SUDAN
RENEWABLE ENERGY PROJECT

REPORT ON
CHARCOAL PRODUCTION

by
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Khartoum, Sudan

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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 responsibilities of the consultant and the Sudan Renewable Energy Project. Endorsement by the USAID is not necessarily implied.
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D E Earl
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GLOSSARY OF TERMS, ABBREVIATIONS AND CONVERSION FACTORS

barrel 0.136 MT oil
feddan 0.42 hectare (ha)
LS Sudanese pound = US$ 1.3-1.9
megawatt 1000 kilowatt
MT metric ton (1000 kg)
TOE ton(s) of oil equivalent

<table>
<thead>
<tr>
<th>Energy Unit</th>
<th>Number of Joules</th>
<th>Percentage TOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 TOE</td>
<td>$42.7 \times 10^6$</td>
<td>100</td>
</tr>
<tr>
<td>1 ton charcoal</td>
<td>$28.91 \times 10^6$</td>
<td>68</td>
</tr>
<tr>
<td>1 ton fuelwood</td>
<td>$13.83 \times 10^6$</td>
<td>32</td>
</tr>
<tr>
<td>1 ton other biomass</td>
<td>$11.31 \times 10^6$</td>
<td>26</td>
</tr>
<tr>
<td>1 megawatt hour</td>
<td>$3.60 \times 10^6$</td>
<td>8</td>
</tr>
</tbody>
</table>
Wood prepared for carbonization

Sudanese kiln ready for thatching
Sudanese kiln soon after lighting

Charcoal raked out for conditioning
Harvesting by hand

A charcoal depot
The sale of charcoal in small quantities, Khartoum

Illegal charcoal-making in a forest reserve, Kassala Province
Missouri kiln producing 400-500 sacks per firing, Ghana

Brick and clay kiln, Kenya
This report examines the Sudanese charcoal industry and comes to the conclusion that the legal charcoal-making industry, which accounts for more than 90% of all charcoal marketed in the centre of Sudan, is well developed in its earth kiln technology and very well organized. Some recommendations for marginal improvements in technology are made for early trial and implementation. More radical recommendations are made, involving a drastic change in technology and organization aimed at improvement in quality and saving some of the estimated 20% of charcoal left at the sites and depots as small-size fuel (fines). As these changes would require capital inputs, it is suggested that they should be introduced by an aid agency at one site and given a thorough trial before any attempt is made at wider implementation, publicity and training. It must be stressed that the charcoal industry at present is providing a good fuel at reasonable price to the consumer with little or no inputs of foreign exchange, and should not be disturbed lightly.

The illegal charcoal-making industry is much less efficient, not controlled, and pays nothing for the trees it utilizes. It should be eliminated as far as it is possible to do so, particularly where it is affecting fragile ecological systems and destroying forest reserves.

The savanna woodlands, which provide the raw material stocks for charcoal, are gradually becoming cleared for mechanized farming and early action is necessary to conserve some of the existing areas of woodland and to use available resources wisely. If the recommendations on raw material supply made in this report are followed, the charcoal industry will be able to continue to play its part as a major supplier of energy to the Sudanese economy for many years to come. Recommendations made in this report for sustaining the raw material supply include:

a) ensuring that all wood cleared from rain-fed mechanized farming schemes is utilized 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 lands to be allowed to grow fuel (including, in some cases, 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.

The report notes that the conversion factors used at present for calculating charcoal production are out of date and recommends that these should be checked and amended accordingly; this should be given very high priority.
Finally, it is noted that although data on charcoal and fuel production are being collected at local level, they are not finding their way up the line for management to use for monitoring resources and planning purposes. Recommendations are made for improving the collection, collating and analysis of these data on a regular basis.
The Sudan Renewable Energy Project (SREP) is part of the bilateral assistance programme of the Government of Sudan and the U.S. 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 focuses 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.

The objectives of the present consultancy (see Terms of Reference, Appendix I) are:

1) to assist in establishing a base of knowledge concerning the traditional methods of charcoal production practised in the various charcoal-making areas in Sudan;

2) to set guidelines for further work on improving production methods to be carried out by the SREP, the FAO Forestry Project and other related activities in Sudan.

In the course of discussions with the SREP executive, it was agreed that this report should include recommendations on what should be done to ensure the continuity of the raw material resources needed to sustain the industry when supplies of trees, from land-clearing for mechanized farming schemes, have become exhausted. It was further agreed that a map showing the present areas and types of land used for charcoal production, for comparison with lands allocated for this purpose approximately 10 years ago, would be prepared by the counterpart consultant.
Sudan, the largest country in Africa, covers an area of over 2.5 million square kilometres. About half the area is desert or semi-desert and 40% of the remainder is savanna woodlands whose soils require careful husbanding to maintain their productivities.

The population of 21 million is thinly spread out in the rural areas and is also concentrated in the cities and towns, especially along the Nile (see map, p.6).

There are three major agricultural systems, accounting for about 11 million hectares: irrigated, rain-fed mechanized and small-holders. 80% of the population is supported by agriculture which employs 66% of the labour force and produces 95% of Sudan's total exports. The more important of these are cotton, sesame oil, livestock, hides, skins, sorghum and gum arabic. This last is produced from Acacia senegal, a savanna tree. An annual total of 45,000 tons makes it the third most important export item.

The Sudanese economy, as with many other countries, has been badly affected by the high price of oil. In 1981 imports of petroleum products amounted to 393 million US$ or to 8% of the value of total exports, valued at 484 million US$.

Sudan is not profligate in its consumption of commercial energy. The per capita energy consumption in 1981 was about 35% of the African average and only 7% of the world average (USAID (1984)).

Consumption of petroleum products in 1983 amounted to 1,106,000 tons oil equivalent. This source of energy amounted to 17.6% of gross energy consumption. Of the remaining 82.4%, 78.6% came from biomass (mainly fuel wood and charcoal) and only 3.8% from hydro-electricity (SNEA (1983)).

The anticipated increased demand for energy is expected to be met as follows:

- **oil**: production of oil from Sudan's own oil field should be at least 25,000 barrels per day by 1985 (about 70% of the country's current consumption);
- **electricity**: a further 300 megawatts will be added to installed capacity of 130 megawatts by 1986 (60% thermal);
- **biomass**: more plantations of fast-growing trees for fuel production will be established.
This report examines the present position of the charcoal industry which supplies about 26% of the nation's energy and makes some recommendations for improving its productivity and profitability. Recommendations for sustaining the flow of charcoal to the market by improving the management of existing resources are also included.
4.1 Location and ownership of the industry

4.1a The Sudanese charcoal market is principally concentrated in the urban centres of central Sudan. Most of the charcoal is produced from trees removed from land required for mechanized agriculture in the Blue Nile, Kassala, South Kordofan and Upper Nile Provinces.

4.1b The industry is generally owned and managed by entrepreneurs. Those operating legally pay the Forests Administration for a permit to make charcoal, in defined areas, in advance of land-clearing operations.

4.1c Illegal charcoal-making is small-scale but widespread and generally takes place wherever trees can be cut down surreptitiously. No money is paid to the Government and the results are unrecorded. It was estimated by MUKHTAR (1982) that illegal charcoal production amounted to about 92% of the recorded total in 1978-9.

4.2 The Sudanese kiln - description of technique

4.2a Almost all charcoal is made in Sudanese kilns; these are cone-shaped, direct draught, earth-covered kilns which require little or no capital inputs.

4.2b Most charcoal-making is carried out in the dry season, between December and May. Wood, most commonly Acacia seyal, is prepared for the kilns during the early part of the dry season (December-January) from trees felled and cross-cut into billets 2-30 cm in diameter and 1-1.5 m in length.

4.2c Sites about 20 metres in diameter are selected for the kilns. Wood is moved to them manually; wood more than 50 metres away is often brought in by means of two-man stretchers. The billets are arranged in at least three diameter size classes (2-10 cm, 10-20 cm and over 20 cm) in concentric rings around the periphery of the sites for convenience in building the kilns.

4.2d The drying period of the wood normally varies from 15-30 days. The wood is watched for intensity of attack by insect borers (they have an adverse effect on the quality of the charcoal) which increases as the billets become drier. One entrepreneur stated that he did not like the wood to dry out for more than one month as he wished to keep his good name for quality.
4.2e The kiln base must be levelled and well-prepared with all cracks in the earth surface filled and trodden-in. An average kiln base would be about 12 m in diameter.

4.2f Construction of the kilns commences by arranging a few billets of wood into a cone at the centre of the base and the space inside filled with dry grass and twigs. The largest logs are next added all round the central cone, but making sure that a tunnel is left on one radius away from the prevailing wind to enable the kilns to be lit from the outside. Medium-sized billets are added, and finally, the kilns completed by covering them with the smallest pieces of wood packed together as tightly as possible. Typical kilns, capable of producing 300-400 sacks of charcoal, measure about 12 m diameter at the base and 3 m high at the centre and contain about 100 m³ of wood.

4.2g After all the available wood is added to the kilns, the surfaces are thatched with grass or any other similar material such as sorghum straw, to a depth of about 15 cm. Finally, soil is dug from around the kilns and thrown on to the thatch to a depth of approximately 10 cm. In cases where the ground is too hard, soil has to be brought in from a previous charcoal-burning site.

4.2h Kilns are lit by means of some burning grass or oily rag inserted, by means of a pole, into the tunnel. They are watched very carefully for 15-30 minutes to make sure that the fires do not go out or burn too fast. When well established, the end of the tunnel is blocked and draught control maintained by making holes through the soil covering or by plugging holes with wood or piling on extra soil as required.

4.2i Carbonization commences from the top of the kilns and its progress checked by observing the smoke, which is emitted gradually, first from the top and finally at a few points around the circumference of the base. Burning lasts normally for 5-15 days depending upon the size of the kiln and the moisture content of the wood. When all smoke has stopped and the kilns have shrunk to about one half of their original size, the cooling process begins.

4.2j The kilns are allowed to cool for 10 days or so before the soil is removed carefully and the charcoal raked-out into concentric rings and allowed to condition (become completely cold and at equilibrium with the atmosphere). At this stage it is essential to be ready to cover with soil any charcoal which may begin to glow. When complete cool, the charcoal is gathered up into sacks by hand, the tops of the sacks are sewn up, and the sacks stacked ready for transport to the depots.

4.2k A selection of kilns of all sizes were measured and stacked volumes of 8 m³ up to 100 m³ were calculated. Although it was not possible,
on this consultancy, to check a charcoal-making cycle right through from start to finish, from close questioning of the men it was estimated that the amount of wood required to make a ton of charcoal was less than the figure of 17 m^2 commonly quoted in the literature. It was noted that yields of charcoal would have been higher if it were possible to separate the fines (dust and small pieces below 2.5 cm diameter) from the soil and to collect it. Measurements of the volume of fines on the sites indicated that at least 10% of the charcoal produced is left behind in this way.

4.21 Very few tools and pieces of equipment were in use: trees were felled and cross-cut with light, locally-made axes. Shovels were used to throw up the soil to cover the kilns, and rakes were utilized to pull out the charcoal from the kilns. The other materials needed were sacks and string. Water was always available for emergencies although it was difficult to obtain.

4.3 Organization of the industry

The industry is well organized and a detailed account will be found in Appendix II. A brief general summary of the organization is as follows.

4.3a Entrepreneurs, usually with other business attachments, obtain permits to make charcoal in defined areas (about 200 ha) on producing evidence that they either have an entitlement to farm or have the owner's permission to make charcoal on his land. A fee of LS 100 is paid to the Forests Administration for each permit which is valid for 15 000 sacks of charcoal. Once this figure is exceeded, a further LS 100 has to be paid. Before charcoal is removed from the site, a removal pass has to be obtained from the Forests Administration for each load, calculated at the rate of LS 0.25 per sack. A further tax of LS 0.02-0.05 is levied by local administrations.

4.3b Most entrepreneurs engage agents to organize and manage the operations. Agents are given money to enable them to travel to Kordofan or Darfur to recruit charcoal-makers who are given advances for food and their fares to El Gedaref or Sennar, where they are met and taken by truck to the work sites. Agents are responsible for any losses incurred on the part of labourers who fail to pay back the loan.

4.3c Camps are established for the charcoal-makers at which the agents operate small shops for essential commodities which are supplied to the men on credit. Water at the rate of 18 litres per day per man is supplied free by the entrepreneurs for personal use. Each
man supplies his own tools but is provided with sacks and string free of charge.

4.3d Charcoal-makers are each allocated areas of about 3 hectares from which they cut the wood for their kilns which are constructed in a central place. Normally only one or two large kilns are made in the season by each man. Co-operation between charcoal-makers takes place on a reciprocal basis for difficult and heavy tasks, e.g. carrying heavy billets of wood and for preparing loads of charcoal for collection.

4.3e Each charcoal-maker is credited with a price per sack for the charcoal produced from his own kiln. The agent organizes the transport and keeps the records in order that the correct balance will be paid to each man at the end of the season. The agent is paid a commission (from which losses resulting from mismanagement are deducted) on every sack of charcoal.

4.3f During the early part of the season (January-February) arrangements are made to take the charcoal directly to Khartoum or other large market for sale. As the season progresses and the market becomes saturated, the charcoal is taken to nearby depots (up to 50 kilometres away), the sacks emptied and the charcoal made into large heaps (see photo). The charcoal is rebagged by hand at the end of the rainy season (October-December) and then sent to the market as demand rises. Depots are generally situated near the railway stations from where charcoal was formerly sent by rail before road transport became quicker and cheaper.

4.3g Some loss of charcoal occurs at the depots because of breakage and spillage during unloading and reloading operations. Rough measurements of area and depth of fines, accrued at three typical depots, indicated that these losses are sizeable:

<table>
<thead>
<tr>
<th>Depot</th>
<th>Estimated tons charcoal fines</th>
</tr>
</thead>
<tbody>
<tr>
<td>El La Kandia</td>
<td>140</td>
</tr>
<tr>
<td>Dinder</td>
<td>2600</td>
</tr>
<tr>
<td>Harun</td>
<td>500</td>
</tr>
</tbody>
</table>

4.4 Costings and marketing

4.4a Several entrepreneurs were interviewed for information on costs. An average break-down of costs for various components, which go towards
the final price of a sack of charcoal in the market, is given for entrepreneurs employing 20-50 men producing 8 000-20 000 sacks of charcoal per year.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost per sack LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>labour</td>
<td>1.50</td>
</tr>
<tr>
<td>agent</td>
<td>0.25</td>
</tr>
<tr>
<td>water</td>
<td>0.40</td>
</tr>
<tr>
<td>sacks</td>
<td>0.70</td>
</tr>
<tr>
<td>transport to depot</td>
<td>0.40</td>
</tr>
<tr>
<td>loading/unloading</td>
<td>0.20</td>
</tr>
<tr>
<td>royalty</td>
<td>0.27</td>
</tr>
<tr>
<td>transport to Khartoum</td>
<td>1.87</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5.57</strong></td>
</tr>
</tbody>
</table>

4.4b In Khartoum, the price per sack wholesale was LS 6.00-6.50 and the price per sack retail was LS 7.00 (controlled). Charcoal is often sold in small quantities by volume and when sold in this manner the price per sack is more than doubled.

4.4c The size of the market for charcoal has been variously estimated by several different writers. Using Forests Administration records as a guide and adding about 90% for charcoal produced and sold illegally, the market is probably in the region of 12 million sacks per year. This market is worth LS 84 million at the present controlled price of LS 7.00 per sack. Checks on sacks of charcoal indicated that the weight of charcoal per sack is now less than it was more than 10 years ago. The reason for this appears to be that the sorghum sack, used now, is smaller than those made for cotton-carrying, once in general use. The conversion factor for calculating charcoal tonnages normally 22:1, is more likely to be nearer 27:1. The charcoal market size is therefore likely to be about 500 000 tons, i.e. between 444 000-545 000 tons. MUKHTAR (1982) estimated that charcoal production in 1978-9 was 472 000 tons calculated from 8.4 million sacks (4.4 recorded and 4.0 unrecorded). His estimate, based on 18 sacks per ton, appears to be too high. The NAE (1983) gives a figure of 2.4 million tons for charcoal consumption in 1982-3 which is much higher. This latter figure was based on household consumption surveys.
5.1 The present raw material supply

5.1a Over 80% of the charcoal marketed in Sudan is manufactured in the Blue Nile and Kassala Provinces by well-organized Sudanese business firms.

5.1b The principal tree used for charcoal is *Acacia seyal* though other *Acacia* species and other genera, e.g. *Balanites*, are also utilized. *A. seyal* regenerates freely if protected and would be an ideal species for sustained charcoal production. *Balanites* produces good timber and was formerly protected; it should not be cut down and converted to charcoal. The charcoal production sites are becoming further away from depots and markets and in some cases have reached the Ethiopian border, e.g. in the El Gergaf area in Kassala district, more than 400 kilometres from Khartoum. A discussion of the present and proposed charcoal production areas for the Blue Nile Province is included in Appendix II.

5.1c The location and scale of the operations are, in theory, controlled by the Forests Administration which issues permits and removal passes to licenced entrepreneurs to make specified amounts of charcoal on land which it is planned to convert into rain-fed mechanized agricultural farms.

5.1d In practice, the Forests Administration is unable to keep a check on the precise location of the charcoal operations because it has insufficient staff with transport, to patrol these very remote areas. Much of the charcoal produced is illegal in the sense that it may have come from areas outside those agreed by the Forests Administration, though it is legal inasmuch that the entrepreneurs pay for the permit and removal passes and the production is recorded.

5.1e Fully illegal charcoal production takes place outside the areas allocated for mechanized farming, frequently in the riverain or forest reserves.

5.2 The future raw material supply

5.2a In the savanna areas planned for rain-fed mechanized farming, lease-holders are commonly allocated about 630 hectares of land of which they are required to leave a belt of trees around the boundaries. In practice, this does not occur because the charcoal-
makers are not told which trees to leave and do not have any maps showing the boundaries, and the farmers want to maximize their profits from the concessions by growing crops right up to the boundary. Thus no attempt is made to save the trees which are supposed to be left between farms.

5.2b Charcoal-makers leave some small trees, especially Balanites, because the amount of work involved in conversion makes it uneconomic to cut them.

5.2c Some of the larger companies with concessions of 4000 ha prefer to clean the land themselves mechanically, and this requires that the trees should remain standing in order that they can be uprooted and dragged into windrows to be dried-out and burnt. These companies do not want charcoal-makers to cut down the trees, ahead of their own operations, as this makes it more difficult to clean the land. This type of land-clearing results in wastage of fuel and the creation of vast plains with no trees for charcoal in the future.

5.2d The savanna area, made available for rain-fed mechanized farming, is very large but finite: it is estimated that this source of raw material for future charcoal supplies will disappear in ten years time (see Appendix V).

5.2e Less than 1% of charcoal is being produced on a sustained basis, to an agreed plan of operation, from some forest reserves. The amount of charcoal from these sources could be increased but would need more land to be allocated to forestry if the growing stock in the reserves is not to be depleted.

5.2f A growing stock increment of 3.5 million m³ per year would be needed to sustain the charcoal market, at the 1983 level, of 500 000 tons (7 m³ per ton). The present forest estate of about 1.3 million hectares for the whole country has an estimated increment of only 1.5 million m³ from which supplies of fuelwood, poles and timber have to be met: so it is clearly inadequate to meet the expected potential demand for charcoal. Another 1.7 million hectares of forest reserves should be gazetted within the next 5 years to bring the total up to a minimum of about 3 million hectares if the target is to be met.
6.1 Conclusions

6.1a The Sudanese charcoal industry has developed over a very long period and the organization and techniques evolved have ensured that production costs and profit margins are reasonable.

6.1b The Sudanese kilns, as operated in legal operations, are more efficient than those seen working under illegal conditions, and similar kilns used in many other countries for three main reasons.

1) The wood is well-prepared and packed closely in the kilns to minimize air spaces.

2) The kilns are carefully watched by the operators who stay in the field throughout the whole carbonization cycle, e.g. the charcoal-makers move their beds to the kiln during the critical period; this cannot be done in the case of illegal operations. In other places labourers tend to leave the job at the end of the working day, e.g. forestry staff on day work.

3) The kilns are built to a very large size (producing between 150-500 sacks) thus reducing the proportion of charcoal contaminated by the soil used as covering.

6.1c The 'depot system', introduced by the entrepreneurs, has safeguarded the industry against damaging recessions and ensured that supply and demand are in balance and the price of charcoal fully competitive with the price of other available fuels.

6.1d This report suggests some marginal technological improvements for fairly rapid trial and possible early implementation; and some more radical solutions for extended trial by a research and development team working in conjunction with a co-operative entrepreneur.

6.1e Any alterations to the organization and techniques will have to be tested and proved in the appropriate environments and followed-up with demonstration and training to procure acceptance. Such alterations will have to take into account the social effects of change on many skilled artisans employed in the industry, whose earnings represent an important means of income distribution in the economy.

6.1f It is in the area of testing, demonstration and training that outside agencies can provide invaluable assistance in bridging the gap between traditional, well-tried practices and modern and/or exotic techniques, the latter often regarded with justified suspicion by those whose
money is at stake.

6.1g The amount of charcoal produced is carefully recorded in the field during the process of issuing permits and removal passes. There appears to be some problem in getting this information together at national level and improvement is required.

6.2 Recommendations

6.2a Wood transport in the forest is time-consuming and imposes a constraint upon the final size of the kilns because of the rising cost of moving wood as the distance away from the kilns increases. Trials could be conducted by a field team at one of the main charcoal-making areas. Courses for people interested in the use of draft animals are being run by the Western Sudan Agricultural Research Project at El Obeid. This project has offered training assistance.

It is recommended that the use of draft animals with sledges or two-wheeled carts for hauling the wood to the kilns be investigated on a trial basis.

6.2b Skilled workers harvest the charcoal by hand, putting it into sacks; this is very dusty work. The health hazard could be reduced if face-masks were worn and the time spent could be shortened by using 2.25 cm square-mesh or 2.5 cm diameter circular-mesh sieves.

It is recommended that a suitable sieve be constructed together with stand and container attachment, and given a trial by a field team working in conjunction with a co-operative charcoal-maker.

6.2c Some recovery of water, wood oil and tar could be obtained from the Sudanese kilns by the introduction of chimneys, made from old oil drums, as tried out successfully at Casamance, Senegal. Receptacles to receive the liquid are placed in holes in the ground under the chimneys which act as condensers. Some slight alteration to the carbonization technique will be necessary, e.g. top lighting, but the necessary changes would not require a departure from the main structure of the kilns. The water could be used for quenching accidental charcoal fires and the oil and tar collected and tested for possible use as wood preservative.

It is recommended that recovery of liquid by-products be attempted and that an expert, familiar with the use of the Casamance kiln, be hired for a period of one month to undertake a trial.
6.2d It is estimated that 25-30% of charcoal fuel is lost as fines, in the forest (where it is mixed with soil), at the depots, in the markets and in the kitchens. The profitability of the charcoal industry could be improved, with possible savings to the consumer, if the charcoal fines were sold cheaply to be utilized as fuel. Charcoal fines from the depots could be burnt in modified sawdust stoves or could be pelletized or briquetted (using a local binder) for domestic or industrial use.

It is recommended that a consultant be recruited to organize the manufacture of a simple pelletizing machine to be tried out at one of the charcoal depots, to advise on the purchase of a small briquetting plant and to introduce suitable stoves for burning charcoal briquettes and fines.

6.2e If charcoal were to be made in fixed kilns at the depots, loss of fines at field sites could be eliminated. The benefits, in addition to easily recovered clean fines, would be that wood could be brought to the site and stacked for carbonization during the rainy season. Fixed kilns would yield better quality charcoal and recovery of some oil and tar would also be easier. The Transportation of the wood from the forest to the kilns would be more expensive than the transportation of charcoal to the depots but the extra costs would most probably be outweighed by the benefits outlined above. It would not be fair to expect an entrepreneur to pay the costs of constructing a fixed kiln for a trial but it would be reasonable to obtain his co-operation in bringing in wood for the exercise. If successful, similar kilns could be built in the vicinity of forests operating under management plans for fuel production.

It is recommended that a fixed kiln be constructed at a charcoal depot and given a trial in co-operation with an entrepreneur.

6.2f Throughout this consultancy it was noted that some of the conversion factors used to estimate the quantities of forest products required to make charcoal were not up-to-date or were inaccurate. The following parameters and conversion factors for Acacia seyal need to be checked:

- volume $m^3$ per ha - at different ages
- $m^3$ solid wood - per $m^3$ stacked
- number $m^3$ solid wood - per ton charcoal
- number tons solid wood - per ton charcoal
- number tons stacked wood - per ton charcoal
- weight charcoal - per standard sack
- number sacks charcoal - per ton charcoal
It is suggested that the calculations be made from 20 samples x 2 kiln sizes x 4 sites, i.e. 160 results. The crop volumes for *Acacia seyal* at different ages should be determined by felling and measuring the trees from at least 30 plots each of 0.1 ha; the yields and estimates of the costs of growing trees for charcoal can then be made. This information is vital for planning purposes.

It is recommended that the parameters and conversion factors for charcoal from *Acacia seyal* be checked and the results made available as a report or booklet as soon as possible.

6.2g In order to bring information on charcoal production quickly to the attention of the Government for planning purposes, it is necessary for the record-keeping system to be improved. The following information should be collected monthly at Provincial offices and sent to the Regional offices:

- number sacks of charcoal removed
- location
- fees paid
- market price

The Regional offices should summarize the provincial information which should be sent to the Central Forests Administration which should summarize regional information and:

- make consumption surveys
- indicate employment patterns
- derive trends
- make the data available in their annual report for monitoring and planning purposes.

It is recommended that data collection and analysis of the charcoal sub-sector at Provincial, Regional and Central Forests Administration be strengthened.

6.2h It has been noticed that in the process of land conversion to mechanized farming, no belts of trees were left or planted. It was further noted that the fertility of the rain-fed farming soils falls-off each year to a point where it is left as fallow. In such areas *Acacia seyal* often recolonizes the sites but is usually cut down and burnt before it can produce a useful fuel. It is not known how long land should be left fallow in order to enable a crop of fuel to be harvested. It is possible that the introduction of *Acacia seyal* for the production of gum arabic and fuel on fallow lands would be beneficial.
It is recommended that a cost-benefit study is made of the areas under conversion to farms with the object of quantifying the costs and benefits of introducing agro-forestry techniques into these areas.

6.2i It was noted that illegal charcoal-makers were operating in forest reserves, it is suggested that the wider interest could be served if such operations could be legalized in fuel-deficient areas.

It is recommended that those forest reserves in fuel deficient areas should be identified and management plans produced so that they can be thrown open to sustained fuel production.

6.2j If the charcoal industry is to expand to meet future demand or even to be able to survive, on its present scale, for more than another few years, it is vital that a secure growing stock for its future raw material needs is assured. The present area of forest reserve, even if it were all to be devoted to charcoal production, would not provide even half of present effective demand from increment. The establishment of fast-growing plantation although desirable is difficult, slow and expensive. For these reasons

It is recommended that the decision of the second agricultural conference (1976) to devote to forestry 10-15% of land allocated to both irrigated and mechanized farming schemes should be implemented.

6.2k To ensure compliance with this decision which is considered to be vital to the economy of this country:

It is recommended that a commission be set up composed of people concerned with the future of land available for farming, to advise the Government of Sudan on the appropriate criteria and procedures needed to ensure that speedy action is taken to allocate the 10-15% of land to forestry.

6.2l The present system of payment of fees on the sacks of charcoal removed from the sites does not encourage the manufacture of charcoal by those large farming corporations to which the profits from charcoal-making are relatively insignificant. It would be preferable to 'encourage' such corporations to save energy by charging a fee for land to be cleared of trees on the assumed potential yield of charcoal. This fee should be calculated at LS 0.45 per sack and paid in advance, with a further LS 0.05 per sack to be paid to the Forests Administration on application for a removal permit.

It is recommended that fees be paid to the Forests Administration on the estimated potential yield of charcoal from all areas in excess of 4000 ha being cleared for farming and that the money collected should go into a revolving fund for the Forests Administration to improve the control of charcoal operations.
6.2m Illegal charcoal-makers are usually wasteful of resources and do not pay taxes for the improvement of community services.

It is recommended that if recommendations 6.2i, 6.2j, 6.2k and 6.2l are accepted, more Forest Guards are recruited to live near the Forest Reserves and that much tougher penalties are imposed on illegal charcoal-makers to discourage their activities.

6.2n Portable metal kilns have a part to play in the Sudanese charcoal industry because of their efficiency, mobility and speed. Because of their comparatively small size they should be regarded as complementary to, rather than as replacements for, the Sudanese kilns or the proposed fixed kilns. Portable metal kilns can be used to clean-up relatively small amounts of wood and can often be used in situations where larger kilns would do damage, e.g. in forest reserves or plantations. Portable kilns are ideal for supplying selected charcoal for specific purposes and for training.

It is recommended that a training programme for charcoal industry workers and forestry technicians should be initiated in a forest reserve using portable kilns which should also supply samples for testing and research.

6.2o Information on the chemical and physical properties of charcoal is required before it can be utilised as an industrial raw material.

It is recommended that a laboratory should be established at the Forest Research Centre, Soba, to carry out chemical and physical analyses of selected charcoals produced in Sudan.
APPENDIX I

TERMS OF REFERENCE FOR CONSULTANT ON CHARCOAL PRODUCTION

Objectives:

1) To assist in establishing a base of knowledge concerning the traditional methods of charcoal production practiced in the various charcoal-making areas in Sudan.

2) To set guidelines for further work on improving production methods to be carried out by the Sudan Renewable Energy Project, the FAO Forestry Project, and other related activities in Sudan.

Activities/Tasks:

1) Meet with officials from the Central Forests Department, the National Energy Administration, and other agencies working on charcoal production. Review literature available on the charcoal production in Sudan.

2) Accompany the SREP local consultant on a study of traditional methods of charcoal production in the Blue Nile Province from 13 to 27 January 1984 (Subsequently revised dates - from 22 January to 2 February 1984).

3) Travel to the Kassala, Upper Nile, and Southern Kordofan Provinces to examine the other principal charcoal sources for the Central area of Sudan. Examine charcoal operations there and note any differences between these and Blue Nile Province operations.

4) Return to Khartoum to produce report.

5) At some point during consultancy, give a public talk organized by SREP on his work on improved methods of charcoal production elsewhere.

Outputs:

1) Report containing: Map indicating present areas of charcoal production, types of land used for this production (Forest reserve, heads designated for clearfelling for agricultural production, etc), and comparison with lands allocated for this purpose approximately 10 years ago.

   - Analysis of traditional methods of production, indicating local and regional variations.

   - Discussion of existing Forest Department System for monitoring and regulating charcoal production and its limitations.
- Recommendations for follow-up work modifying and improving traditional production methods.

- Recommendations for improving the Forests Department System for monitoring and regulating charcoal production.

2) Analysis of manpower involved in work in this area, and recommendations for co-ordination and distribution of effort between Sudanese Government and donor agencies in charcoal production, management and improvement.

3) Outline program for extension/dissemination of improved production methods.

4) Outline methods of testing charcoal kiln performance and list measuring equipment necessary.

Timetable:

2 - 3 months consultancy, to begin no later than 10 January 1983.

Counterparts:

1) Dr Hassan Osman Abd El Nour, Forest Ranger Technical College (former Conservator of Forests, Blue Nile Province, and local consultant for analysis of traditional production methods in Blue Nile Province).

2) Dr Taj El Din Nasrcon, Head, Timber Technology Section, Forests Research Centre.

3) FAO Fuelwood Project, Charcoal Production Specialist.

4) Local and regional Forests Department officials to be identified by the consultant. (Assistance can be obtained here from Hamza Hamoudi, SREP Forestry Advisor.)
APPENDIX II

ITINERARY

January 1984

10 Left London.
11 Arrived Khartoum.
12 Introductions and meetings with SREP staff.
13 Planning the consultancy.
14 Left Khartoum, arrived Kassala.
15 Forest Office and field visits.
16 Forest Office and market survey.
17 Left Kassala, arrived Gedaref.
18 Left Gedaref, arrived Wad Menani Forest Office. Visited illegal charcoal operations.
19 Left Wad Menani, arrived Khartoum.
20 Research and discussions, Khartoum.
21 Forest Research Centre, Soba.
22 Left Khartoum, arrived Sennar - Forest Office.
23 Left Sennar, arrived Wad El Nail Forest Office.
24 Visits to legal charcoal operations.
25 Visits to legal charcoal operations.
26 Visits to legal charcoal operations.
27 Left Wad El Nail, arrived Damazine, Chief of Party arrived by air.
28 Forest Office and Finnish Forestry Project.
29 Left Damazine, visited charcoal operations, arrived Daiwa.
30 Left Daiwa, arrived Dinder.
31 Visited charcoal depot. Left Dinder, arrived Khartoum.
February 1984

1 Visited USAID. Meetings with technical staff.

2 Forestry Administration meeting with Utilisation Officer and FAO Project Manager.

3 Research at SREP office.

4 Meeting Director Forests Administration Headquarters. Meeting at Forest Research Centre, Soba.

5 Meeting Western Sudan Agricultural Research Project.

6 Meeting SREP.

7 Market survey Khartoum and Omdurman.

8 Meeting SEP.

9 Meeting Wood Technologist, Soba.

10 Research and discussions.

11 Examined and tested charcoal stoves.

12 Outlined report for discussion with Chief of Party.

13 Meeting Director NEA.

14 Writing draft report.

15 Writing draft report.

16 Draft report circulated for comments by SREP staff.

17 Draft report comments discussed with SREP staff.

18 Meeting SREP.

19 Visited SREP Project, Seleit.

20 Left Khartoum, arrived London.

21-29 Finish and print 100 copies of final report.
# APPENDIX III

## PEOPLE CONTACTED IN SUDAN

<table>
<thead>
<tr>
<th>Name</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dr Hassan Wardi Hassan</td>
<td>Director, Energy Research Council</td>
</tr>
<tr>
<td>Dr Ahmed Hassan Hood</td>
<td>Co-ordinator, SREP</td>
</tr>
<tr>
<td>Gaafar El Faki Ali</td>
<td>Assistant Co-ordinator, SREP</td>
</tr>
<tr>
<td>Dr Yahia Hassan Hamid</td>
<td>Head, Technology Development and Implementation Section</td>
</tr>
<tr>
<td>Hamza Hamoudi</td>
<td>Chairman, Energy Research Council</td>
</tr>
<tr>
<td>Donal B Peterson</td>
<td>Forestry Advisor, SREP</td>
</tr>
<tr>
<td>Matthew S Gamser</td>
<td>Chief of Party, SREP (Georgia Tech)</td>
</tr>
<tr>
<td>Lester Bradford</td>
<td>Energy Economist, SREP (EDI)</td>
</tr>
<tr>
<td>El Tayeb El Bashir</td>
<td>Forestry Consultant, SREP (EDI)</td>
</tr>
<tr>
<td>Shadia Naser Eldin</td>
<td>Mechanical Engineer, SREP</td>
</tr>
<tr>
<td>Dr Abdul Rahman Shulli</td>
<td>Charcoal Stove Project, RERI</td>
</tr>
<tr>
<td>Dr Abdul Rahim Ahmed Belal</td>
<td>Director General, NEA</td>
</tr>
<tr>
<td>Dr C Frank Laukaram</td>
<td>Consultant, NEA</td>
</tr>
<tr>
<td>Paul F Cough</td>
<td>Consultant, NEA (EDI)</td>
</tr>
<tr>
<td>Mark Dawdon</td>
<td>Field Manager, Sudan Energy Policy and Planning Project (EDI)</td>
</tr>
<tr>
<td>William Taylor</td>
<td>Reservoir Economist, Consultant, NEA (EDI)</td>
</tr>
<tr>
<td>Abu Bakr Abdel Rahman Kamil</td>
<td>Consultant, NEA (EDI)</td>
</tr>
<tr>
<td>Ali Ahmed Saleem</td>
<td>Director, Forests Administration</td>
</tr>
<tr>
<td>Mubarak Ahmed Awad Karim</td>
<td>Chief of Afforestation, Forests Administration, Co-Director, FAO</td>
</tr>
<tr>
<td>Kamal Mohamed Osman Satti</td>
<td>Project Manager, Fuelwood Development in Sudan (FAO)</td>
</tr>
<tr>
<td>James B Ball</td>
<td>Director, Forest Research Centre, Soba</td>
</tr>
<tr>
<td>Name</td>
<td>Position/Position Details</td>
</tr>
<tr>
<td>-------------------------------------</td>
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</tr>
<tr>
<td>Dr Hassan Osman Abd El Nour</td>
<td>Head of Entomology &amp; Forest Protection, FRC, Soba</td>
</tr>
<tr>
<td>Dr Tag El Din Nasroun</td>
<td>Head of Wood Technology, FRC, Soba</td>
</tr>
<tr>
<td>Abdel Rahman El Gorashi</td>
<td>Director Natural Resources, Eastern Region Government</td>
</tr>
<tr>
<td>Abul Gasim Mohamed Suliman</td>
<td>Senior Conservator of Forests, Blue Nile Province</td>
</tr>
<tr>
<td>El Tayeb Ahmed Abdalla</td>
<td>Conservator Forests, Gedaref, Blue Nile Province</td>
</tr>
<tr>
<td>Ahmed El Tayeb Ibrahim</td>
<td>Conservator Forests, Singa, Blue Nile Province</td>
</tr>
<tr>
<td>Ibrahim Said Bregaie</td>
<td>Conservator Forests Utilisation, Blue Nile Province</td>
</tr>
<tr>
<td>Umran B El Tahir</td>
<td>Assistant Conservator Forests, Roseires, Blue Nile Province</td>
</tr>
<tr>
<td>Ali Mohamed Osman</td>
<td>Forest Officer, Suki, Blue Nile Province</td>
</tr>
<tr>
<td>El Hag Makki Awouda</td>
<td>Assistant General Manager, Gum Arabic Corporation</td>
</tr>
<tr>
<td>Dr James J Riley</td>
<td>Senior Advisor, Western Sudan Agricultural Research Project</td>
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<tr>
<td>Eric N Witt</td>
<td>Agricultural Development Officer USAID</td>
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<tr>
<td>Jay B Carter</td>
<td>Energy Advisor, USAID (EDI)</td>
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<td>E S F Martella</td>
<td>Agricultural Economist USAID</td>
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<tr>
<td>Dr K Scharmen</td>
<td>Energy Consultant, SEP</td>
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<td>Y Schildt</td>
<td>Director of Development, Finnish Forestry Project</td>
</tr>
<tr>
<td>Maxwell Kinyanjui</td>
<td>Consultant, SREP (EDI)</td>
</tr>
<tr>
<td>Kamal Osman Khalifa</td>
<td>Director, Tree Planting Project, Sudan Council of Churches</td>
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</tbody>
</table>
APPENDIX IV

BIBLIOGRAPHY


APPENDIX V

REPORT ON

CURRENT CHARCOAL PRODUCTION COMPONENTS IN THE BLUE NILE

by

Dr Hassan Osman Abd El Nour
Forester/Entomologist
INTRODUCTION

Sudan has a population of 21.6 million persons. 20% of the population is urban, 69% is rural and 11% is nomadic. 8.7% of the total population resides in the Three Towns making up the capital (Khartoum, Khartoum North and Omdurman). The total population grows at an average of 2.8% per year. (Anon 1983)

The country is administratively divided into 18 provinces which are grouped into eight regions besides the capital.

Since 1973 the country is facing energy crises which are growing increasingly severe. Petroleum imports are becoming more difficult to obtain as foreign exchange becomes increasingly scarce. Disruptions in, and shortages of, power supplies are negatively affecting the national economy as industries curtail production for want of energy or turn to self-generation, thereby increasing demand on scarce petroleum resources. Rapid deforestation is causing severe short-term economic effects as the price of charcoal and wood products rise above the means of many. Its long-term soil deterioration effects seem likely to threaten the agricultural base of many currently productive provinces (SNEA 1983).

In 1980 the country consumed energy equivalent to slightly less than 7 million tons of oil equivalent (TOE). 77% of this was in the form of fuelwood (firewood and charcoal); 8% as other biomass (agricultural residues, dung etc); 14% as petroleum products and 1% as hydropower.

The wood and charcoal consumed in 1980 amounted to 68 million m$^3$ (stacked), which represented 3.4% of the total growing stock and was 23 million stacked m$^3$ in excess of the allowable cut (Op. cit).

In the short to medium term, the fuelwood resource will continue to be the most important resource (UNDP/World Bank 1983).

The energy crisis, as regards fuelwood, is accentuated even more by the considerable imbalance between fuelwood resources and population concentrations. A third of the total population resides in the urbanized, fuelwood deficit provinces of Gezira, White Nile, Khartoum, Red Sea, Nile and Northern. Although their total fuelwood consumption in 1980 came to 20 187 000 m$^3$, (30% of the country's total), their charcoal consumption accounts for 16 416 000 m$^3$ (37% of the country's total) due to differences in per capita consumption of charcoal and firewood in rural and urban areas. The wide arc from which they draw their requirements of fuelwood (referred to by Foggie (1967)) which extends from Gadaref in Kassala, across the Blue Nile, White Nile and North Kordofan provinces, is getting depleted and the distance of haul
is increasing.

The present study was proposed for current charcoal production components in the Blue Nile Province because:

A. The Blue Nile Province is the main source of fuelwood, particularly charcoal, for the conurbation of the Three Towns and the Gezira; and

B. It was thought that conversion figures such as metre cubes of stacked wood into charcoal, sacks of charcoal/ton and kantars/stacked metres of wood, upon which recent consumption levels were based, were outdated.

CONVERSION FACTORS IN THE LITERATURE

Foggie (1967) reviewed the literature on per capita consumption studies. He referred to the works of Kippling (1950), Jackson (1960), Department of Statistics (1963) and Saini (1964).

With regard to conversion factors:

Jackson (1960) based his fuelwood consumption figures on small quota sampling carried out to estimate the National Income of the Sudan in 1955-6. He pointed out that the figures obtained were liable to a considerable margin of error due to the fact that people in rural areas did not keep accurate records of fuelwood consumption. He considered 1 ton of fuelwood as equivalent to 3.3 stacked m³ based on Forest Department checking of fuelwood transport by rail. Out of these he extrapolated the figure of 17 stacked m³ of fuelwood per ton of charcoal.

Saini (1964) quoted the Assistant Conservator of Forests, Khartoum in that

\[
\begin{align*}
1 \text{ camel load of fuelwood} &= 4.0 \text{ Kantars} = 0.44 \text{ m}^3 \\
1 \text{ donkey load of fuelwood} &= 1.5 \text{ Kantars} = 0.17 \text{ m}^3 \\
1 \text{ head load of fuelwood} &= 0.5 \text{ Kantars} = 0.03 \text{ m}^3
\end{align*}
\]

He also quoted Jackson's figure of one ton charcoal = 17 m³ of stacked wood, and that one m³ stacked = 0.71 m³ of solid wood. Saini did, however, warn that his figures were at least subjective estimates in view of the time and resources available for their collection.

Foggie (1967) used the figure of 1 m³ stacked firewood as equivalent to
0.71 m³ solid in round overbark; that 1 sack of charcoal averaged 110 rotles, i.e. 20 sacks to 1 metric ton. He also quoted the figures of 17 m³ stacked to equal 12.07 m³ solid to yield 1 metric ton of charcoal. He considered that 1 m³ solid of *Acacia nilotica* and *Eucalyptus microtheca* weighed 0.96 metric ton.

The National Energy Administration (1982-3) assumed that under conditions prevailing in much of Sudan, 1 metric ton (MT) of dry fuelwood is equivalent to 3 m³ of growing stock and that it requires 6 MT of wood to yield 1 MT of charcoal. Therefore, the growing stock equivalent of 1 MT of charcoal is 18 m³.

Bayoumi (1983) used the figure of 17 m³ stacked to produce 1 ton of charcoal.


**TERMS OF REFERENCE**

The Sudan Renewable Energy Project agreed to support the proposed study so as to yield the following outputs:

a) a map of existing charcoal production activity in the area surveyed;

b) a map of charcoal production activity in the period approximately 10 years ago;

c) a system for differentiating among and categorising charcoal production operations in terms of relative quality;

d) the application of this system to classify the production operations surveyed and the selection of a representative sample of these for future quantitative analysis.

**FIELD WORK**

Field work commenced on 22 January 1984 and terminated on 31 January 1984.

The field mission comprised Dr D E Earl, Consultant Economist - Forest Energy; Mr Kamal Sati, a Counterpart designate to an FAO Charcoal expert; the consultant Dr H O Abd El Nour, a forester/entomologist. On 27 January the group was joined by Mr Donald B Peterson, Chief of Party, SREP.
Itinerary

22 January 1984

Left Khartoum to Wad Medani, administrative capital of Central Region. Paid a courtesy visit to Regional Ministry of Agriculture and Natural Resources. Discussed mission programme with Sayed Yahia Ibrahim Bushara, Director of Natural Resources, who kindly furnished the party with a letter to the Chief Conservator of Forests, Blue Nile, requesting him to yield information on the matter as might be necessary. Night at Sennar; Headquarters of Blue Nile Forests Administration (BNFA).

23 January 1984

Conferred with Chief Conservator of Forests, Blue Nile Province, Sayed Abul Gasim Mohamed Suleiman and Utilization Officer, Sayed Ibrahim Seedi Beraigie. Discussed the party's programme. Issued an itinerary which was dispatched by the Chief Conservator to Forest Circles to be visited. He requested the Conservators of these Circles to prepare relevant information on the subject according to format agreed upon. Collected information on charcoal production over past decade. Transcribed past, current and projected production sites.

Arrived Singa; Headquarters of Northern Fung Forest Circle. Conferred with Conservator in charge, Sayed Ahmed El Tayeb Ibrahim, who kindly escorted the party to Wad El Nail. On the way to the latter the party called at Abu Hugar. Interviewed biggest entrepreneur in the business, Sayed Ahmed Suleiman Abd El Mageed (Al Arabi), whose annual production is in excess of 100 000 sacks. Because Abu Hugar is the check-point commanding all charcoal hauled from west of the Nile, their removal pass book for the year 1980-1 was borrowed for analysis. That of Sennar Dam check-point, commanding transport east of the Nile was also borrowed for the purpose. Night at Wad El Nail.

24 January 1984

Visited charcoal burning site west of Wad El Nail, accompanied by Conservator of Forests Sayed Ahmed El Tayeb Ibrahim and Forest Officer Sayed Mohommed Adam Abd El Hamid. Inspected several kilns at various stages of readiness, measured external dimensions of stacked kilns of various sizes, witnessed various operations such as charcoal withdrawal, packing, loading, etc. Randomly sampled weight of some sacks together with that of a stacked cubic metre of wood. Collected specimens from current season's wood immediately prior to charring and freshly felled wood for purposes of moisture content determination. Interviewed a small entrepreneur, Sayed Ahmed El Nour (produces 10 000-15 000 sacks/annum). Interviewed several workers and noted tools and utensils used. Production of measured kiln, as estimated by owner, was noted and the actual production of some kilns was requested from the entrepreneur who promised to provide it when ready. Night at Wad El Nail.
25 January 1984

Consultant returned to Sennar, attended a meeting there, collected further information and returned to Wad El Nail in the evening together with Utilization Officer Sayed Ibrahim S Beraigie who accompanied the party for the rest of the mission.

Night at Wad El Nail.

26 January 1984

Visited a 25,000 feddan private mechanized farming scheme; that of Kamal Gar El Nubi, where wood felled late in the summer of 1983 was being converted to charcoal. Kilns at various stages were inspected, external dimensions of some were taken together with production estimates. Actual production of some was requested from entrepreneurs. Specimen sacks were weighed together with a stacked $\frac{1}{3}$ m$^3$. Interviewed an agent of the entrepreneur and several workers. Back at Wad El Nail in the evening an entrepreneur, well established in the business, Sayed Osman Abdalla was interviewed.

Night at Wad El Nail.

27 January 1984

Visited a check-point, charcoal depot and production sites around Haroun railway station. Interviewed an entrepreneur new in the business and using powersaws for felling, Sayed Zein El Abdin Abbas. Inspected various sized kilns at various stages. Weighed specimen sacks at production sites and at depot. Interviewed several workers. Mr Donald B Peterson, Chief of Party SREP, joined the group and stayed for the rest of the mission.

Night at Damazine, Headquarters for Southern Fung Circle.

28 January 1984

Conferred with the Conservator of Forests in charge, Sayed Umran B El Tahir. Collected relevant information. Visited Khor Dunia forest where some Eucalyptus provenances were being tried under rain conditions. Also visited Rosieres Dam and Rosieres forest research nursery. The party was briefed by the consultant on current and projected agricultural expansion in the Province using a map depicting those. The Chief of Party SREP agreed to meet the cost of a small-scale map transcribed from the original and a draftsman was chartered to carry out the task.

Night at Damazine.

29 January 1984

Left early morning for Soallil Range. Visited charcoal production area north east of Roseires. Production just started in earnest and some kilns at the stacking stage were of large size and are expected to yield about 900 sacks. Collected wood specimens for moisture content determination and interviewed some workers. Visited Soallil Forest.
Reserve. The group was escorted by the Conservator in Charge, Sayed Omran B El Tahir, and Forest Ranger, Bashir El Siddig.

Night at Daiwa where Sayed Omran departed.

30 January 1984

Left early morning for Bunzuga, Suki Forest Circle and met Forest Officer Sayed Ali Mohamed Osman and Forest Ranger Hag Geili Mohd. Visited Bunzuga Forest Reserve. Visited Kardus production area. Production just started and the area is not expected to produce much charcoal this or following seasons. Visited part of Okalma Forest Reserve, one of the areas set aside for future charcoal supply. Interviewed some workers. Visited Allakandi Charcoal Depot and weighed some sacks.

Night at Dinder, Headquarters of Dinder Forest Circle.

31 January 1984

Conferred with forest staff, Forest Officer Osman El Sheikh and Forest Officer Mohamed Ali Abdalla. Visited one of the largest charcoal depots in the country, by Dinder Railway Station. Weighed some sacks and interviewed some workers. Interviewed the oldest entrepreneur in the business, Sayed Mohd. Abdel-Rahim who started in 1945. Also interviewed entrepreneur Sayed Abdel Ati Mohgoub. Proceeded to Suki sawmill, next to Sennar and then to Khartoum, arriving there at 22.00 hours.

The group was unable to visit the production site of Dinder Forest Circle

a) due to the fact that the production had only just started there

b) the group crossed roads with the Conservator, Sayed Izz El Din Saeed who left the night before to meet us at Bunzuga.

THE BLUE NILE PROVINCE AND ITS NATURAL RESOURCES

The Blue Nile Province, with administrative Headquarters at Damazine is one of three provinces making up the Central Region; the other two being Gezira and White Nile.

It has a population of 1.06 million persons and an area of 63,000 square kilometers. It lies between longitude 33° and 35° 30' E and between latitude 13° and 9° 30' N. It is bordered on the north by the Gezira Province, on the east by Kassala Province and the Ethiopian border, on the south by Upper Nile and on the west by White Nile Province.
Except for the Ingessina Hills in the south-east and a few inselbergs, the terrain in most of the Province is flat, gently sloping north and north-east. The most salient feature in the Province is the Blue Nile and its tributary, the Dinder River.

In the flat uniform plains, making up the greater part of the Province, the soils are dark cracking clays (cotton soils). These appear to be alluvial in origin, from soils transported by the Blue and White Niles, but some may have been formed in situ from basalt rocks. Those soils are alkaline (pH 9) and have a high clay content (60%). On drying, these soils shrink considerably and a network of wide and deep cracks is formed. At the onset of the rains, water penetrates the soils through these cracks which then close up so that the soil when moist is practically impermeable (Harrison & Jackson 1958).

On and around the rocky hills the soils are of clay formed in situ together with boulders. Along the Blue Nile and tributaries the soils are deep, alluvial sandy loams and silts.

The rain falls between July and October and varies from 300 mm per year in the north to 800 mm in the south.

Ecologically the Province falls within the woodland savanna with three distinct vegetation associations: (Op cit)

(i) **Acacia mellifera** thornland on dark cracking clays alternating with grass areas (rainfall 400–570 mm/year). Associated with the dominant *A. mellifera* are *Cadaba* spp., *Boscia senegalensis*, *B. aegyptiaca* and *A. seyal* only on water-receiving sites.

(ii) *A. seyal/Balanites* savanna alternating with grass areas (rainfall 570 mm/year). Associated with *A. seyal* and *B. aegyptiaca* is *A. senegal* and *A. campylacantha*.

(iii) **Anogeissus/Combretum hartmannianum** savanna woodland (rainfall > 600 mm/year). Associated with *Anogeissus* and *Combretum* are *A. seyal* and *Sterculia setegra*.

On the clay soils formed in situ and usually associated with small inselbergs such as the Ingessena Hills, an association of *A. mellifera*, *Commiphora africana* and *Boscia senegalensis* occurs and with it are found *Adansonia digitata*, *Lannea* spp., *Albizia sericeophala*, *Dalbergia melanoxylon*, *Terminalia brownii* and *Pterocarpus lucens*.

Along the Blue Nile and its tributaries *Acacia nilotica* is dominant. On the (azaz) soils near the river, *Acacia savanna* is locally replaced by non-thorny woodland in which *Combretum hartmannianum*, *Sterculia setegra* and *Adansonia digitata* are dominant.
The economy is largely agricultural, with forestry and livestock production. With various animal units (camels, cattle, sheep and goats) the Province is one of the richest in the country. The Province is a site for extensive agricultural activity. Some 500,000 feddans are under irrigated agriculture mainly for cotton, kenaf and sugar production. Some 3 million feddans are under rain-fed agriculture, mainly for the production of sorghum and sesame (1.62 million feddans planned, mechanized crop farming, 1.2 unplanned, mechanized crop farming and 0.18 million under traditional shifting cultivation). These are in the form of 1000-1500 feddan schemes in the case of mechanized agriculture and 5-100 feddans in the case of shifting cultivation. Another 1.6 million feddans in the form of large mechanized rain-fed schemes ranging between 20,000-600,000 feddans is being implemented. A further 600,000 feddans are earmarked for the same purpose. The total area of reserved forests and those under various stages of reservation is 1.1 million feddans. Of those, only 32,000 feddans are under management plans, and another 35,000 feddans were mechanically seeded with A. senegal. The rest of the area is under natural forest. The Province is also rich in wildlife and is home for the most important game reserve in the country, the Dinder Game Reserve, with a total area of 100,000 feddans.

CURRENT CHARCOAL PRODUCTION COMPONENTS

POLICY - INSTITUTIONAL - METHOD

Policy

The Forest Policy for 1932, calls for the concentration of all commercial wood cutting inside forest reserves, where regeneration is assured.

Of the 1.1 million feddans of forest reserves in the Blue Nile Province, only the riverain forests with an area of 32,000 feddans are under management plans. These mostly carry Sunt (Acacia nilotica) in the depressions and Eucalyptus spp., Mahogany (Khaya senegalensis) and Bamboo (Oxytropis abyssinica) in the Gerfland. In accordance with the declared policy, the large-size sawlogs go to the government sawmills, the smaller logs are sold to private sawmills and branchwood is chopped into firewood. 50,000-80,000 m$^3$ of Sunt firewood is produced annually and hauled mainly to the Three Towns. The local bakeries and brick kilns are either content with small branchwood or rely upon dead Talh (A. seyal) wood obtained on permit from outside forest reserves.

The forest reserves which carry tree species suitable for charcoal production (the Dahara Forest) are not covered by management plans and
are, with very few exceptions, left aside as a reserve for the future.

Contrary to the declared forest policy, however, the Blue Nile Forests Administration wisely concentrates all production of charcoal and industrial wood outside forest reserves. Logging of Heglig (B. aegyptiaca) for bentwood chair factories and other furniture together with charcoal production are directed to areas destined for agricultural expansion. The idea is to salvage the wood there rather than leave it to be burned into ashes.

To instil this concept an agreement was reached with the Mechanized Farming Corporation, The Government Bureau which allots 1000-1500 feddan schemes, that a scheme approval is complete only after the Forests Administration had certified that the prospective proprietor had paid royalty on the estimated standing tree crops on the plot. Royalty is charged at LS 0.250 per sack on a flat rate of 30 sacks per feddan. An estimate is made if the proprietor disputes the rate. The minimum chargeable royalty is on 5 sacks per feddan. This is not the case, however, with schemes in excess of 70 000 feddans which are approved centrally in Khartoum. A lot of charcoal is produced in the latter schemes but the proprietor is not obliged to wait for salvage operations or pay royalty.

Accordingly, and throughout most of the past decades, charcoal production in the Blue Nile Province, came in the proportions and from the sites detailed * in Table 1.

TABLE 1 Charcoal production in the Blue Nile Province (expected to continue for the next 5 years)

<table>
<thead>
<tr>
<th>Annual output</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>65%</td>
<td>Areas earmarked for imminent or future agricultural expansion in the form of macro rain-fed mechanized schemes. These are individual, company and multinational holdings approved centrally (from Khartoum) by the Investment Bureau; e.g. Sudanese Saudi Scheme, Sudanese Egyptian Integration Scheme, etc.</td>
</tr>
<tr>
<td>20%</td>
<td>1000/1500 feddan rain-fed mechanized farming schemes approved by the Mechanized Crop Farming Corporation at Damazine mostly for individuals but could be for corporations, firms or institutions.</td>
</tr>
<tr>
<td>5%</td>
<td>Rotation areas of irrigated schemes such as the B.N. Agri. Corp., Kenaf, etc. These areas are left fallow for periods of 5-10 years.</td>
</tr>
<tr>
<td>10%</td>
<td>Small holdings for rain-fed traditional agriculture (shifting cultivation). These used to be 5-10 feddans now up to 500 feddans and are mechanized.</td>
</tr>
</tbody>
</table>

* Ref: Ahmed El Tayeb Ibrahim, Conservator of Forests, Northern Fung Circle
The Blue Nile Forests Administration, with Headquarters at Sennar, comprises seven Forest Circles. Charcoal is produced in four of these and in the proportions given in Tables 2 and 3.

**TABLE 2** Charcoal production levels in Blue Nile Province*

<table>
<thead>
<tr>
<th>Year</th>
<th>Total (charcoal sacks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>73/74</td>
<td>1 184 228</td>
</tr>
<tr>
<td>74/75</td>
<td>1 716 454</td>
</tr>
<tr>
<td>75/76</td>
<td>1 846 454</td>
</tr>
<tr>
<td>76/77</td>
<td>1 764 368</td>
</tr>
<tr>
<td>77/78</td>
<td>1 317 899</td>
</tr>
<tr>
<td>78/79</td>
<td>1 218 959</td>
</tr>
<tr>
<td>79/80</td>
<td>1 552 000</td>
</tr>
<tr>
<td>80/81</td>
<td>2 460 660</td>
</tr>
<tr>
<td>81/82</td>
<td>2 337 654</td>
</tr>
<tr>
<td>82/83</td>
<td>3 150 966 **</td>
</tr>
</tbody>
</table>

* Ref: Blue Nile Forests Administration

** Estimate

**TABLE 3** Charcoal production levels in Blue Nile Province by Circles

<table>
<thead>
<tr>
<th>Year</th>
<th>Forest Circle, production %</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Singa</td>
<td>Damazine</td>
</tr>
<tr>
<td>80/81</td>
<td>57</td>
<td>7</td>
</tr>
<tr>
<td>81/82</td>
<td>51</td>
<td>8</td>
</tr>
<tr>
<td>82/83</td>
<td>50</td>
<td>10</td>
</tr>
</tbody>
</table>
NB In Table 3, the percentages are based on royalty collected. This depends largely on the strategic position of check-points, irrespective of the charcoal source. Wad El Neil and Ahu Hugar check-points command all the charcoal hauled from the south and south west which could include charcoal produced in Damazine Circle. The same goes for Karkuj and Kardus on the east bank. Royalty levied there could be for charcoal produced in Damazine or Dinder. The percentage, therefore, does not necessarily indicate the exact level of production in the particular circle.

Before 1980-1, Karkuj check-point was administratively part of Dinder Circle.

Institutional

Charcoal, in the Blue Nile Province, is produced entirely by the private sector. It is an institutionalized business with well established division of responsibility and work relations.

The listed producers who obtained permits for the current season 1983-4 approximates 150. Three quarters of them obtained the permit either as part of the process to acquire a mechanized farming scheme, or on behalf of established entrepreneurs. In either case the permit ends up with practicing entrepreneurs. The list of permanent entrepreneurs, i.e. those who have been in the business for 20 years or more, approximates 25. A handful of entrepreneurs have recently ventured into the business in the last 3-5 years.

To most entrepreneurs, charcoal production is one of several occupations. They are invariably traders who own one or more lorries and practice some form of agriculture, mechanized and/or pump-irrigated orchards.

Entrepreneurs obtain permits and start work immediately after the onset of the dry season, November-December. The permit fee is LS 100 and covers an area of 500 feddans assumed to produce 15 000 sacks of charcoal. A new permit is required for every 15 000 sacks or part thereof.

Entrepreneurs employ agents to act as supervisors and a link between them and the workers (charmen). The agents are usually experienced, trustworthy ex-charmen. The agent is paid a commission of LS 0.20-0.25 per bag produced. His responsibilities include recruitment of workers, supervision of operations, running of provisions shop on the site and bearing of risk for any losses resulting from his conduct of duties. He can be penalized by deduction from his commission for sums of money owed by fleeing or sick workers, for bad quality charcoal produced, etc.
Each entrepreneur employs 1-3 agents according to business volume. Each agent supervises some 50 workers. Agents and entrepreneurs get together early in the season, October/November. Agreements are written but not necessarily legally documented. Accordingly agents are issued with an advance for labour recruitment. Some entrepreneurs have a semi-permanent lot of workers in the sense that the same workers are employed each season. The agent travels to their traditional labour areas where they pay the recruited charmen an advance to leave with their next of kin and travel cost to gathering centres such as Sennar or Damazine. Here lies one of their fragile risk areas. Besides the advance the charman receives at home, he is fed, perhaps clothed, and provided with tools, on loan until his kilns come into production. The agents, therefore, have to recruit people they know and trust.

From their side, the agents appoint mess leaders on a commission basis of LS 0.02-0.05 per sack. Messes usually comprise 7-10 men from the same family, village or ethnic group. The mess leaders receive and issue rations, repair and sharpen tools and keep empty sacks and sewing gear.

The greater majority of charcoal workers, i.e. about 80%, are 'westerners', people from Darfur and Kordofan. The balance is Blue Nile locals and people from White Nile. Of the westerners, the Fur are a majority followed by Zaghawa, Tama, Burgo, Masalit, Kawahla, Buzzi and Shiwaibat. Most of the ones interviewed were of 20-50 years of age and have been practicing charcoal production for three or more years. 50% of the workers interviewed were illiterate. The other 50% have either been to Khoranic school or received primary education. According to most entrepreneurs, the 'westerners', even if less productive than the locals, are more devoted to the harsh business and by virtue of their distant homelands, they have no social ties to urge their visits to nearby settlements. There is no particular bias against local Arabs who are basically nomads or shifting cultivators not interested in charcoal-making and are thus not available.

Arrival at gathering points and consequently start of charcoal work depends on the workers' harvest of their crops back at home.

On arrival at gathering points, mess leaders get in touch with entrepreneurs. A lorry is usually sent to transport them to the entrepreneurs' domiciles or centres of activity. There they are supplied, on loan, with urgent needs of food, domestic utensils and tools. Utensils noted at most messes include cooking pans, metal plates, pails, mugs, teapots and glasses. These are bought communally as part of the mess. Water containers, usually 44-gallon metal drums, are the property of the entrepreneurs. Working tools include light, locally made axes, locally made rakes, spades, and hoes.

The workers are then transported to the sites, which are usually
marked by a Forests Administration representative. There they start by building their huts from local materials such as building poles and straw. They also hand hew their own beds and weave them with dom ropes.

By this time the agent would have arrived and set camp, usually a hut acts as both shop and living quarters. The shop contains such items as durah (sorghum), flour, salt, sugar, tea, onions, dried fish, dried beef, edible oil, soap, bleach, torch batteries, dom ropes, string, axes, sandals of old motor car tyres, snuff, cigarettes, and a pair of scales.

Each charan keeps a notebook where value of personal effects borrowed by him are entered immediately in his presence. Communal effects such as mess items are entered in the mess leader's book. This double entry in the charman's book and the agent's book is a safe-guard for both parties.

Charcoal workers are provided with water, free of charge, at the rate of 4 gallons/man/day. Entrepreneurs who employ more than 70 workers need to devote a lorry with a driver and assistant to cater for his squad.

Workers are paid a rate per bag produced and packed. This varies with locality and entrepreneur and ranges between LS 1.35-1.80 per bag.

Charmen work individually. Each cuts enough wood to suffice for one kiln at a time. They co-operate on a reciprocal basis in difficult tasks such as transport of heavy billets and kiln guarding over the first few days.

Method

The tree species preferred by all parties is the Talh (Acacia seyal) followed by Kitir (A. mellifera) and Heglig (Balanites aegyptiaca). Some charcoal is produced from Habil (Combretum hartmannianum) and Sailek (Anogeissus leiocarpus). The former has a high conversion ratio but produces light charcoal and is generally rejected by the entrepreneurs and the latter is not very common.

Large trees are either felled by axe or by burning their root collar zone in the fashion preferred for areas destined for mechanized farming. Medium sized trees (23-30 cm diameter) are felled by axes about 30-40 cm from ground level. Hashab (Acacia senegal) gum producers and small trees (less than 5 cm diameter) are spared by charcoal producers.
Except for a few central billets which are cut to about 2 metre length, the rest of the wood is cut into 1.0-1.5 metre billets. Branchwood is utilized down to 2 cm diameter. The billets are left to sun and air dry for a period determined by many factors:

1. Entrepreneurs concerned with charcoal quality, especially for storage, do not allow drying for more than 4 weeks.

2. Others prefer the 4 week duration in order to catch the 'hot' market especially at the beginning of the season.

3. The short duration, 4-5 weeks, serves the purpose of the small entrepreneurs. The shorter the period from start to production, the less advance is owed by workers and the greater are the chances for recuperating their losses.

4. Drying periods in excess of 6 weeks are followed by some in the case of large size kilns which produce 500-1000 sacks. These are usually produced at the end of the season.

5. Certain factors may impose drying periods for many months. Examples include late land clearance, sickness or desertion of some workers. In such cases, the wood is left over for the following season.

The conditions of sunshine and wind prevailing in the Sudan induce rapid wood drying. Moisture content determined for specimens collected from various charcoal production stages indicated that freshly felled Talh (Acacia seyal) has a moisture content of around 50%. After drying for a month, wood from the species had a moisture content of 15-20%. One year of drying had produced Heglig and Talh at equilibrium moisture content of 6-10%.

Talh (A. seyal), Heglig (Balanites aegyptiaca) and Kitir (A. mellifera) are very susceptible to attack by Brochid borers such as Sinoxylon senegalense and termites. Talh is attacked immediately after felling and small wood can perish within two months.

While the wood is drying, the kiln site and cover grass are being prepared. Sites average 10, 15 and 20-30 metres diameter for small, medium and large size kilns. Cracks are filled-in and compacted. The thoroughness with which this is done has a great bearing on the charcoal recovery and quality. If soil for kiln burial is not readily available, it has to be brought in by lorry. Transported soil could be fresh or that of a previous kiln. The entrepreneurs, and indeed the workers, realise the importance of a good soil cover for the carbonization process, and they prefer areas poorly stocked with trees but with good soils to well stocked areas that have no suitable soils.
Wood billets are then transported to kiln sites using wooden stretchers. The charcoal burners are generally very methodical. All the wood is stacked round the kiln site. Twigs are stacked at the bottom followed by medium and large sized billets respectively. In this way sufficient wood to make a kiln is stacked round the site inside out.

At this stage the kiln owner may enlist outside help, more frequently on a reciprocal basis, but sometimes as paid.

Charcoal burners speak of three distinct kiln shapes and sizes. The only shape seen around the Blue Nile Province is the pyramid shape which they call 'simbiryin' (Abdim stork) type. The other two shapes they talk about are the square bottomed or 'um kursi' (the one sitting on the chair) and the 'tumsahiia' (the crocodile) shape. These were not seen. They refer to the small kilns, which produce less than 100 sacks or 'kliatoon' (small locomotive). They refer to the medium size, 100-300 sacks and the large size, more than 400 sacks, as such.

The pyramid-shaped kilns are stacked starting from the centre outwards. A few large billets are stacked as a tripod, filling the space between the legs with dry grass. Larger billets are stacked followed by medium and then small billets to the outside. A tunnel is left away from the wind direction, leading to the central hay stack inside the tripod.

The experienced burners go for shorter, straighter billets and for very close stacking.

The entire shape is first draped in dry grass or straw and then with 10-20 cm of earth. A heap of earth and wooden pegs are always there as a standby to plug in any outlets.

A piece of cloth or sacking dipped in diesel is ignited and introduced to the central haystack using a long pole or piece of bamboo. No vent is used. Combustion is through direct draught.

After 15 minutes or so to make sure that the kiln had 'caught', the tunnel is closed in with earth and the kiln is closely watched for several days depending on the size. This is another area of reciprocal co-operation. The owner actually moves his bed close to his kiln.

Complete charring may require 4-14 days depending upon the kiln size. The longer, the better. Well charred billets are whole with charred bark and produce rustling metallic sounds.

When no more smoke is being emitted, the kiln is gradually opened in
concentric circles starting from the outside. Everyday, charcoal is withdrawn from the circle, and earth used to extinguish any glowing bits of charcoal.

Cold charcoal is packed progressively. Each burner manually packs his own. He uses a hook hanging from around his neck to keep the sack open. Loading on to lorries is outside the burner's responsibility. He might do it on payment. Usually charcoal transport lorries have their own loading squad.

Charcoal produced early in the season, December-March, is hauled directly from the kilns to the market.

Storage in depots starts after March and sales from depots start after the rainy season, before the new product gets to the market.

Transport of charcoal, as indeed of all forest products in the Blue Nile Province, is governed by removal passes. A chain of check-points commands all major road junctions. There, forest overseers make a note of all vehicles carrying forest produce and make sure that each carries a removal pass. The latter are issued by forest offices throughout the Province after payment of royalty for legal produce from outside forest reserves and a value for produce from forest reserves.

An analysis of Abu Hugar check-point removal pass book indicates that half of the charcoal transported by road to Khartoum went by 5-6 ton lorries. The other half went by 16-20 ton articulated lorries. The trend is for bigger trucks. The fact that 5 ton lorries and 16 ton articulated lorries carry 150 and 500 sacks respectively, indicates that sacks do not really weigh more than 80 lbs. - see conversion figures.

Conversion figures

The following conversion figures are only indicative, since they are a result of a very small sample which may not be representative of the population in question.

A. One stacked cubic metre of Talh (Acacia senegal) wood, which been air dried for one month and attained a moisture content of about 16%, weighed 905 lb., i.e. there are 2.48 stacked cubic metres to a metric ton.

0.546 m$^3$ (stacked) of Heglig (Balanites aegyptiaca) which was drying for one year and attained a moisture content of 6% was 283 lb., i.e. there was 4.32 stacked cubic metres to a metric ton.
B. When the approximate volume of wood in several kilns measured is divided by the estimated number of sacks expected by the owners, a ton of charcoal is likely to be obtained from 9-10 stacked cubic metres of wood. The actual production is still to be obtained from the entrepreneurs.

C. The average weight of sack for 17 sacks measured in 5 localities was 84.5 lb. This would mean that there are nearly 36 sacks of charcoal to a metric ton.

D. In most kilns inspected, 5-10% of the product is unburnt wood and a further 5-10% is in the form of fines (dust and broken bits).

Production costs

All entrepreneurs interviewed were prepared to disclose their production costs. These varied as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost range LS</th>
</tr>
</thead>
<tbody>
<tr>
<td>labour/packed bag</td>
<td>1.35 - 1.80</td>
</tr>
<tr>
<td>water</td>
<td>0.40 - 0.20</td>
</tr>
<tr>
<td>agent</td>
<td>0.20 - 0.20</td>
</tr>
<tr>
<td>empty sack</td>
<td>0.70 - 0.60</td>
</tr>
<tr>
<td>transport to depot</td>
<td>0.55 - 1.30</td>
</tr>
<tr>
<td>royalty and other local tax</td>
<td>0.27 - 0.30</td>
</tr>
<tr>
<td>sundries, including deficit</td>
<td>0.30 - 0.10</td>
</tr>
<tr>
<td>resulting from repacking</td>
<td></td>
</tr>
<tr>
<td>Total at depot</td>
<td>4.77 - 4.50</td>
</tr>
</tbody>
</table>

NB The cost at depot is exclusive of entrepreneurs' own supervision cost and interest on investment.

If sales take place at kiln site, which rarely happens, then transport costs to depot are omitted.
OBSERVATIONS, CONCLUSIONS AND RECOMMENDATIONS

1. If the trend of agricultural expansion continues at the current rate in the Blue Nile Province, then in 10 years, i.e. by the mid 1990s, all land which is now the source of charcoal production would be under the plough.

2. If the current trend of removing all tree cover from agricultural schemes continues, then by the mid 1990s most of the presently productive schemes would cease to be so, due to environmental deterioration.

3. Charcoal production could continue at current rates of around 3 million sacks for the next decade, but the distance of haul would greatly increase.

4. The only alternative for charcoal production would be forest reserves.

5. Of the present forest reserves, less than half, i.e. >500 000 feddans carry tree species suitable for charcoal production. The other half, which is situated at the southern tip of the Province (Kurmuk area) does not carry trees suitable for charcoal and was never meant for the purpose.

6. Therefore, if charcoal is to come only from forest reserves carrying trees suitable for the purpose, in 10 years time the production would drop to less than a quarter of the present rate. (500 000 feddans at 0.5 m³/year x 3 sacks/m³ = 750 000 sacks)

7. But things need not go the way they do:

a) Tree cover need not and should not be removed from agricultural schemes for protective and productive purposes.

b) In many of the ongoing schemes the tree cover can easily be reinstated if given the chance. Talh (Acacia seyal), the tree best suitable for charcoal-making and for improving soil fertility, regenerates naturally and prolifically. In 10-20 years it can improve soil fertility and attain a size optimal for charcoal-making.

c) In schemes under implementation and those on the drawing board, tree belts, trees on uncommandable land (low-lying or high ground) should be left to provide both direct and indirect benefits. A proper
fallow system which incorporates trees as an integrated part of the agricultural rotation ought to be adopted.

d) More land should be reserved for forests for protective and productive purposes. Current and future forest reserves could and should be put under management plans.

e) The land requirements of other land users ought to be considered, such as range and pasture for domestic and wildlife.

f) Certain parts of the Province need particular care, such as Damazine Dam Basin, river tributaries, catchment areas, etc.

8. To determine the exact stock of Talh (A. seyal) per unit area, permanent sample plots need to be established. Until these yield results, stocking can be constructed from different age gradations.

9. A rational land use policy is required. A board representing all land users needs to be established and entrusted with revision of present land uses and drafting and implementing future ones.
REFERENCES


