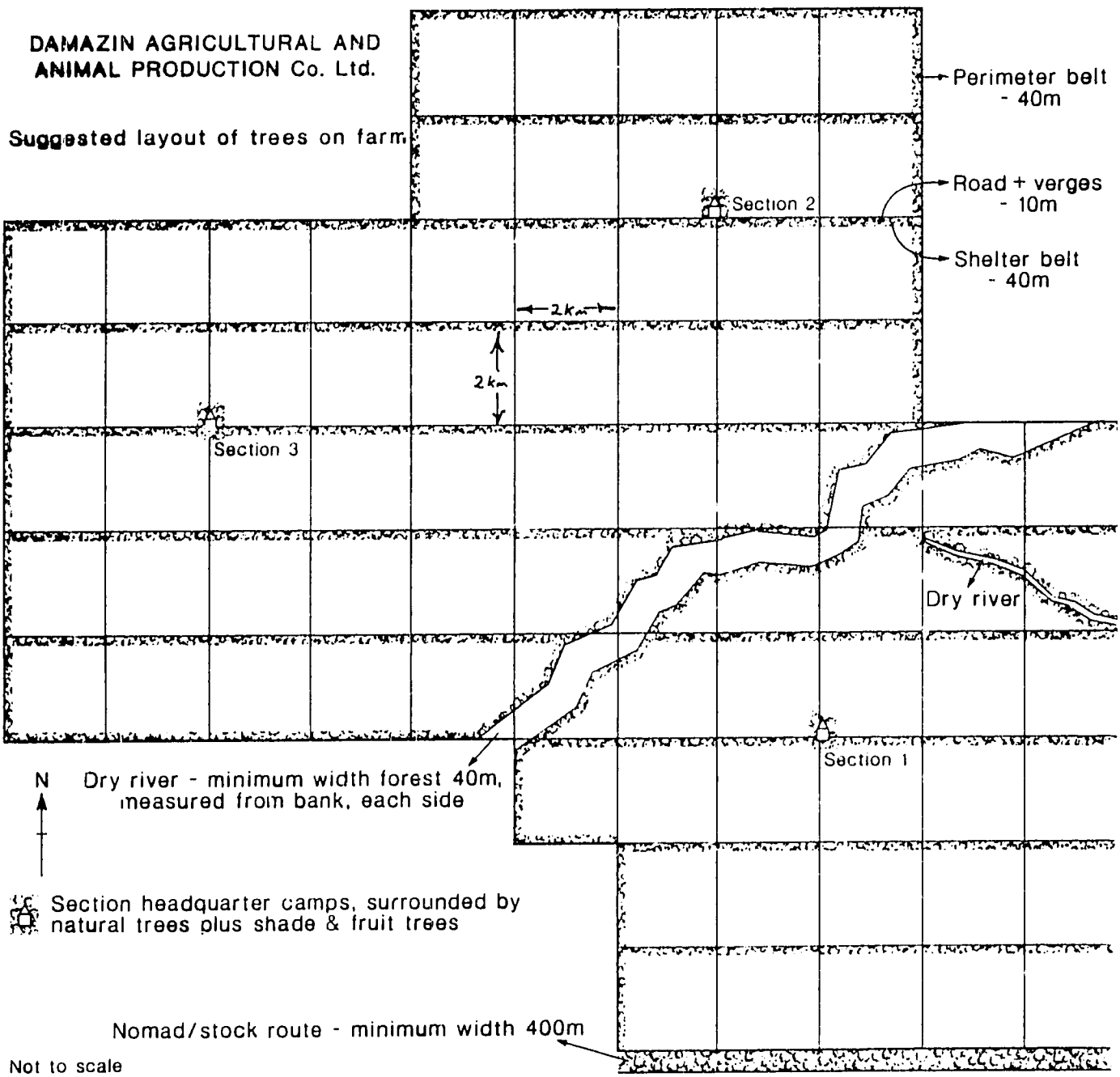
** Anogeissus leiocarpus, Combretum hartmannianum, Lannea spp. Lasiosyphon kraussianus

Summary of sample plot data per feddan (and hectare)

	Plot 1		Plot 2		Combined Plots	
	fd	ha	fd	ha	fd	ha
Total number of trees	165	(392)	153	(346)	159	(378)
BA of trees m2	1.33	(3.16)	1.46	(3.48)	1.40	(3.32)
BA of Acacia seyal m2	0.65	(1.55)	1.04	(2.49)	0.85	(2.02)
Stacked vol. wood m3	16.2	(19.2)	15.3	(36.5)	15.8	(37.5)
Stacked vol. A. seyal m3	8.1	(19.2)	12.4	(29.6)	10.3	(24.4)

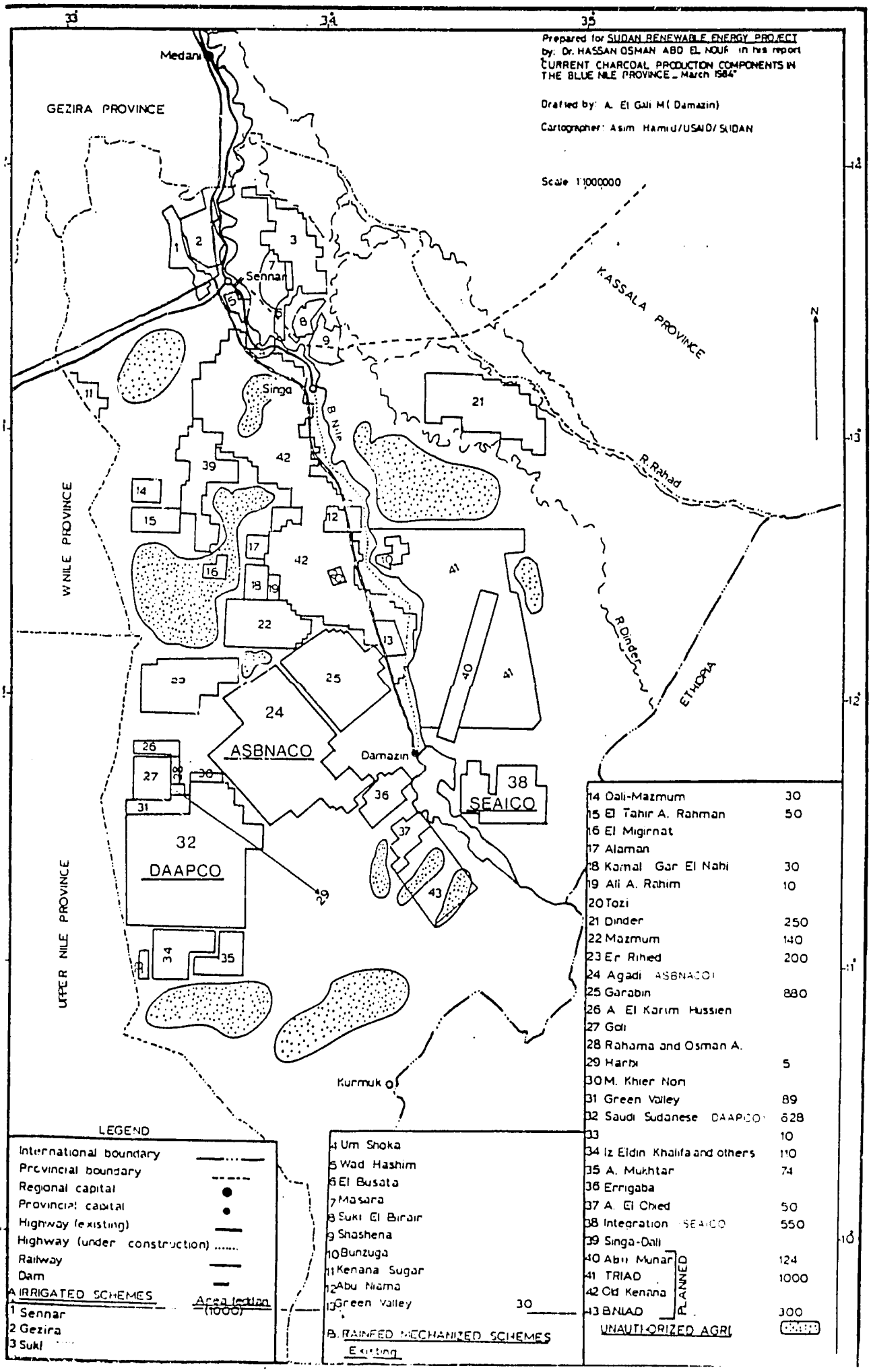
APPENDIX 5

DIAGRAMMATIC PLAN OF FARM ROADS AND SHELTERBELTS

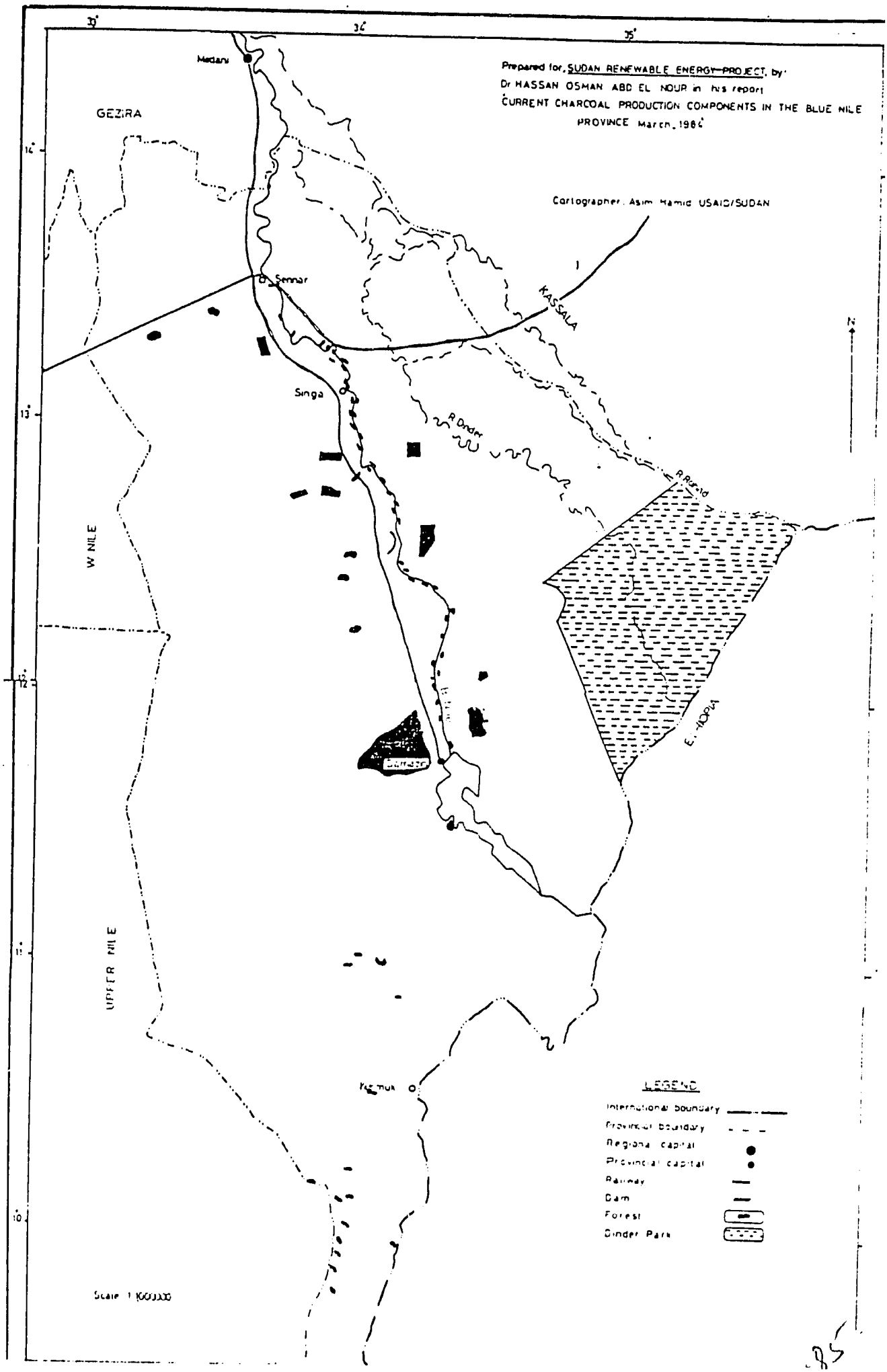


See pp. 84-5 for diagrammatic plans of mechanised farms and forest reserves in Blue Nile Province.

MECHANISED FARMS IN THE BLUE NILE PROVINCE



BLUE NILE: FORESTS AND GAME RESERVES



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APPENDIX 6

RAINFALL DISTRIBUTION AT AGADI (ASBNACo) 1980-84

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	TOTAL
				mm				
1980	2.5	16.0	48.0	248.5	171.5	24.5	9.5	520.5
1981	-	100.0	101.5	158.5	159.5	100.0	24.5	644.0
1982	-	27.0	93.0	148.5	191.0	83.5	48.5	591.5
1983	-	26.0	180.5	193.5	175.0	71.5	4.5	651.0
1984	-	25.5	98.0	157.0	123.5	59.5	12.0	475.5
TOTAL	2.5	194.5	521.0	906.0	820.5	339.0	99.0	2882.5
MEAN	0.5	38.9	104.2	181.2	164.1	67.8	19.8	576.5

APPENDIX 7

SOIL PROFILE DESCRIPTION
DAAPCo

Soil type:	Vertisol
Site location:	Pilot area
Parent material:	River alluvium:
Land form:	Interfluve:
Microtopography:	Very gentle undulating with some poorly developed gilgai
Vegetation/landuse:	Acacia savanna
Drainage:	Poor
Surface features:	Well developed cracking, granular surface structure and few, fine, hard calcium concretions
Profile moisture;	Nearly dry 0-250 cm

Profile description:

0-20 cm - Very dark greyish brown (2.5Y3/2) moist and dry, weak to moderate fine and medium subangular blocky, sticky and plastic wet, friable moist, hard dry, common cracks, many very fine, and fine, few medium tubular pores, few small hard whitish $CaCO_3$ nodules, very few, very small shell fragments, non calcareous matrix common fine and few medium roots, clear smooth boundary pH8.

20-50 cm - Very dark greyish brown (2.5Y3/2) moist and dry clay moderate very coarse columns breaking into moderate fine medium and coarse subangular blocky structure, sticky and plastic wet, firm moist very hard dry common wide cracks (1-5 cm wide) very few slickensides at the bottom of the horizon, common very fine and few medium tubular pores few to common small hard whitish $CaCO_3$ nodules, non calcareous matrix, few to common fine and few medium roots, gradual wavy boundary, pH8.

50-80 cm - Very dark greyish brown (2.5Y3/2) moist clay moderate fine and medium angular blocky and subangular blocky structure, with parallelpiped aggregates, common pressure faces, few small slickensides, few to common fine and very fine tubular pores, few small hard whitish $CaCO_3$ nodules, slightly calcareous matrix, few very fine decayed roots, gradual smooth boundary, pH 8.2.

80-115 cm - Very dark greyish brown (2.53/2) moist, clay massive, sticky and plastic wet, very firm moist common small slickensides, few very fine pores and very few small hard whitish $CaCO_3$ nodules, slightly calcareous matrix, few very fine and fine medium roots, diffuse smooth boundary, pH 8.2.

115-200 cm - Very dark greyish brown (2.5Y3/2) friable moist, clay massive sticky and plastic wet, very firm moist common small and large slickensides few very fine tubular pores, few to common small hard whitish $CaCO_3$ nodules, (on the opposite side of the profile these nodules are many) slightly calcareous matrix, very few fine and very fine roots, pH 8.3.

200-250 cm - Very dark greyish brown (2.5Y3/2) moist, clay common small whitish $CaCO_3$ nodules and few coarse soft whitish $CaCO_3$ aggregates, pH 8.2.

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Extract from Damazin Agricultural and Animal Production Company Ltd. The Democratic Republic of Sudan. Interim Report, First Season 1978-9. By Dalgety Agricultural Development International Ltd.

APPENDIX 8

DRAFT SCOPE OF WORK FOR MECHANIZED FARMING SCHEME AND FOREST ADMINISTRATION ACTIVITIES

Introduction

Whilst field data were being collected in the Blue Nile Province, by the consultant for this report (SREP 008), three mechanised farming schemes and the Forest Administration became interested in producing charcoal from the trees being cleared for agriculture and maintaining shelterbelts for environmental protection and future fuelwood production. The Consultant was joined by the Chief of Party of SREP, and together they discussed methods of initiating this work with the representatives of the Damazin Agricultural and Animal Production Company ltd., the Sudanese Egyptian Agricultural Integration Company Ltd., the Arab Sudanese Blue Nile Agricultural Company ltd. and the Forest Administration - Damazin circle. It was agreed that the work should begin as soon as possible. The Chief of Party offered to assist the individual institutions in organizing and implementing this work through grants to each group.

The following is an outline of the overall project proposed with the individual responsibilities of each participant. Each of the three farms and the Forest Administration will submit individual grant proposals in relation to their respective parts of this project.

Objectives

The three mechanised farms selected for study are providing essential crops of grain and valuable cash crops from previously under-utilised land resources. These farms are well organised, efficient and providing what they were intended to produce: their clearing operations, however, are labour intensive and very costly.

1. It has been calculated from data collected from sample plots laid out in the farms that a minimum of 30 bags of charcoal per feddan (71 per ha) could be produced from trees destroyed during clearing operations. If this charcoal could be manufactured and marketed at a sufficiently fast rate to meet the clearance programme, the farms would benefit financially and would at the same time contribute materially to the improvement of the energy sector of the Sudanese economy.

The following Table 1 gives a breakdown of the potential supply of charcoal for the farms for 1985 and 1986.

TABLE 1

Year	Area to clear fd	Ave. cost of clearing per fd LS	Total cost of clearing LS	Bags charcoal which could be produced
1984	53,000	35	1,855,000	1,590,000
1985	85,000	40	3,400,000	2,550,000

From Table 1 it is clear that if the farms were able to make charcoal and sell it at a profit of just LS 1.17 per bag in 1985 and only LS 1.33 per bag in 1986, they would save all their clearing costs.

As a means of initiating charcoal production in the areas being cleared by the schemes, assistance is needed to organise charcoal-making on the farms and to begin establishing shelterbelts.

2. It is apparent that the farms will eventually run short of fuelwood and charcoal for the use of management and labour unless provision is made now for supplies to become available once all clearing has ceased. The policy to be adopted by the farms should be that they will ensure that sufficient fuelwood, charcoal and building poles will be available for the needs of both management and labour in the future after all land destined to become cultivated has been cleared. The criteria to be adopted for leaving natural forest should be as follows:

		Minimum width m
1.	Rivers, each side	40
2.	Nomad/Stock routes	400
3.	Farm perimeters	40
4.	Shelterbelts at the South side of every road running East-West	40

In addition, Balanites aegyptiaca and other shade trees should be left at every work camp and living quarter area.

Finally, areas of potentially low agricultural productivity should be left under forest.

Shelterbelts which do not follow the suggested pattern should not be removed until new shelterbelts, at the recommended width and location, have been established.

Assistance is needed:

1. To establish nurseries to raise seedlings of suitable species to be planted in the farms, e.g. Acacia, Azadirachta, Balanites, Cassia, Casuarina, Citrus, Eucalyptus.

2. To enrich, with suitable species, e.g. Acacia senegal, Cassia siamea, existing shelterbelts where they are found to be too narrow or poorly stocked.

3. To lay out new shelterbelts in areas being cleared for agriculture and enrich where necessary.

4. To lay out and plant new shelterbelts where none exist in land already under agriculture.

5. To plant shade trees as marker trees at 40m intervals along boundaries, e.g. Azadirachta indica, Balanites aegyptiaca, Cassia siamea.

6. To plant shade trees and fruit trees in camp sites.

Manpower

A senior Forester and a Technical Assistant (Peace Corps Volunteer) will be posted to Damazin to help oversee the overall SREP programme.

The Damazin Circle Forestry Department will second three Foresters, one to each of the three schemes, to co-ordixnate selective land clearing, charcoal production, and nursery/afforestation activities therein.

Land clearing and charcoal production will be carried out in one of a number of options open to the schemes (using scheme labour, hiring contractors, hiring new labour, etc.). Manpower requirements have been estimated, assuming charcoal production of 30 bags per feddan cleared and 1,500 bags per charcoal labourer per season:

Scheme	Feddans for clearing/charcoal	Labourers needed
Arab Sudanese	35,000	700
Damazin	30,000	600
Sudanese-Egyptian	20,000	400

Nursery rehabilitation will be carried out by local Forestry Department staff. Flying nursery establishment and afforestation will require scheme labourers or hiring new casual labour.

Outputs

a) Charcoal production

Scheme	Bags	Revenue at site LS 3/bag
Arab Sudanese	1,050,000	3,150,000
Damazin	900,000	2,700,000
Sudanese-Egyptian	600,000	1,800,000

b) Nurseries:

- Expansion of production at Damazin by seedlings.
- Expansion of production at Roseires by seedlings.
- Establishment of 1 flying nursery on each of the schemes.

c) Forest Management/Afforestation:

- Establishment of 1 East-West shelterbelt (2000 x 40 m i.e. 8 ha) for at least 4 square kilometers of new land cleared.
- Leaving belts along rivers, stock routes, and farm perimeters.
- Establishment of shade trees for animal and human welfare.

Organization programme for the 1986 planting season

Task	1985 Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	1986 Jun	Jul	Aug	Sep
1. Seed collection						—	—	—				
2. Nursery establishment & raising of seedlings				—	—	—	—	—	—	—	—	
3. Planting in the field (shelterbelt)										—	—	—
4. Land demarcation	—	—	—									
5. Organizing labour & management for charcoal-production	—	—										
6. Charcoal-making		—	—	—	—	—	—	—				
7. Shade and ornamental tree planting										—	—	—

Implementation plan programme for charcoal production and shelterbelts in three mechanised rainfed agricultural schemes (1985 rains planting)

Task	1985 Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	1986 Jan	Feb	Mar	Responsible
1. Seed collection	—	—											
2. Nursery establishment & raising seedlings	—	—	—	—	—								
3. Planting seedlings in the field & beating up				—	—	—							
4. Land demarcation	—	—											
5. Organizing labour & management for charcoal-making							—	—					
6. Charcoal-making								—	—	—	—	—	to June '86
7. Shade & ornamental tree planting				—	—	—							

Budget

a. Nursery Rehabilitation

Item	SREP Support Damazin	SREP Support Roseires	Total
1. Seed collection	150	300	450
2. Nursery establishment raising of seedlings	1,500	4,500	6,000
3. Polythene tubes	300	600	900
4. Soil mixture	300	600	900
5. Tools	300	600	900
6. Incentives for nursery workers	300	600	900
	2,850	7,200	10,050
10% others	285	720	1,005
TOTAL	3,135	7,920	11,055

b. Local Management and Afforestation

Staff	Costs
Senior Forester	Salary (paid by SREP) Per diem (paid by SREP)
Technical Assistant (PCV)	Salary (paid by SREP) Per diem (paid by SREP)
Forest Officer - ASBNACo Forest Officer - DAAPCo Forest Officer - SEAICo	) Salary from Forest Dept.) and) Incentive (paid by SREP)

c. Charcoal production - sample financial analyses

Item	Benefit/Unit	Quantity	Total Benefit (cost)
ASBNCo (In-house charcoal production)			
Charcoal production	(LS 2.50/bag	1,050,000 bags	(LS 2,625,000)
Land clearing	(LS 25/fd)	35,000 fd	(LS 875,000)
Savings on normal land clearing costs	LS 25/fd	35,000 fd	LS 875,000)
Charcoal sales (at site)	LS 3.00/bag	1,050,000 bags	LS 3,150,000
Net benefit (cost)			LS 525,000
Normal land clearing cost (with overhead	LS 50/fd	35,000 fd	(LS 1,750,000)
DAAPCo (Contractor production)			
Land clearing	(LS 20/fd)	30,000 fd	(LS 600,000)
Savings on normal land clearing costs	LS 20/fd	30,000 fd	LS 600,000
Charcoal royalty (from contractor)	LS 0.25/bag	900,000 bags	LS 225,000
Net benefit/cost			LS 225,000
Normal land clearing costs	LS 40/fd	30,000 fd	(LS 1,200,000)
SEAICo (Contractor production)			
Land clearing	LS 20/fd	20,000 fd	(LS 400,000)
Savings on normal land clearing costs	LS 20/fd	20,000 fd	LS 400,000
Charcoal royalty	LS 0.25/bag	600,000 bags	LS 150,000
Net benefit/cost			LS 150,000
Normal land clearing costs	LS 40/fd	20,000 fd	(LS 800,000)

Assumptions:

1) In-house land clearing costs will be halved when employees paid additional piece rate for bags of charcoal produced (approximately LS 1.00/bag.

2) Contractor will accept half normal land clearing fees when allowed to sell all charcoal produced.

3) Contractors will agree to pay LS 0.25 per bag royalty to schemes for charcoal produced.

D Peterson
(Chief of Party)

APPENDIX 9

AGRICULTURAL COMPANIES WITH FARMS APPROVED BY
THE GENERAL ADMINISTRATION OF AGRICULTURAL INVESTMENT
MINISTRY OF AGRICULTURE

Areas approved and areas cleared to 1985

No	Company	Total area approved fd	Area cleared to 1985 fd	Location
1	Southern Fung	12,000	2,000	East of Blue Nile
2	Saffa	50,000	15,000	"
3	Berrair and Sons	12,000	4,000	"
4	SEIACo	250,000	100,000	"
5	ASBNACo	210,000	160,000	West of Blue Nile
6	DAAPCo	500,000	70,000	"
7	The Green Valley	89,000	25,000	"
8	The Irrigated of V.	33,000	-	"
9	The Agadi Agr. Co.	15,000	12,000	"
10	Dalli & Mazmon	50,000		
11	The Jibeillab	70,000	10,000	"
12	Mohamed Kheir Norri	14,000	7,000	"
13	El Aman Co.	32,000	8,000	"
14	Barbar Co.	5,000	5,000	"
15	El Sharaffa Co.	5,000	5,000	"
16	Salih Brothers	7,000	3,000	
17	Mazmom Co.	12,000	2,000	East of Blue Nile
18	Haggo Atia	4,000	4,000	West of Blue Nile
19	Aball El Taieb	4,000	-	"
20	El Megaranab	25,000	11,000	"
21	Gargour	4,000	-	"
22	Mahadi Mohamed	20,000		East of Blue Nile
23	El Waffa Co.	60,000	12,000	"
24	El Raha Animal Prod.	36,000	20,000	"
25	Osman Abed Gadit	12,000	-	
26	The United Sudanese Co.	25,000	3,000	"
27	El Masara Co	20,000	10,000	West of Blue Nile
28	TRIAD	1,000,000	-	East of Blue Nile
TOTAL		2,576,000	498,000	

APPENDIX 10

CHARCOAL TRANSPORT COSTS in LS

From	To	Distance in km	Cost Lorry (200 bags)	Cost /bag	Cost truck & trailer (650 bags)	Cost /bag	Cost railway truck (450 bags)	Cost /bag
Field HQ ASBNACo	Damazin	35	150	0.75	335	0.52		
"	Khartoum	535	750	3.75	2,250	3.46		
"	Port Sudan	1,310	1,500	7.50	3,750	5.77		
Field HQ DAAPCo	Damazin	95	180	0.90	400	0.62		
"	Khartoum	585	1,050	5.25	2,250	3.46		
"	Port Sudan	1,370	1,500	7.50	4,500	6.92		
Field HQ SEAICo	Damazin	65	150	0.75	335	0.52		
"	Khartoum	555	750	3.75	2,250	3.46		
"	Port Sudan	1,340	1,500	7.50	3,750	5.77		
Damazin	Khartoum	490	600	3.00	2,000	3.08	970	2.16
"	Port Sudan	1,275	1,350	6.75	3,300	5.08	2,220	4.93

APPENDIX 11

NEA TEAM'S REPORT ON
FUEL SUPPLY FOR REFUGEES IN THE EASTERN REGION OF SUDAN
MARCH 1985

The recent influx of refugees into the Eastern Region of Sudan has highlighted the problem of how to provide for their fuel needs, cost-effectively and without accelerating the process of deforestation already advanced in the refugee camp areas (see map, ANNEX 1, page 105). A recent report by COUGH (1985) has estimated that about 1,600,000 bags of charcoal would be needed annually for an estimated refugee population of 400,000. This amount, (12.4% above the annual Sudanese recorded consumption) if bought from local traders, would seriously disrupt the market and would furthermore increase the destruction of tree cover as traders search for new sources of supply.

An NEA team, consisting of a consultant recruited by EDI and two NEA analysts (see ANNEXES 2 & 3, pp. 106 and 107) was formed on 14/3/85 to investigate the possibility of obtaining fuel from a new source for the refugees, has confirmed the findings of SREP Report 008 (1985) that a sufficient supply of charcoal from forest clearance for farming (at present wasted) could be obtained if suitable incentives and markets were to be made available. At the start of the present dry season a potential new source of more than 1,600,000 bags of charcoal was available from three of the agricultural companies in the Damazin area of the Blue Nile Province, provided that it could be manufactured and transported before 1 June (when the rains are expected to arrive in force). Although the present land preparation process of clearing by fire has, at the time of writing, substantially reduced this potential it was strongly recommended by the NEA team that a plan should be prepared for approval by the Director General of NEA, which could be implemented immediately.

The chief advantages of the plan to bring charcoal from the Damazin area to refugees in the Eastern Region were as follows:

1. The fuel would be produced in Sudan from presently wasted resources.

2. Useful work and income would be created in the rural areas.

3. There would be no need for the refugees to cut trees for fuelwood in the surroundings of the camps.

4. The agricultural companies and farms would reduce their costs of clearing land and have an incentive to leave a percentage of the land under managed forest (see SREP Report 008 [1985]).

5. If successful, the scheme could be expanded to meet all the expected increased market for charcoal including a possible export demand up to and including 1990

The NEA team visited the offices of the UNHCR and COR at Khartoum, Gedaref and Showak to discuss the situation with senior staff and to assess the demand and distribution pattern. The team then travelled to two of the three farms previously identified in the Damazin area to investigate the technical and economic feasibility of manufacturing charcoal and then transporting it from the farms to the refugee camps in the very short time available. Discussions were held with the General Managers and senior staff of the three agricultural companies (listed below) in the field and at Khartoum.

Arab Sudanese Blue Nile Agricultural Co. Ltd. - (ASBNACo)
Damazin Agriculture and Animal Production Co. Ltd. - (DAAPCo)
Sudanese Egyptian Agricultural Integration Co. Ltd. - (SEAICo)

The NEA team received very positive and encouraging responses from the agricultural companies who agreed to manufacture charcoal provided that the market could be guaranteed. The following proposed arrangement was put to the COR who agreed to sign a contract with NEA to purchase all charcoal made on these farms provided that the criteria laid down in the Draft Contract (see ANNEX 4, p. 111) were satisfied.

Proposed arrangements for procurement of refugee cooking fuel

General

An adequate supply of charcoal can be produced in two months on mechanised farms in the Blue Nile Province to meet the needs of refugees in the Eastern Region (480,000 bags over 2 months). Farm managers, co-operative societies, and contractors are interested and willing to begin immediate production. The charcoal can be produced and transported to the camps before the rains begin in June (see ANNEX 5, p. 114).

We recommend that the Commissioner of Refugees purchases up to 1 million bags (six months requirement) from the mechanised farming areas at a price of LS 3.00/bag load, without bag. COR would then tender for the pick-up, transport and delivery of the charcoal. COR would provide bags and thread and, through the UNHCR, the fuel for transport.

In addition, we recommend that COR contract, on a fee basis, for a management team to represent its interests in the production area. This team would be responsible for: signing contracts with each potential producer; ensuring that all start-up problems are resolved so production begins immediately; and monitoring the

production process. Without such direct representation, actual production may be limited, as major start-up problems could be incurred.

Finally, since time is short, we propose the following schedule:

March 23 -	24:	COR reviews proposal
March	25:	COR gives its decision. If favourable:
March	26:	COR hires management team. Agent signals go-ahead to ready producers.
March	25:	Production begins.
March	27:	Management team begins signing contracts with producers.
April	5:	Management team provide COR with firm estimates of production.
By April	10:	COR contracts with transport/general contractor.
By April	30:	Initial shipments under way.
By June	1:	Final shipments for 3 months supply dispatched.

Costs to COR - estimated (all costs estimated @ +/- 20%)

Unit:		LS/bag
Charcoal produced	:	3.00
Bag and thread	:	1.00
Royalty fee	:	.25
Transport including fuel, load, unloading:		
El Fau	:	2.9
Showak	:	3.6
Kassala	:	4.2
Additional:		
Management fee	:	25,000
Expenses	:	10,000

Production by Contractors - estimated**

		Bags
DAAPCo	Co-operative Society	75,000*
	Contractor Omer Ali	150,000***
ASBNACo	Direct Labour	150,000
SEAICo	Contractors	400,000
		775,000

* 5,000 now ready on site

** Production by these contractors to begin immediately upon verbal agreement by COR to purchase

*** Additional quantities to be contracted for by management team from March 26 - April 5.

Production terms and conditions

See proposed contract - ANNEX 4)

Pick-up - Transport and delivery

Tendered by COR - open or short listed for transport and general contracting

Bags and thread

To be procured by COR

Fuel for transport

to be provided by UNHCR

Responsibilities of each party - proposed

Commissioner of Refugees/UNHCR

- Contracting to purchase charcoal at roadside (through management team).
- Decision on management team
- Tendering and selection of general contractor/transporter
- Supervision of general contractor/transporter
- Procurement of bags and thread
- Payment of royalty fee

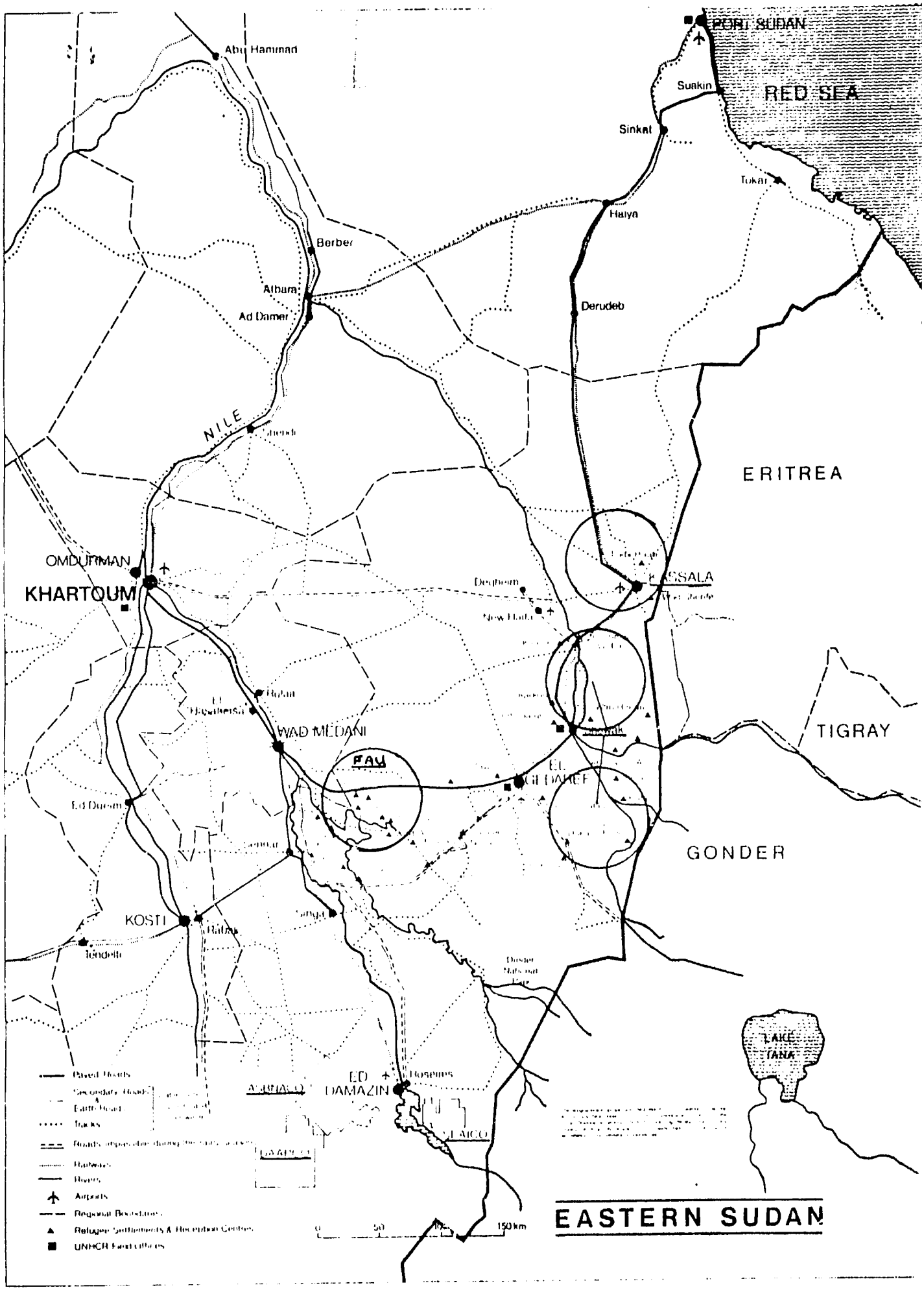
Production Management Team

(Leader, Forester, Local representative)

- Arranging contracts for charcoal-making with each producer, up to an estimated 1 million bags.
- Field troubleshooting to ensure production begins.
- Supervision of production to ensure proper procedures and techniques are executed (See terms and conditions of contract).

General Contractor/Transporter

- All transport arrangements
  - shipment of bags and thread
  - shipment of bagged charcoal
- Delivery of charcoal to camps
  - inspection of roadside charcoal
  - loading
  - unloading
  - full accounting
- Arranging payment for charcoal at roadside
- Arranging payment of royalty


PORT SUDAN
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Suakin
Sinkat
Tokar
Haiya
Berber
Atbara
Ad Damer
Derudeb
NILE
ERITREA
OMDURMAN
KHARTOUM
KASSALA
Deqheim
New Halfa
Rufaa
El Hasaheisa
WAD MEDANI
GEDAREF
TIGRAY
Ed Duem
GONDER
KOSTI
Rabak
Tendelti
LAKE TANA
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Railways
Rivers
Airports
Regional Boundaries
Refugee Settlements & Reception Centres
UNHCR Field Offices
ED DAMAZIN
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EASTERN SUDAN

ANNEX 2

MEMBERS OF NEA TEAM

Marc Daudon	Team Leader, NEA/EDI
A/Rahim Ahmed Belal	NEA/EDI
Derek E Earl	Consultant NEA/EDI

PARTICIPANTS

Abdel Rahman Shulli	Director General NEA
Hassan Attia	Deputy Commissioner, Refugees
Christopher Thorne	UNHCR
Omar Bakhet	Deputy Chief Emergency Unit UNHCR
Hussein Ahmed Osman	Eastern Region Commissioner of Refugees
Fred Cuny	Advisor to E. Region Comm. of Refugees
El Tag Seif El Din	Executive Manager ASBNACo
Hamid Mohed Mahmoud	Executive Manager DAAPCo
Salah El Din El Khalifa	General Manager SEAICo

ANNEX 3

TERMS OF REFERENCE

DEREK EARL CONSULTANCY

FUEL SUPPLY FOR EASTERN REGION REFUGEES

BRIEF

1. With a team of NEA analysts, quantify energy requirements for refugee population in the Eastern Region. Identify and analyse alternatives to meet those needs.

2. Establish contacts with local charcoal producers (or potential producers). If possible, arrange for a local supply of fuel to meet needs for the next six to nine months from a source which will not affect the local market.

3. Produce a short report summarising the analyses to be presented to the Government of Sudan Commissioner of Refugees, the UNHCR, and other concerned bodies.

BACKGROUND

approximately 400,000 refugees are now temporary residents of the Eastern Region of Sudan. This total may rise to 720,000 in the coming months. The international donor community is providing minimum food and shelter for these people. The critical question now is: how to meet their fuel requirements for the next 6 months and the next year or so.

Currently refugees are providing their own fuel by foraging wood from around the camps. This resource, though, is expected to be exhausted in a short time. The alternative is to provide some commercial fuel as part of the ration for each refugee. Locally produced charcoal is the most likely source of supply although kerosine could be imported.

Careful analysis is needed of these and other options. In the current emergency, time is short. Fuel must be purchased and stockpiled before the rains begin in June. However, it all supplies are purchased from the local market, the local consumers might be adversely affected by higher prices and shortages. One possibility to minimize the impact is to introduce more efficient methods of consumption in the camps (e.g. shared cooking and energy efficient stoves).

The NEA supported by EPM can provide the analysis needed to identify and quantify the viable alternatives. With its extensive data base and newly formed biomas analysis group, the NEA is in an excellent position to conduct this study.

Derek Earl with many contacts among charcoal producers and mechanised rainfed farmers may be able to locate a source of charcoal immediately to satisfy needs for the coming months.

PROJECT FOCUS

1. Assessment of demand.

    - minimum consumption requirements:
        - per family unit

    - ways to reduce demand:
        - combined cooking arrangements
        - efficient stoves

    - % of local market

2. Meeting the Immediate Need.

    - constraints:
        - rains coming
        - more people coming
        - minimum local supplies
        - logistics; transport and fuel

    - alternatives:
        - charcoal
        - kerosine
        - local wood
        - other

    - sources of supply:
        - local
        - imported

    - cost of options

    - issues:
        - impact on local market if no increase in supply
        - need to act immediately

3. Arranging Dedicated Local Supply.

- major charcoal purchases likely required.
- mechanised rain fed schemes likely source.
- requirements:
  - contacts with managers
  - liquidity
  - transport and fuel
  - incentive price

4. Defining a framework for the future.

- potential to lock in supply source
- projects to reduce demand
- alternatives to charcoal

5. Work plan

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                          Day 1----3----5----7----9----11----13

meet COR/UNHCR reps:          x

initial demand/supply
assessment                    /------/

initial industry contacts      x x

field trip, schemes
and camps:                            /--------/

arrange supply source,
purchase:                                   x          x

prepare report:                                  /---------/
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ADDITIONAL TASKS UNDER DEREK EARL

TERMS OF REFERENCE EPM CONTRACT

MARCH 14 - MARCH 28

1. Discuss with the Minister of Energy and the Under Secretary proposals to improve forestry and land use practices in the Blue Nile Province. This discussion is in the context of improving the fuelwood supply demand balance for Sudan.

2. Review the National Energy Plan woodfuels section. Prepare brief memo on practical first steps towards implementation.

Marc Daudon

3/18/85

ANNEX 4

DRAFT CONTRACT

NATIONAL ENERGY ADMINISTRATION (NEA)

WITH CHARCOAL FOR PRODUCTION

The undersigned agrees to sell all charcoal produced by the signator or his agents on the farm exclusively to the National Energy Administration (NEA) for 3.00 LS/bag stacked at the roadside. This contract is binding for all charcoal produced between 1 April - 15 June. In addition, the NEA has first rights to purchase other charcoal from the farm produced before 1 April provided all terms and conditions specified below are met.

The estimated charcoal production under this contract is:
bags from feddans.

Terms and Conditions

1. The producer agrees to immediately begin production of charcoal on all forests to be cleared or in the process of being cleared for the upcoming planting season.

2. The NEA will purchase charcoal made only from trees to be cleared for planting. In addition, adequate environmental safe-guards must be observed on cleared land - shelterbelts and stock routes are to be maintained.

3. The raw material for charcoal manufacture should contain not less than 60% of Talh (Acacia seyal).

4. The charcoal should be clean (no stones, unburnt wood, etc.) and tightly packed into used sorghum bags and sewn at the top.

5. The average weight of the charcoal (including bags) should be about 39 kg (range 35-43 kg).

FROM : NEA
TO : COR
DATE : 26/3/85

SUBJECT: Management Contract of Charcoal Project

1. NEA obligations

NEA accepts to manage the whole project; production and transport.

Team leaders: Ishag Adam Beshir
Dr Abdel Rahim A Belal

2. Total Cost

Cost + administrative fees (LS 0.25 per bag)

3. Cost

- Charcoal production costs LS 3.00 per bag
- Bags LS 0.80 - 1.50 per bag
- Transport cost of bags from Khartoum to production centres
- Royalties LS 0.25 per bag
- Transport costs

4. Documents required

- Contract NEA/COR
- Contracts NEA/Producers (4)
- Contract NEA/Transport Contractor
- Operation budget (NEA)
- Cash flow projections (NEA)
- Financial control procedures (NEA + COR)
- Near term action programme (NEA)
- Work plan (NEA)

5. Manpower and equipment

A. Manpower
   1. Project Manager
   2. Legal Advisor
   3. Production team/manager
   4. Transport team/manager
   5. Administrative/accounting arrangements

B. Equipment
   1. 3 cars
   2. Weighing instruments, etc

6. Up front cash

   1. LS 50,000 first instalment of administrative fees
   2. Sack cost + transport costs of sacks

7. Near term action programme

Urgent issues and steps

-	Work plan and project team	26/3
-	Arrangements with legal advisor	27/3
-	Contract with COR	27/3
-	Financial control procedures	27/3
-	Contract with producers	28/3
-	Down payments	28/3
-	Bags procurement arrangements	27/3
-	Prepare decision on transport arrangement - railway option	28/3

Work plan

CHARCOAL FOR REFUGEES

Note on transport costs

Charcoal has to be picked up from the three main producing areas as follows (see map ANNEX 1, p. 105):

ASBNACo - 35 km from Damazin

DAAPCo - 95 km " "

SEAICo - 65 km " "

Charcoal has to be delivered to three main consumption centres as follows:

1. El Fau - distance from Damazin 300 km

2. Showak - " " " 400 km

3. Kassala - " " " 500 km

The estimated distances from the charcoal producing areas to the camps are as follows:

Farm	Camp area El Fau	Camp area Showak	Camp area Kassala
ASBNACo	355	455	555
DAAPCo	405	505	605
SEAICo	365	465	565

The estimated costs in LS of the truck and trailer transport from the farms to the refugee camps are as follows:

Farm	Camp El Fau	Camp Showak	Camp Kassala
ASBNACo	1420	1820	2220
DAAPCo	1620	2020	2420
SEAICo	1460	1860	2260

The estimated number of bags of charcoal per truck and trailer is 600 (or 23 tons).

The transport costs per bag of charcoal including LS 0.20 per bag for loading and unloading charges is as follows:

Farm	El Fau	Showak	Kassala
ASBNACo	2.6	3.2	3.7
DAAPCo	2.9	3.6	4.2
SEAICo	2.6	3.3	4.0

480,000 bags of charcoal (18,462 tons) to be delivered by 1 June
300 trips in 6 weeks starting mid April = 42 days.
Therefore, assuming 20 trucks will take 2 days for the round trip, and allowing 1 day for contingency, 60 trucks will be needed.

The best and shortest routes (see map) are through Roseires, along the East side of the Blue Nile through Es Suki to the Fau camps and through Simsim to Gedaref for both Showak camp clusters and for the Kassala camps.

N.B. The transporter is to be responsible for bringing empty bags, diesel fuel and for payment of royalty on bags of charcoal (LS 0.25 per bag).

23 March 1985