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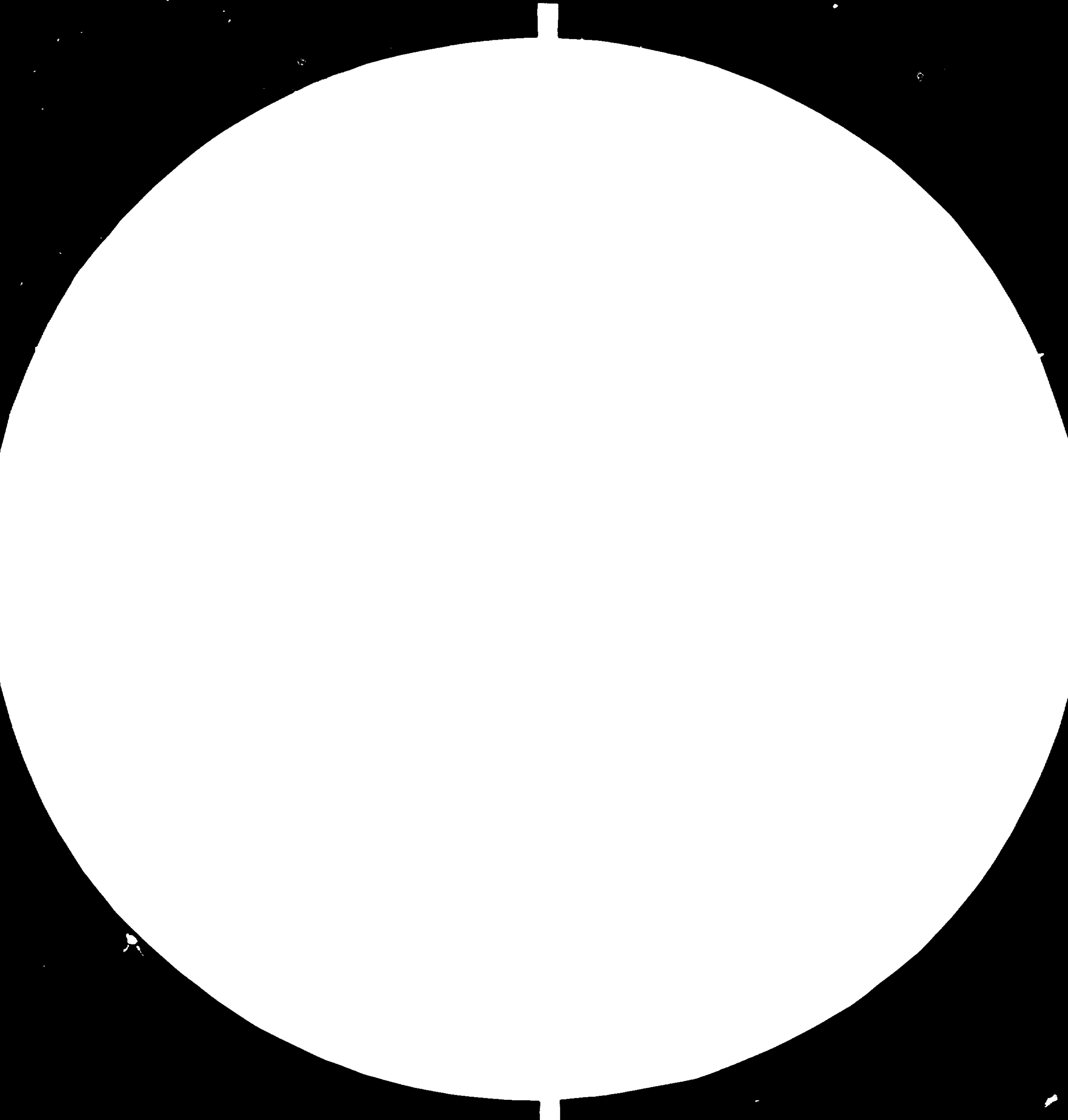
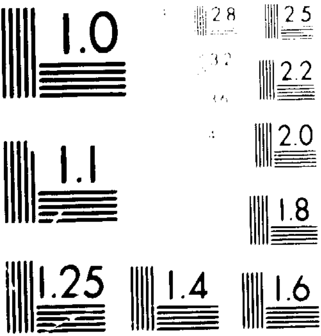
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org





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DEVELOPMENT OF CHARCOAL INDUSTRY AND ESTABLISHMENT OF A PILOT PLANT*

SI/SOM/78/803

SOMALIA

Technical Report: Plans for the development of the charcoal industry

Prepared for the Government of Somalia
by the United Nations Industrial Development Organization
executing agency for the United Nations Development Programme

Based on the work of Walter Emrich, consultant in charcoal
manufacturing, and pyrolytic conversion technology
for agricultural wastes

United Nations Industrial Development Organization
Vienna

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Explanatory notes

References to dollars ($) are to United States dollars, unless otherwise stated.

The monetary unit in the Democratic Republic of Somalia is the Somali Shilling (SSH). During the period covered by the report, the value of the SSH in relation to the United States dollar was $1.00 = SSH 6.23.

The use of a hyphen between dates (e.g. 1960-1965) indicates the full period involved, including the beginning and end years.

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1.00 ABSTRACT

The charcoal consumption of Somalia will be well over 80,000 tons in 1979. The main problem in the future will be to find enough raw material because of the general deforestation and the poverty of the Savannah forests.

To stop this continuous resource depletion, the adoption of new charcoal technologies is necessary, which will improve the weight percentage yield of the production, in particular from the present 10 per cent up to 35 per cent.

It is also proposed to introduce charcoal extenders.

Somalia also has agricultural wastes in abundance which can be utilized for future charcoal supply and would contribute very much to the improvement of the charcoal situation.

At the end of this report, recommendations are given for the financial and technical implications of the programme to be carried out within the second phase of this mission.

2.00 Introduction

The Government of Somalia is greatly concerned with the steady increase of charcoal consumption and the resulting alarming rate of resource deterioration.

In order to conserve the existing forest resources a total ban of the export of charcoal has been declared in 1969.

The Government of Somalia has therefore decided to start with action that in the long range will ensure adequate supply of charcoal to satisfy the needs of the country.

The Somalia mission of Mr. W. Emrich, UNIDO expert, took place from 14 November 1979 to 20 January 1980 (first phase).

The aim of the first phase of this mission was to recommend measures to improve the situation of the charcoal production in Somalia, to suggest a research project with an adjoint training programme.

The report consists of seven chapters: the first part (chapters 2-3) presents the present situation, the second part (chapters 4-7) deals with the proposed measures to improve charcoal production and outlines the research plant and training programme.

The expert was attached to the National Range Agency of the Ministry of Livestock, Forestry and Range.

The expert wishes to thank the staff of this Agency in particular the General Manager, Dr. Abdulahi Ahmed Karani, the Acting General Manager, Mr. Yusuf Mohamed Ahmed, the Director of Forestry, Dr. Mohamed Mahamud Jumallah and the UNDP/FAO Project Managers, Mr. Yusuf Abdileh, Senior Programme Manager in particular, for their kind co-operation and assistance in the matter of providing transportation and guidance, which facilitated the successful accomplishments of the mission's first phase.

3.00 Assessment of the present charcoal production and demand

The last comprehensive description of the prevailing charcoal supply situation was undertaken by the ECA/FAO Forest Industries Advisory Group for Africa in 1976.

Working from their report (M76-752 Run 120/Ind) we have made re-assessments wherever it appears necessary or have limited our efforts to updatings if permissible.

3.01 General

The forest areas of Somalia provide the only sources for the total charcoal supply of the country.

Estimates of forest areas vary considerably but 100,000 km^2 may have some forest cover of which some 150,000 to 200,000 ha is classed as closed forest.

The main vegetation type is semi-desert low bush savannah with acacias as the main species.

Potentially productive high forest occurs only in the Southern region of the country, particularly in the Lower Juba Valley, where some estimated 40,000 ha contain 400 to 450 m^3 per ha.

The Forestry and Wildlife Section of the Ministry of Livestock, Range and Forestry is implementing a three year development plan (TYDP 79-81) which itemises seven points.

With respect to the future charcoal supply, the point 1 may become of importance to the charcoal industry in the future, as it stipulates a programme of reservation and management of the natural woody resources in a manner which will improve the natural regeneration and provide substantial supply of wood and wood products.

The idea behind this programme is stated clearly: "The critical problem in implementing the forestry programme would appear to rest not so much in the lack of interest in forestry as in lack of trained and sufficient professional and technical personnel for the programme."

Literally this problem applies to any charcoal programme to be implemented in the future.

The demand of charcoal during the past five years has steadily increased with the growth of the population.

Identical growth rates can be expected in the foreseeable years also. It is reported that the charcoal consumption for Mogadishu was 25,500 tons in 1973 and 36,500 tons in 1975. Reliable figures for other provincial towns were not available.

Apart from some soft wood growing stocks in the north, the forests are not protected against free grazing livestock. This would be difficult to prevent if not impossible for a country whose main foreign income rests on cattle export.

Therefore, it appears indispensable for a sound charcoal programme not only to focus on methods to protect forest resources but on the utilization of alternative reserves in the agricultural sector as well.

3.10 Charcoal production and marketing

In January 1973 the Government of Somalia decided to create two types of co-operatives, one for charcoal production and one for charcoal marketing. Both have their own organizations to meet the targets set by their boards. In actual practice they co-operate closely and operate as a single profit-making organization.

3.11 Co-operatives for charcoal production

Presently 110 co-operatives are managing charcoal production in the area of Baidhoa (300 km NW of Mogadishu) alone. Therefore Baidhoa may be considered as the charcoal centre of Somalia. Each co-operative or working camp has 12 to 30 workers and is run by a business manager. The foreman of the camp represents his co-operative in the co-operative council. He is responsible for the production and transportation of charcoal. The charcoal is produced by the ordinary kiln method.

We have observed several variations: the wood is piled up in a rather loose structure and the logs can be relatively short. All wood is piled horizontally and no special floor wood is necessary to ease the circulation of the gases. Before the kiln is closed airtight with soil, a layer of metal sheets are put on top, covering about 80 per cent of the surface. Each kiln contains about 18-30 air holes at distances of 20 cm. For the ignition, a shovel full of glowing charcoal is introduced through the centre hole on top of the kiln. It is then closed soon after the burning has started (dark coloured smoke).

The kiln sizes vary greatly between diameters of 5 and 15 m and the centre height between 2 and 5 m. One cycle from the piling to the cooling-off of the char, may take up to 21 days.

Presently, the charcoal burners use only Acacia bussei (Gallol). The rule of the forestry department is that only dead or unsound wood can be cut.

We were not able to determine the exact yield (expressed in the weight percentage of the wood input) of charcoal in the Baidhoa area. The complex chemical composition of wood varies widely with the species and within each species. Depending on the moisture content of the wood, between 15 and 20 per cent will be consumed as heat source until the carbonization process becomes self-sustaining through an exothermic reaction, which takes place at 250-270°C. Also the kiln type, size, shape and the skill of the operator are very much related to the yield.

The experience in other countries is that charring in earth kilns gives lower weight yields, usually not exceeding 12 per cent. We estimate a figure around 10 per cent as a realistic yield in the Baidhoa area.

For the truck transportation of charcoal a rather unique method is being used. The charcoal pieces are stacked on the lorry like firewood. This eliminates bags and the circumstantial manual bagging. However, for special deliveries 25 kg jute bales are used. Any technical changes of the charcoal supply in the future should give special considerations to this proved transportation method which allows utilization of the full loading capacity of a truck.

Source: Charcoal production co-operative Baidhoa, Mr. Abdulah Ulscn Fidow, Chairman
Mr. Basaic Satal Huseen, Regional Forest Officer

3.12 Co-operatives for charcoal marketing

In every town there exists one co-operative for charcoal marketing. The municipality grants the necessary licence for the business. Present selling price of charcoal is SSH 30/100 kg. This includes SSH 4 to cover licence fees and overhead burdens. In Mogadishu alone the co-operative maintains 240 retail stores. The number is likely to increase in 1980. On average each store is run by three people. The assistance by family members is not accounted for.

The co-operative also owns trucks. However most of the transportation services are hired. Deliveries of charcoal to the stores are made either in bulk or in jute bales.

Charcoal shortages have occurred frequently. However, consumers are not likely to switch over to other household fuels, for instance kerosene. Taste of the food and traditional habits are strong barriers to the change; so are the significant price hikes of imported oil derivatives during the past years.

Figures for charcoal sales are not easy to obtain. Illegal burning (i.e. making) of charcoal is sometimes widespread; and this also depends very much on the particular local situation.

Compiled numbers of charcoal co-operatives for several areas display a fairly representative picture:

1977			1978	
Mogadishu	25,000 t		Banaadir	36,000 t
Marka	3,600 t		SH/Hoose	3,100 t
Baidhoa	1,500 t		SH/Dexe	2,600 t
Djowhar	2,400 t		Bay	2,200 t
Afgooye	1,400 t			

It has been estimated that the total charcoal sales this year will be well above the 80,000 t mark in the Democratic Republic of Somalia.

Source: Charcoal Marketing Co-operative, Mr. Shek Abdusamman Halane, Chairman of the Board
National Range Agency, Mr. Mohamed Mahamud Jumallah, Director of Forestry Department

3.20 Comments

Attention has to be given to the content of fixed carbon in the charcoal arriving at the market places. Complaints about "half burnt" charcoal are frequently reported. We estimate that 40 per cent of the kiln discharge has lower percentages of fixed carbon than desirable (80-82 per cent), thus having a calorific value closer to fire wood. On the other side, about 20 per cent of the total kiln discharge seems to have values exceeding 85 per cent of fixed carbon, having little volatiles and being very brittle. These occurences, however, have to be considered as the draw-backs of all earth kiln types.

Presently only Acacia bussei is cut by the burners. Other acacia species could be utilized for charcoal making as well: Acacia ethbaica, Acacia mellifera, Acacia arabica and Acacia spirocarpa. These species have the typical hardwood structure, offering very good charcoal characteristics.

Besides acacia species, two non-fodder trees are of high charcoal value also: Melia azadirakhta l. (meri-meri) and Casuarina equisite-folia. The latter has become a major charcoal source in other countries and plantation growing has provided good results.

Since the charcoal "burners" (charcoal makers) do not use heavy duty tools, they are forced to cut convenience wood only. Consequently trees are taken at a point too high from the ground and leaving too much waste. Certainly the charcoal burners are willing to follow the rules set by the Forestry Department and take dead and diseased wood only. Their preference is based on the experience that green wood, due to the higher moisture content, will extend the burning cycle significantly, thereby depressing the monthly output of char and the remuneration of the workers.

The earth kiln method does not permit the recovery of charcoal by-products at all. It may be reasonably assumed that 40 per cent (related to the total input of firewood) could be collected as by-products from acacia species also.

These condensed by-products are obtained as pyrolytic oils consisting of methanol, acids, creosotes, tars, etc. (see table annex 3). Also the calorific values of pyrolytic oils are high (9,000-9,500 Kcal per kg.). They are frequently used as substitutes of heating oil or as fuel in power generation plants.

4.00 Possibilities for improvement of the present charcoal supply

To cope with the present charcoal supply and future demand, several options are open in a continuous development programme. The targets are: more effective utilization of forest resources by raising the weight percentage output of char to significantly higher levels than presently, usage of charcoal extenders (briquetting) and the recovery of charcoal by-products (pyrolytic oil, heating gas) in a final stage. These goals could be achieved with indirectly heated and continuously operated modern converters. However, high investment in sophisticated equipment and the alteration of the entire existing charcoal production and marketing scene of Somalia would be necessary. Obviously the destructive social impacts for several economically important areas and the high risks to be taken by the Government do not justify following this route.

Fortunately, other options are available: kilns operating under similar conditions as those prevailing in Somalia are usually of the batch type. They do fulfil perfectly important requirements: construction with domestic materials, low investment costs, durability, easy maintenance and movability. Reference is made to the beehive brick kiln, with an achievable weight percentage output of up to 25 per cent, in contrast to the current 8-10 per cent. Higher yields than 25 per cent in charcoal manufacturing can only be reached in a stationary plant.

Most suitable for the situation in Somalia would be the buggy-retort process, which allows preparing of the firewood in a rather simple way, but maximum yields of char up to 40 per cent have been achieved in the past.

The question as to what degree the charcoal production in the Democratic Republic of Somalia should be modernized, has to be left open to further consideration during the second part of the mission.

4.10 Description of the beehive brick kiln

Circular kiln with domed roof, two doors - one for charging and one for discharging, three to four wall stacks, six outlet ports, 20 emergency ports, minimum of 12 air inlets.

Heating is done internally (combustion of wood as earth kiln method) before self-sustaining carbonization commences.

Lifetime of kiln:	1,000 to 1,500 m^3 of char
Operational cycle:	8 to 10 days (earth kiln of same capacity up to 20 days)
Charcoal yield:	up to 25 per cent depending on firewood species
Dimensions:	Diameter 5-6 m Centre height ca 4 m Kiln volume ca 50 m^3
Construction material:	8,400 to 8,800 fire bricks 4 m metal belt, three sections Mortar consisting of clay, charcoal fines, water
Estimated investment:	$ 1,500.00. The kiln can be built by two "burners" within 10 days. For a complete charcoal operation, a battery of eight to ten kilns is necessary. This battery is able to produce up to 7,000 m^3 of charcoal from acacia species per year.

Suggested location for test kiln:	Any charcoal camp in the Baidhoa area or the Forestry Training Centre in Afgooye.

4.20 Description of buggy-retort process

The stationary plant consists of eight to ten units. One carbonizer unit has a cylindrical metal retort with a corresponding cooling vessel of the same size and shape. Both containers are arranged horizontally in front of each other with the doors facing. Carbonizers and cooling vessels are linked together by rails on which the buggies travel. The buggies are mounted with lattice-type containers. Each of them can carry 4.3 to 4.8 tons firewood. Maximum length of the wood is 1.20 m. The buggies are directed by manual or electric-powered winches to any station of the plant.

For heating the retorts flue gas is blown externally through a rather sophisticated circumferential system. Part of the carbonizer gas is used to supply the energy for the heating system. Exothermic reaction sets in very soon and after completion of the carbonization the buggies carrying the hot char are pulled over into the cooling vessels. Water sprayed over the vessels helps shorten the cooling time very much.

A by-product recovery system can be easily attached to the plant and increases the overall economics considerably. Despite high maintenance costs the process has proved to be very economical where wages and salary burdens are low, and a highly efficient raw material usage is a necessity.

Plant capacity: 12,000 to 14,000 t of charcoal per year.

4.30 Usage of charcoal extenders

During the last decade the briquetting of charcoal has become one of the most important technologies throughout the entire charring industry. Special binders have been developed which compact the char with extenders (fillers), which are usually of the limestone type. Compared to traditional lump charcoal, charcoal briquets offer very important advantages: the heat release rate of briquets is significantly slower, but the same high temperatures are attained, thus saving fuel during cooking. Due to the uniformity of the briquets, the dosage is easier also for household cooking. Also the fact that more and more charcoal is produced from other sources than firewood (saw dust, saw mill wastes, agricultural residues, etc.) contributes to the dominance of charcoal briquets in the market. The average composition of charcoal briquets is:

65 per cent	fixed carbon
5 per cent	volatiles
15 per cent	extender (filler)
10 per cent	binder
5 per cent	moisture

Experience with many briquetting plants has proved that raw material sources may be stretched easily over a third of their original capacity. Consequently, an up-dated charcoal development programme must consider these possibilities seriously.

5.00 Possibilities for improvement of the charcoal supply by utilization of agricultural wastes

5.01 General

Since the energy crisis became relevant, alternative raw materials are being explored to satisfy the increasing demand for charcoal and its by-products. Application of modern "Integrated Carbonization" (I.C.) processes has proved that agricultural residues can be ideal resources.

Unlike traditional methods of charcoal manufacturing, I.C. employs continuously-operated converters tailored to fit or to be attached to existing industries, processing plants, etc. All fractions yielded by the process - solid char, pyrolytic oils, converter gas - can be collected and utilized entirely.

Thus the overall efficiency of the plant is above 60 per cent, which is considerably higher than those of other methods.

5.10 Bagasse conversion of the S.N.A.I. sugar factory in Djowhar

This sugar factory is the only plant of its kind in Somalia and supplies the total sugar demand of the country. Presently 700 workers are employed at the plant site. Attached to the factory is a distillation plant to produce alcohol from the molasses. Bagasse is the only waste material of the plant and is used as boiler fuel for the production of steam and electricity. Since the generated electricity exceeds by far the demand of the plant, a public network is provided to serve the Djowhar area with electric power.

The distance between Mogadishu and Djowhar is 90 km northward and a fairly good road permits regular truck transportation even during the rainy season.

A second sugar plant is under construction in the area of Kisimayo, Lower Juba. The reported capacity of sugar is equal to the plant in Djowhar.

5.11 Plant data

Crop season (operation of the plant):	15 December to 15 April 15 June to 15 October 240 days of full production, three shifts per day
Sugar cane consumption:	1,800 tons/day
Sugar production:	200 tons/day
Molasses:	80 tons/day
Bagasse wet:	600 tons/day
Analysis of bagasse:	Fibre - 43.4 per cent H_2O - 51.6 per cent Brix - 5.0 per cent Calorific value, dry - 4,500 Kcal " " wet - 2,150 Kcal

Source: Mr. Matan Abra, Deputy Plant Manager

5.12 Estimated char production

The analytical data of bagasse do not differ very much from bagasse varieties elsewhere. Therefore it can be reasonably assumed that the achievable yield of char with an I.C. process will be in the proximity of 10 per cent (based on dry bagasse).

Applying the full production figure of 300 t/d bagasse, a total char quantity of 30 t/d or 7,200 t per crop season may be extracted.

5.13 Estimated steam production

The installed boiler capacity of the Djowhar factory (five boilers) is 90 t/h, 25 kg/m^2.

Source: Mr. Matan Abra, Deputy Plant Manager

A survey of the steam boiler area of the plant has confirmed the technical feasibility for the attachment of an I.C. converter within easy distance to the boiler furnaces. Necessary changes of the burner chambers will be of minor degree and the installation of gas distribution pipes is practicable. Also the main stack of the existing boiler system can be hooked-up with a duct providing emission gases for the bagasse pre-dryer.

Based on this technical survey the estimated steam production with converter gas being fully utilized will be:

Total available energy: (4.5 Mio Kcal/t dry bagasse)	1,350 Mio Kcal/d
Char extracted: (5.0 Mio Kcal/t)	150 Mio Kcal/d
Difference:	1,200 Mio Kcal/d
10 per cent losses of tangible heat:	120 Mio Kcal/d
Balance converter gas:	1,080 Mio Kcal/d
Estimated steam production 1,080 ÷ 700 ÷ 24	approx. 65 t/h high steam pressure

5.20 Usage of banana plantation wastes

The banana fruit is the second important export commodity of Somalia and the SOMALITA brand name has gained market dominance especially in Italy.

According to the annual report 1978 of the Banana Board in Mogadishu the total area now under production is 2,784 ha at Lower Shabelle and 1,820 ha in the vicinity of Chismaio. Approximately 2,225 ha are under cultivation but not yet in production.

After three times pruning a banana tree bears fruits only once a year. Therefore after harvesting it will be cut, giving space for the rapidly up-coming sprouts. 10,000 trees per hectare are torn down yearly, having an average weight of 50 kg per piece.

Methods for the disposal of this waste differ very much. Whereas in some areas the felled trees are just left on the ground, in others they are hauled to a dump to prevent sheltering of fungis and rodents in the plantation field. Obviously these tremendous quantities of residues seem to offer abundant resources for charcoal making.

However, two critical points have to be considered, which will not allow the "in situ" usage for pryolytic conversion.

Collectibility: Since the plantations are spread over large areas, collection of banana wastes and transportation will be labour and capital intensive. We have estimated that only 15 per cent of all banana residues can be carried over to a central carbonization plant economically.

Moisture content: The water content of freshly cut banana trees reaches on average the extremely high value of 80 per cent. Therefore evaporation of the water before carbonization would require almost 75 per cent of the calorific value contained in the remaining organic matter. The achievement of an energy self-sustaining pyrolysis process in a necessarily continuously operating plant will therefore be impossible.

All these drawbacks may be overcome by the design of special methods for storing and pre-drying (solar and open air drying) of banana plantation wastes. A careful study has to be carried out focusing on the technical and economical feasibility to reduce the water content from 80 per cent to about 30 per cent before transportation and carbonization.

Source: Dr. Xassan Mohamed Gibin, Manager of technical section, Banana Board, Mogadishu
Mr. Karlo Branca, Agronomist, Afgooye area

5.30 Utilization of other waste materials

In general the agricultural sector of Somalia provides wastes and residues suitable for pyrolytic conversion processes in abundance. For instance the torn down trees of papaya plantations, cotton field residues and wastes of the cotton ginnery in the vicinity of Somalitex may be very well usable.

It will take some time of concentrated research to identify locations where these resources may be worth collection and conversion. Also the question where to erect a central pyrolytic conversion plant has to be left to further evaluation.

6.00 Recommended research and pilot plant project

6.01 General

Presently no studies for pyrolytic conversions are under way in Somalia. Also we were not able to locate suitable laboratory facilities or equipment. For undertaking improvements of the present charcoal supply and further introduction of new raw materials several feasibility studies have to be carried out. Customary suppliers of charcoal production equipment provide testing facilities on their own premises and it is not necessary to invest money in sophisticated apparatus, however basic laboratory equipment is indispensable.

The training and research programme should start with the second phase of this mission. It is not necessary to provide the fully equipped pyrolytic laboratory as described in the next chapter. But for the beginning, laboratory equipment worth approximately $5,000 to $7,000 has to be purchased. The programme to be conducted then is designed to produce practical results within a short period of time. It can be adopted by the existing charcoal production co-operatives immediately.

Another aim of the second phase of this mission is to acquaint the assigned staff with details of the new technologies and to make them capable of relying on their own judgement in the future.

6.20 <u>The laboratory and bench scale capabilities</u>

The three-room laboratory should have approximately 100 m^2 space with an additional storage room for spare parts and equipment. Necessary utilities are electricity, cold and hot water and bottled gas.

<u>Furniture</u>: One laboratory table, several ordinary tables, chairs, cabinets with security locks, one desk and one or two corrosion resistant sinks for the disposal of chemical wastes. It must also have a sliding-door glass cabinet with an open air exhaust fan to handle experimental work resulting in poisonous and hazardous fumes.

The laboratory will provide facilities to conduct experiments on the pyrolysis of organic waste materials, firewood and forest residues under a variety of conditions.

Some of the usual basic test data to be established are: moisture content and density of raw materials, amount of char produced, quantity of condensible organic materials, water and gases in the volatile materials formed during pyrolysis.

For the determination of the charcoal quality, the analysis of fixed carbon content, ash, volatile matter and bulk density are the essential data, as well as the sizing through screen tests. The laboratory provides the supportive work necessary for a pilot plant experimental programme.

Therefore it has to deal with particular raw materials and their derivatives which are important for the improvement of the present and future charcoal supply in Somalia.

The scope of the work to be conducted comprises the following raw material types:

Acacia species
Sugar cane bagasse
Banana plantation wastes
Cotton wastes
Hardwood bark
Hardwood chips

The complete equipment for the pyrolysis laboratory is given in annex 1. It may be purchased step by step as the programme demands and progresses. The personnel should include one technician for the physical and chemical work and two helpers for preparing material.

6.21 The pilot plant capabilities

All data for the production of charcoal, in particular yield values obtained on a bench scale basis are not reliable enough. They have to be confirmed by pilot plant tests. Therefore it is necessary to erect a beehive kiln. The details have been described in chapter 4.10.

It is conceivable that this kiln could be built by the charcoal trainees during the training period in Afgooye.

The Forestry Training Centre in Afgooye also has a small metal test kiln in possession, which was used once during a former FAO programme in 1975. We have tried to conclude a test for the determination of the operational cycle with acacia species, but incurred difficulties due to heavy deformations of the kiln body (test report annex 7). After restoring, this kiln could be employed further to generate test materials for the laboratory. It has to be pointed out that both kilns cannot be used for the conducting of test runs with agricultural wastes since this matter requires different technology.

However, as previously mentioned, suppliers of this equipment will provide their own test facilities. Therefore only the preparation of the raw material is necessary. The equipment list for the pilot plant programme is attached in annex 2.

Personnel requirements: One foreman or technician, two assistants, two charcoal burners.

6.30 The objectives and the timing of the research and pilot plant programme

The investigations undertaken have to be aimed towards the following objectives which are achievable within two distinct phases:

1. Develop a suitable low cost beehive brick kiln battery to produce charcoal with significantly higher weight percentage yields than those presently achieved.

2. Develop reproducible operational characteristics for these kilns which can be easily adopted by the charcoal burners.

3. Develop kiln structures and mechanization methods to provide extreme movability and low maintenance (in this respect a single wall concrete masonry kiln should also be erected in a later phase of the programme).

4. Determine the economics of kiln operations with variable hardwood species, wood fines and agricultural wastes.

5. Determine the composition and quality standards of charcoal briquets made from local raw materials.

6. Determine the economics of by-product recovery for a later stationary charcoal plant.

Timing of the programme

Programme development — one month

- training of charcoal technicians assistants, burners
- organization of laboratory and pilot plant work
- literature research

First phase of programme	five months

(a) Raw charcoal

- kiln charging, discharging
- ignition characteristics
- temperature cycle
- air flow
- yield determination
- char classification

(b) Charcoal briquets

- grinding of raw char
- binder, extender tests
- drying and curing
- yield determination
- burning performance

Second phase of programme	ongoing research, time not specified

- extended studies with alternative raw materials (agricultural wastes and residues)
- economics of by-product recovery
- calorific values of off-gases
- design of a stationary charcoal plant with by-product recovery
- standardization of charcoal and charcoal products

6.40 Charcoal training programme

The training of students in charcoal manufacturing and marketing is profoundly linked to any progress in the charcoal supply situation of Somalia in the future. The Forestry Training Centre in Afgooye provides facilities for approximately 15-20 students. This number can be considered as sufficient for the start of a charcoal development programme

The courses for the training programme can be combined with the "programme development" phase, as outlined under 6.23. Therefore it is not necessary to design different schedules and lectures. Also this would not be advisable from an economic point of view. After the successful completion of courses, the staff for the pyrolysis laboratory may then be appointed.

Schedule of the four week training programme:

(a) Lectures with experiments

- The pyrolysis of organic matter
- Charcoal manufacturing technology
- Composition of charcoal and charcoal briquets
- Composition of charcoal by-products
- Present and future resources for the charcoal supply in Somalia

(b) Laboratory courses

- Sampling of test material
- Determination of basic data in raw materials (moisture, ashes, bulk, density)
- Determination of basic data in charcoal (fixed carbon, ashes, volatiles)
- Sieve analysis, tumbler test, friability test
- pH and viscosity
- practical mathematics applied to charcoal production

(c) Training in kiln technology

- Construction of a beehive brick kiln (single wall concrete masonry kiln to be constructed later)
- Charging, discharging methods
- Ignition techniques
- Control of airflow, kiln temperature
- Determination of yields

6.50 Cost estimate for the charcoal research and training programme

(a) Investment costs

Pyrolysis laboratory

- Three room building, 100 m^2 storage room, 30 m^2	$ 35,000*	
- Furniture, lab. table, four tables, five cabinets, one desk, six chairs	$ 2,500	
- Lab. utilities	$ 1,000*	
- Glassware, apparatus, chemicals	$ 30,000	
		$ 68,500

Pilot plant programme

- Beehive brick kiln	$ 1,500	
- Equipment	$ 1,000	
		$ 2,500

Training programme

- Lecture room (available)	$ -	
Total investment:		$ 71,000

(b) Operational costs

Salaries/wages

- 2 technicians	SSH 1,400 + 400/m	$ 222 + 64.00/m*
- 4 assistants	SSH 1,300 + 400/m	$ 206 + 64.00/m*
- 1 foreman	SSH 300 + 100/m	$ 48 + 16.00/m*
- 2 charcoal burners	SSH 540 + 120/m	$ 86 + 25.00/m*
	Total operational costs:	$ 562 +169.00/m
- Overhead burden, transportation, etc.		$ 300 /m

* Figures given by the NRA-Forestry Department.

ANNEX 1

Equipment for the pyrolysis laboratory

4 hand sieves
1 sieve shaker
2 muffle furnaces
2 ball mills, two tier
5 electric or gas heated hot plates
1 pyrometer, high temperature range
1 viscosimeter
1 sorptometer for measuring surface area and pore volume
1 pH meter
1 precision metering pump
2 gas test meters
2 shaking water baths
4 stirrers
1 bomb calorimeter
2 precision balances
2 heavy duty balances, 50 and 100 kg
1 visible range spectrophotometer
1 X-Y temperature recorder
2 cutting mills, heavy duty and laboratory model
1 band saw, laboratory model
2 platinum crucibles
3 drying ovens
2 timers
2 calculators
1 typewriter

Glassware, crucibles, gas burners, vacuum equipment, hoses, tubes, laboratory tools

1 complete kit containing chemical reagents and equipment for wet analysis
1 maintenance kit for mechanical and electric repairs
1 first aid kit for laboratories

Safety goggles, rubber gloves

ANNEX 2

Equipment for the pilot plant programme

Construction material for the beehive brick kiln (as described in chapter 4.10)

10 metal drums for charcoal sampling (100 l)

1 blow torch

1 container (50 l)

2 balances (100 kg)

2 sets of wood cutting tools

1 light-weight chainsaw, fuel powered

1 first aid kit

ANNEX 3

Charcoal products and by-products

End Products	Markets
1. Raw Char	
- Raw char, unclassified	Steel industry, metallurgy, chemical industry, private households
- Raw char, classified	Foodstuff, pharmacy, bottling of high pressure gas
- Raw char, powder	Metallurgy, iron-casting industry, pyrotechnics
- Raw char, briquettes	Leisure market, private households, orchards
2. Activated Carbon	
- Activated carbon, granular and powder	Potable water purification, waste water treatment, chemical industry, solvent recovery, petro-industry, environmental control, exhaust emission control, sugar refinery, vitamin production, breweries, food industry, tobacco industry, pharmacy, metallurgy, tyre industry, dry cleaning
3. Tar	
- High density and low density tar	Chemical industry, optical industry, roperies, veterinary, cutlery
4. Acids	
- Acetic acid	Vinegar, food conservation, flavour and fragrances, chemical industry
- Butyric acid	Fragrances, pharmacy
- Propionic acid	Preservation and conservation
5. Other Chemicals	
- Methanol	Paints and varnishes, alternative fuel, chemical industry
- Creosotes	Preservation and conservation

ANNEX 4

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ANNEX 5

List of contacts

UNDP Mogadishu:	Mr. O. Svennevik, Resident Representative Mr. Yusuf Abdileh, Senior Programme Officer Mr. M.I. Kaireh, Library Assistant
National Range Agency:	Dr. Abdulahi Ahmed Karani, General Manager Mr. Yusuf Mohamed Ahmed, Acting Deputy General Manager Dr. Muhamed M. Jumallah, Director of Forestry Mr. Abdi Egeh Bohoreh, Regional Forest Officer (Expert's counterpart) Mr. David Field, FAO - Advisor to Range Agency Dr. S.M.A. Kazmi, Range Taxonomist
Regional Range Agency Baidhoa:	Mr. Ali Hadshi Hassan, Acting Regional Range Officer Mr. Aden Isaak Aden, Range Regional Officer Mr. Bashir Satal Huseen, Regional Forest Officer
Charcoal Co-operatives:	Mr. Mohamed Shek Abuken, Chairman of Production Co-operative Mr. Abdulah Ulsow Fidow, Chairman of Baidhoa Co-operative Mr. Shek Abdurahman Halane, Chairman of Marketing Co-operative (Mog.) Mr. Hadji Saniy Ibrahim, Chairman of Djowhar Co-operative
Forestry Training Centre Afgooye:	Mr. Abdulahi Hassan Mohamed, Range and Forestry District Officer
Sugar Factory Djowhar	Mr. Matan Abra, Deputy Plant Manager
National Banana Board Mogadishu:	Dr. Xassan Mohamed Gibin, Manager of Techn. Section Mr. Karlo Branka, Agronomist Afgooye
National Planning Commission:	Mr. Mohamed Hersi Khaire, Manager Techn. Unit Mr. Jama Omar Kujog, Librarian
Marca:	Mr. Omar Hadji Hassan, Regional Director of Range Agency

ANNEX 5 (cont'd)

Kisimayo:	Mr. Mohamad Isar Farah, Acting Regional Range Officer Mr. Gabow Sanwa Salad, Acting Accounting Manager of Regional Range Agency
Juba Sugar Project:	Mr. Mohamad Adan Dheri, Director of J.S.P. Kisimayo
Charcoal Co-operative Kisimayo:	Mr. Isaac Malin Omar, Chairman of Charcoal Co-operative
	Mr. Ahmed Dahir Abdullah, Manager of Accounting

ANNEX 6

Test Report

Location: Date: 10.01.1980

Forestal Training Centre in Afgooye

Kiln Type:

Cylindrical metal kiln, two tiers with hood, four emission outlets, eight air inlets.

Diameter: 2.0 m; Height: 2.30 m

Summary of the results:

The kiln was charged up to 85 per cent of capacity with firewood consisting of acacia species only; length of the logs: 1.30 m maximum. Charging time approximately two hours.

The logs were stacked vertically, the upper layer was partly covered with kindle.

Ignition through centre hole with two shovels of glowing charcoal.

The kiln started firing 2-3 minutes later and the ignition hole was closed then.

Temperatures at open air ducts reached normal peak after three hours. After 44 hours burning time the kiln was turned down and cooling off was finished three days later.

The burning cycle has been intentionally cut off to allow early inspection of the kiln.

Approximately 40 per cent of the total charge was converted into char. Eight Kintals (1 Kintal = 100 kg) could be recovered.

The quality of the charcoal looked good (drop test).

Due to the lack of balances and laboratory equipment, no analytical data could be established.

Remarks:

The assembling of the kiln parts created great difficulties due to the fact that all tiers were heavily deformed. We were not able to straighten out these damages and gaps between the upper tier and hood remained. To prevent combustion effects by the intrusion of air, the gaps were sealed with a mixture of nine parts clay and one part charcoal fines. The sealing had to be renewed frequently and did not stand during heavy rainfalls.