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1/2
16032

Distr.
RESTRICTED

IO/R.14
2 December 1986

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ENGLISH

CHARCOAL PRODUCTION USING PORTABLE STEEL KILNS

US/GBS/86/057

GUINEA BISSAU

Technical report*

**Prepared for the Government of Guinea Bissau
by the United Nations Industrial Development Organization**

**Based on the work of Dr. Derek E. Earl
Expert in charcoal and forest energy production**

Backstopping officer: R. O. Williams, Chemical Industries Branch

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GLOSSARY OF TERMS, ABBREVIATIONS AND
CONVERSION FACTORS

Currency unit . . . : Guinea Bissau Peso (PG)
PG200 : US\$1.00 November 1986

Wood

m^3 : cubic metre solid
stere : cubic metre stacked
 m^3
1 m³ tropical hardwood
(air dried) . . : approximately 900 kg
1 stere tropical hardwood:
(air dried) . . : approximately 700 kg

Charcoal

m^3 : approximately 250 kg
1 sack, jute, large . : approximately 32 kg
1 sack, jute, small . : approximately 16 kg
1 sack, nylon, large : approximately 40 kg

Kiln capacities

TDAI Mk V . . . : 7 steres
Guinea-mini . . . : 3.75 steres

Calorific values

Fuelwood : 16.8 joules
Charcoal : 28.1 joules
Fuel oil : 40.2 joules

ABSTRACT

Charcoal Production Using Portable Steel Kilns

UF/GBS/86/057

The objective of this one month mission was to introduce portable steel kilns for use by sawmills for the conversion of logging waste to charcoal.

Two portable steel kilns, made in Guinea Bissau for Mr M G Brandao owner of the Bambadinca sawmill, were tested and found to produce very good charcoal from sawmill waste and roundwood. About a dozen Bambadinca sawmill employees and two workers from another company were instructed in the use of the kilns.

Modifications to the kilns were introduced to simplify their operation especially in the forest. The modified kiln, named the Guinea-mini, was readily accepted by Mr Brandao who arranged for the necessary changes to be incorporated in an order for more kilns.

It is estimated that the Bambadinca concession could support a batch of twelve Guinea-mini kilns (10 in the forest and 2 at the sawmill) which would be capable of producing 50 tonnes of charcoal per month. Pre-feasibility studies indicate that at the anticipated production level, a favourable return for charcoal could be obtained if marketed in Guinea Bissau (Appendix 1) but it was likely to be much more profitable if exported to Mauritania (Appendix 2).

RECOMMENDATIONS

The sawmill at Bambadinca is powered by belt drive 150 HP diesel engine. The engine is old and is liable to breakdown. Diesel oil is expensive and in short supply.

1. IT IS RECOMMENDED THAT A STUDY OF THE ECONOMIC AND TECHNICAL FEASIBILITY OF INTRODUCING ALTERNATIVE POWERED ENGINES, E.G. PRODUCER GAS OR STEAM BASED UPON WOOD WASTE AS FUEL, FOR THIS AND OTHER SAWMILLS. IT IS SUGGESTED THAT THE GOVERNMENT SHOULD MAKE A REQUEST FOR ASSISTANCE TO OBTAIN A SUITABLY QUALIFIED CONSULTANT.

At the present time the lop and top from trees felled for timber is left in the forest.

2. IT IS RECOMMENDED THAT THE FOREST DEPARTMENT SHOULD ENCOURAGE CHARCOAL MAKING TO FOLLOW ALL FOREST LOGGING OPERATIONS IN ORDER TO AVOID WASTAGE AND TO RATIONALISE THE USE OF LABOUR, TRANSPORT AND MANAGEMENT.

The production of charcoal in the forest will clear debris to reduce fire hazard and provide suitable sites for planting trees with minimum ground preparation.

3. IT IS RECOMMENDED THAT THE FEASIBILITY OF FOLLOWING-UP LOGGING AND CHARCOAL MAKING OPERATIONS WITH TREE PLANTING BE INVESTIGATED BY THE FOREST DEPARTMENT.

Although there are sufficient trees on public land to maintain national fuel supplies for some years, the long-term outlook is not assured because there are no forest reserves and reforestation is on a very small scale and far below the rate of depletion.

4. IT IS RECOMMENDED THAT A MINIMUM OF 10 PERCENT OF THE REMAINING PUBLIC LAND WITH TREES SHOULD BE DECLARED FOREST RESERVE AND MANAGED BY THE FOREST DEPARTMENT SO AS TO PROVIDE TIMBER AND FUEL IN PERPETUITY. AS RESERVATION IS LIKELY TO BE COMPLICATED, IT IS SUGGESTED THAT A REQUEST FOR ASSISTANCE SHOULD BE MADE BY GOVERNMENT TO THE UNDP.

INTRODUCTION

As part of overall Government strategy to improve the supplies of domestic cooking fuel, this project to assist in improving charcoal production from waste wood using portable steel kilns, was identified by the TAS Mission RF/RAF/85/609 to Guinea and Guinea Bissau in October 1985. The objectives were identified and stated as follows:

(a) Development Objectives

- To develop the production of charcoal from forest industry and sawmill waste for both domestic use and export.
- To upgrade the value of these wastes.
- To promote a more rational approach to the use of the forest resource.
- To help alleviate shortages of domestic cooking fuel.

(b) Project Objectives

To install operating portable steel kilns for use in logging areas, for the conversion of logging waste (tops, branches, etc.) to high grade charcoal. One or more kilns may also be used at a sawmill to make charcoal from slabs and trim ends. Total output of charcoal will be in the order of 6 tonnes per week.

A sawmill in the private sector, located at Bambadinca near Bafata, Guinea Bissau, was selected as the base for a pilot scheme to try out new methods of converting forest and sawmill waste to charcoal suitable for both domestic use and for export. Activities began in April 1986 with the manufacture of two portable steel charcoal kilns in Bissau to specifications from the TDRI, based on the Uganda Mk V kiln, translated into French and submitted by UNIDO. A consultant with experience in the production of charcoal arrived in October 1986 to assist in the introduction of the new technology and to train local personnel in the manufacture, preparation and marketing of the product. The report with conclusions and recommendations for future action was submitted to UNIDO in November 1986.

I BACKGROUND

In Guinea Bissau, electricity production and fuel for transport is obtained exclusively from imported oil which takes a disproportionately high percentage of scarce foreign exchange. (18% total imports, 86% of export earnings).

Although the prospects for finding offshore oil supplies are promising and the potential for developing hydro-electric power resources are also very good, fuelwood and charcoal will continue to provide the basic energy needs of the majority of the population for the foreseeable future.

It is calculated that about 90% of the population of about 900,000* use fuelwood or charcoal for domestic cooking purposes. Home produced fuelwood and charcoal do not require foreign exchange for their utilization, but uncontrolled exploitation of trees for fuel will deplete forest resources and eventually adversely effect the economy and the environment.

The provision of adequate sustained supplies of charcoal for both home use and export will require a determined effort to avoid wastage at sawmills and in the forest, by improving the efficiency in the production and utilization of charcoal, and by safeguarding the renewability of suitable trees by good forest management practice.

* The population was 777,214 in the latest census, April 1978

There is currently no shortage of fuelwood in the rural areas because there is no apparent restriction on felling trees. Waste wood has no market unless it is first converted to charcoal and transported for sale in the urban centres, where fuel is in short supply and expensive. Eg. a 32 kg sack of charcoal in the forest, off the road near Bambadinca is 350 pesos, on the road near Bafata - 700 pesos and in the market in Bissau - 1200 pesos.

The present pilot project is aimed at slowing down the depletion of the available resource of standing trees at present being cut for charcoal by providing the market with good quality charcoal from waste material, left behind in logging operations and at sawmills. It is hoped that part of this environmentally acceptable charcoal will be produced profitably and sold at a price that people can afford and that the rest will be exported to Guinea Bissau's neighbours in order to help improve the country's balance of payments problem.

II ACTIVITIES AND OUTPUT

Two kilns, manufactured by Guimetal engineering works in Bissau had been purchased and brought to the Brandao sawmill in Bambadinca. One kiln had been fired but it was not possible to judge how successful it had been as some of the charcoal and brands had been removed. The kilns were assembled and checked and although there were a few departures from the drawing submitted by UNIDO, they were relatively minor and the general standard of construction and workmanship was very good. It was not possible to obtain corten steel sheet (as recommended) in Guinea Bissau but good quality 3 mm thick sheets of constructional steel (Aco de Construction specification C.K.45 was used for both cylinders) and 12.2cm square chimneys were made from 2 mm thick steel plate.

It was noted that the average external diameter of the upright flanges on the basal vents was 12.2 cm which was the same as the internal diameter of the chimneys. This absence of tolerance made fitting and removing the chimneys during carbonisation extremely difficult and it was therefore decided to overcome this problem by attaching a collar to the bottom of the chimneys to increase their internal diameters to 12.8 cm. This modification was carried out successfully to all eight chimneys by a welder employed by the tile factory at Bafata.

The kilns were installed at the sawmill where there was a pile of several hundred cubic metres of good quality sawn offcuts of Bissalon (Khaya senegalensis) and two large heaps consisting of roundwood pieces of Pau sangue (Pterocarpus erinaceus).

After the initial loading and firing of the kilns, difficulties were encountered which were remedied by making some minor changes to procedures. One of the difficulties was that the tropical wood used (Khaya senegalensis) produced a great deal of pitch and tar which served to join the two cylinders together and made it impossible to disassemble and unload the kiln in the recommended way. The entire kiln, with lid removed, had to be levered up and lowered on to its side, a relatively easy task as men

were available but extremely difficult for a few men to accomplish without incurring injury. Once on its side, the two cylinders could be separated after rolling and gently tapping with a log mallet and prising with a jemmy. The second problem was encountered in obtaining a good fit for the lid because of a slight ovality in the cylinders. The difference in the diameter was only between 4 and 6 cm but enough to cause trouble in sealing with sand.

It was found that a quicker conversion with better yields (pro rata) and much easier working conditions were obtained by using one cylinder only. Later it was discovered that the reverse draught could be reduced to 6 vents and 3 chimneys with no loss of yield or lengthening of the carbonisation cycle. The sawmill owner and trainees were pleased with the new version of the kiln which was also demonstrated to the technicians from Guimetel who visited the carbonisation area and took careful note of the necessary modifications needed to fulfil an order for 8 more kilns appropriately named the Guinea-mini.

A further firing using round branches of Pterocarpus erinaceus (Pau sangue) was tried using the Guinea-mini kiln.

Results (see Appendix 4) obtained were as follows:

TABLE 1
Summary of results from trials with portable steel kilns

Kiln	Cycle days	Load steres	Yield kg	Type input	Remarks
mini	2	3.5	352	s/mili waste	Approx. extra 50kg charcoal as brands
maxi	5	7	741	" "	Overloaded 10 cm - difficult to seal & very difficult to unload.
maxi	4	7	575	" "	Very difficult to unload.
mini	2	3.5	424	" "	6 vents, 3 chimneys
mini	2	3.5	450	roundwood	" " " "
mini	2	3.5	-	s/mill waste	" " " " (results to come)

Training

10 men from the Brandao sawmill work-squad received training for at least part of the time and most of the staff of more than 20 men showed considerable interest in the charcoal activities and were always ready and willing to assist in any difficult task. 1 man was given special training to enable him to teach further men and to take on the job of supervision. 2 further men were brought from Contuboel sawmill to undergo training for a few days.

RESULTS AND FINDINGS

Two portable steel charcoal kilns made in Guinea Bissau to specifications provided by UNIDO were tested and found to provide high yields of good quality charcoal. Average yields of more than 100 kg per stere, i.e. greater than 20% on an 'as received' basis were obtained. Using a modification of the TDRI Mk V kiln, yields of 113 kg per stere for sawmill waste and 120 kg for forest roundwood were obtained by the trainees with little interference or supervision. These yields are above those normally obtained from earth kilns and the carbonisation cycle was very short: only two days for the modified kiln, i.e. the Guinea Mini.

The standards of workmanship at the kiln manufacturers were high and there was no difficulty in getting modifications to the design to suit Guinea Bissau conditions accepted.

It was decided to introduce a one-cylinder kiln because it is much easier to fill and handle than the TDRI MkV, has a quick cycle and there is much less chance of things going wrong. The two kilns purchased will be converted to four Guinea-mini kilns after the purchase of two more lids, 4 chimneys and 8 vents (the mini kilns require only 3 chimneys and 6 vents each).

Most of the trainees assigned to the charcoal making operations showed interest and obviously enjoyed the work. A senior trainee was able to instruct trainees from another sawmill in the use of the kilns and after another 2 weeks, working in sole charge, should be capable of handling kiln operations in the field.

Samples of charcoal were brought to the UK for analysis. Ocular examination and simple hand testing indicated that all the charcoal produced was of good quality.

Loading the charcoal into sacks was by hand assisted by shovel. 10 mm mesh

for constructing sieves was not available to the consultant and therefore a screen was constructed from an old grill with additional wire woven into it. This apparatus was supported on a wood frame and used successfully to obtain the last 1 or 2 bags of charcoal from the kilns. (Later it was noted that 10 mm mesh is sometimes available and further sieves will be made to the plans submitted by UNIDO.

Several trips were made to other sawmills and to the forest concession area where a large potential for charcoal to be manufactured from waste was noted. It was difficult to estimate how much wood is available for charcoal at the sawmills as there appeared to be no control on waste disposal. Some wood and sawdust was being burnt and some waste appeared to be taken by people, not always sawmill employees. Gambiel sawmill was selling some of its sawdust to a businessman in Gambia for transshipment to Europe: some charcoal was being made using simple earth kilns. Contubcel sawmill was making about 100 sacks of charcoal per month in earth kilns and the owner was keen to improve his yield. The charcoal was sold locally at PG800/bag (\$4). Some waste wood was used to heat a timber seasoning kiln. This owner sent two men to Bambadinca for training and intends to purchase kilns.

No felling has taken place in any concession area since June 1986 to enable concession holders to plant trees. The Bambadinca concession is lightly stocked with Azelia africana (pau conta), Dialium guineense (pau velude) and Erythrophleum guineense (mankone) all of which are suitable for charcoal, but mainly with Khaya senegalensis (Bissalon). The trees have short trunks and massive crowns. Assuming the cut is 1500 m³ per year of which 1000 m³ is exported as logs, it can be roughly estimated that at least three times this volume is contained in the crowns and is therefore available for charcoal. This would indicate a potential of 550 tonnes per year from the forest waste and about 50 tonnes per year from the sawmill waste which is enough to justify the purchase of 12 mini kilns.

APPENDIX 1

Pre-feasibility study of expected return from manufacturing 50 tonnes charcoal per month from wood waste, using portable kilns, and selling it locally.

	Costs PG per month
<u>Costs</u>	
12 kilns @ PG150,000 = PG1,800,000, 2 year life, depreciation per month	75,000
6 chain saws @ PG80,000 = PG480,000, 2 year life, depreciation per month	20,000
Spares and repairs @ 20%	4,000
Jute sacks 32 kg capacity @ PG200, used 4 times, returnable	78,125
Hand tools, string, etc	2,200
Tax on wood PG 1/kg charcoal paid to Government	50,000
Labour: 2 men/kiln = 24 men @ PG5,200 per month	124,000
Labour overheads: food, accommodation, transport and social security @ 100%	124,800
Petrol and oil, 540 litres @ PG90	48,600
Transport charcoal from 10 kilns in concession area to sawmill estimated at PG120 per sack)	<u>160,000</u>
TOTAL	<u>687,525</u>

Cost of charcoal delivered to/made at sawmill = PG13,750/tonne
= PG444/32kg sack

- (a) Assuming selling price if PG500 per sack, estimated profit per month is: $PG775,000 - 687,525 = 87,475$ or 11% of selling price
- (b) Assuming selling price is PG600 per sack, estimated profit per month is: $PG930,000 - 687,525 = 242,275$ or 26% of selling price.
- (c) Assuming selling price is PG700 per sack, estimated profit per month is: $PG1,085,000 - 687,525 = 397,475$ or 37% of selling price.

This study is given as an indication only of the possible financial outcome as much will depend upon the organization and management of the operation as well as changes in effective demand for charcoal.

APPENDIX 2

Pre-feasibility study of expected return from manufacturing 50 tonnes charcoal per month from wood waste, using portable kilns, and exporting it by road to Nouakchott, Mauritanie.

	Cost \$ per month
<u>Costs</u>	
12 kilns @ \$750 = \$9000, 2 year life, depreciation per month	375
6 chain saws @ \$400 = \$2400, 2 year life, depreciation per month	100
Spares and repairs @ 20%	20
Petrol and oil, 540 litres @ PG90	243
Sacks, nylon, 40 kg capacity, @ PG107 each, non-returnable	669
Hand tools, string, etc	11
Tax on wood @ PG1/kg charcoal paid to Government	250
Labour: 2 men/kiln = 24 men @ PG5200/month	624
Labour overheads: assistance with food, accommodation, transport and social security @ 100%	624
Transport charcoal Bambadinca-Nouakchott @ \$60/tonne	3000
SUB TOTAL	5916
Contingency @ 50%	<u>2958</u>
TOTAL	8874

The estimated value of charcoal landed at Nouakchott is \$500/tonne.

- (a) Assuming selling price of \$300/tonne with sacks, the estimated profit per month is: $\$15000 - 8874 = \$6126 = 41\%$ of selling price.
- (b) Assuming selling price of \$400/tonne with sacks, the estimated profit per month is: $\$20000 - 8874 = \$11,126 = 56\%$ of selling price.
- (c) Assuming selling price of \$500/tonne with sacks, the estimated profit per month is: $\$25000 - 8874 = \$16,126 = 65\%$ of selling price.

This study is given as an indication only of the possible financial outcome, as some of the assumptions, including the price of \$500 claimed to be obtainable for bulk deliveries of charcoal to Nouakchott, Mauritanie need to be checked. Of utmost importance will be the organization and management of the operation through all stages.

APPENDIX 3

Job description

UF/GBS/86/057/11-51/32.1.1.

Post title Expert in the production of charcoal from wood waste using portable steel kilns

Duration 1 month

Date required August 1986 or as soon as possible

Duty station Bambadinca, Guinea Bissau

Purpose of project To introduce portable steel kilns for use in logging areas for the conversion of logging waste to charcoal.

Duties In co-ordination with Sr Manuel Gomes Brandao of Bambadinca and the Ministry of Natural Resources and Industry, the expert will execute the following tasks.

- 1 Assist with the construction of one or more portable kiln(s) and ensure that they have been fabricated to the appropriate standards (fabrication will have begun prior to the expert's arrival at Bambadinca).
- 2 Install the kiln(s) at an appropriate location (selected by the project personnel following discussions with the consultant), commission and supervise the first firings of the kiln(s).
- 3 Instruct the local personnel in charging the kiln(s), the firing cycle and in preparation of the charcoal product.
- 4 The expert will be expected to arrange for the

analysis of a sample of the charcoal product at either his home base or another appropriate laboratory.

- 5 Instruct local personnel in the use of simple sieves and bagging procedures for the charcoal product.
- 6 Advise local personnel on the marketing of the charcoal product.

The expert will prepare a report in English presenting an account of his activities during the mission and his recommendations for follow-up work to be undertaken in Guinea Bissau and an indication of the future role which UNIDO can play.

Qualifications

Engineer or scientist. University degree and considerable practical experience in the fabrication and use of small-scale charcoal kilns. Practical experience in developing countries an asset.

Language

English and a working knowledge of either Portuguese or Spanish.

Background information

A private sector forest industry located in Bambadinca, Guinea Bissau, is currently logging 2000 m³ cut roundwood per year for further processing at a sawmill into merchantable timber and stakes. 20 tonnes/day of waste are left in the forest and generated at the sawmill. The wood waste is known to make high quality charcoal for which there is an export market in Europe. Charcoal is also used extensively in Bissau for domestic cooking.

UNIDO has been requested to furnish technical assistance with the installation of transportable metal

kilns and the introduction of kiln operators. The kilns will be used for the efficient conversion of the wood waste to charcoal. The following major categories of portable kiln, for use in making wood charcoal, are available:

- Drum kiln (of which there are numerous designs used worldwide.
- TDRI (G.B.) Mk V Kiln
- Cusab kiln
- Cuve Basculante (France)

The TDRI kiln has been used extensively for the manufacture of wood charcoal in several African and Asian countries. Its portability makes it particularly useful for making charcoal in the forest from logging waste.

The Rural Technology Guides Nos. 12 and 13 prepared by the Tropical Development and Research Institute of Great Britain concerning the fabrication and use of a transportable steel charcoal kiln have been forwarded to project personnel in Guinea Bissau. Project authorities have been requested to fabricate one or more kilns prior to the expert's arrival.

APPENDIX 4

Kiln firing notes

A. Firing No 1

Guinea-mini (Charge: Khaya senegalensis sawmill waste)

NB No note was taken of the timing for the loading of this kiln as the men were under initial instruction. The kiln was loaded enough to enable the lid to remain about 10 cm above the cylinder at time of lighting to allow for better through draught and settlement of wood.

3/11

- 09.20 Wind direction tested and kiln lit on the leeward side through the inter-vent channels.
- 09.55 Inter-vent base and horizontal vents sealed with wood and soil.
- 09.45 4 chimneys put in place.
- 09.50 Draught successfully reversed.
- 10.15 Ports sealed.
- 10.30 Lid dropped into position and sealed with moist sand.
- NB To avoid overheating, vertical air vents almost sealed.
- 10.30 One hot chimney with blue smoke removed.
- 16.00 Kiln smoking well on 3 chimneys, fourth one returned to use.
- 16.30 3 chimneys smoking well. Staff well instructed re hot spots and control of air supply.
- 17.15 Port inspection revealed charge partly carbonised. Chimney positions changed. Vertical vents fully opened to facilitate establishment of down draught in new chimney positions.
- 17.45 Air intake reduced to ensure slow, safe overnight burn.
- 22.30 2 chimneys smoking.

4/11

- 09.15 Kiln stopped smoking and sealed for cooling.

6/11

- 11.45 Unloading commenced.

Charcoal yield 352 kg (14 standard bags of approximately 25 kg per bag).

Number of brands (approximately equivalent to 2 bags of charcoal) indicated a cool burn. No ash.

B. Firing No 2

TDRI MkV (Charge: Khaya senegalensis sawmill waste)

NB No note was taken of the timing of this loading as the men were under initial instruction. The kiln was overloaded in order that the lid remained 10 cm above the top cylinder at the time of lighting to allow for better through draught and for settlement of wood.

3/11

- 11.00 Wind direction tested and kiln lit through inter-vent channels.
- 11.10 First section of inter-vent base closed with wood and soil.
- 11.30 All base, including horizontal air vents closed. 4 chimneys in position.
- 11.35 Lid not settled. Kiln too hot on the windward and too cool on the leeward side.
- 12.45 All ports closed.
- 12.55 Lid finally settled, despite difficult manhandling of the hot lid a poor seal was effected leading to potential draught and overheating difficulties because the top cylinder is slightly oval.
- 13.00 Extra sand seal applied to lid/top cylinder joint.
- 13.30 Sealing continued, one chimney producing blue smoke was temporarily removed and its station sealed.
- 16.00 Smoking quite well on three chimneys - the fourth one was repositioned.
- 16.30 Clay/water seal applied to the lid/top cylinder joint in preparation for safe night burn.
- 16.40 All chimneys smoking well. Staff competent to detect hot spots in the base cylinder and to restrict air intake at or near those points.

- 17.35 Chimney positions changed.
17.45 Air intake put on minimum to ensure cool safe overnight burn.
23.00 All under control.

4/11

- 09.15 2 leeward chimneys smoking, also leeward area of lid/top cylinder joint. Further clay seal applied to this joint.
09.50 1 chimney smoking.
16.00 Port inspection revealed uncarbonised charge. All air vents opened.
16.20 All ports opened.
16.35 All ports closed after copious smoke produced. Draught reversed successfully in 3 chimneys. (1 on leeward side not smoking).
18.00 Exothermic reaction in one part of the top cylinder.
23.00 Exothermic reaction moving round. 1 vent closed and the others on minimum air intake. Only 1 chimney smoking.

5/11

- 09.30 1 chimney smoking. Still a lot of brands/wood. All air vents and ports opened.
09.40 Ports and horizontal vents closed and chimneys moved round one place. Draught successfully reversed and 4 chimneys smoking but all vertical vents giving off smoke - all vertical vents temporarily closed to stabilise the reversed draught.
22.15 A small amount of blue smoke from one chimney only. Percussion of the cylinders indicated that the top is empty and the bottom full. All chimneys finally removed and the kiln sealed for cooling.

7/11

- 16.00 Top cylinder still hot in one area. Old clay seal round Lid/top cylinder joint and top cylinder/bottom cylinder joint removed (it had a number of fine heat cracks) and new seals applied.
17.20 Top cylinder cooling.

8/11

- 08.30 Kiln cold.

There were a number of problems when opening the kiln, chief of which was the heavy amount of tar which completely stuck the cylinders together. This was resolved only when both cylinders were rolled off the charcoal and

rocked back and forward and eventually a jemmy used to prise them apart. Despite all the difficulties encountered with this burn, there were relatively few brands, little or no ash and a good charcoal yield.

Charcoal yield 741 kg (18 bags of approximately 41 kg per bag).

C. Firing No 3

TDR1 MkV (Charge: Khaya senegalensis sawmill waste)

6/11

- 09.15 2 men allocated to clear a site for this firing, a third joined them.
- 09.45 Air vents cleaned of tarry residues.
- 10.00 Base cylinder in place and sealing ring cleaned.
- 10.10 Air vents positioned and stringers placed.
- 10.15 Central firewood cone built, some short brands added.
- 10.25 Dry grass placed radially from cone through vents for thru-vent lighting (to reduce possible heat damage to cylinder).
- 10.35 Base laid using a mixture of wood and brands, general loading commenced using sawmill waste and packing the interstices with available small offcuts.
- 11.20 Loading of base cylinder completed.
- BREAK
- 16.00 Moist sand seal applied to horizontal 'U' track at top of base cylinder to form a seal between base and top cylinders. Top cylinder manoeuvred into position and charging with sawmill waste continued.
- 17.05 Top cylinder full, final layers cone-shaped to take the lid.
- 17.15 Moist sand seal put in horizontal 'U' track of top cylinder to act a cylinder/lid seal.
- 17.30 Lid manoeuvred into position. Small pieces of sawmill waste posted through ports to completely fill available space.

17.45 Heavy sand/water seal put all round lid. Soil round base of kiln loosened for quick sealing use.

7/11

08.40 Kiln lit through air vents.

09.00 Gaps between vents closed. Thick smoke through ports.

09.20 2 windward horizontal vents closed. The 4 chimneys set in position. Remaining horizontal vents closed.

09.30 Ports closed, draught reversed. 4 chimneys smoking well. No hot spots.

16.15 Going well.

17.10 Chimneys changed and draught successfully reversed.

17.15 1 chimney giving off blue smoke - all air vents almost closed.

17.20 Smoke under control, 2 vents opposite the rogue chimney opened.

8/11

08.30 All 4 chimneys going well. All vertical air vents opened after overnight safety semi-shut down.

19.30 4 chimneys producing thin white smoke. All horizontal air vents remained closed and the vertical ones almost sealed.

9/11

08.15 No smoke. Kiln sealed for cooling.

10/11

08.30 Kiln cold.

17.15 Lid removed for use on another kiln. Top and base cylinders completely stuck together with tar.

17.25 Conjoined cylinders levered over and manually rolled on their sides.

Charcoal yield 575 kg (14 bags of approximately 41 kg per bag).

D. Firing No 4

Guinea-mini (Charge: Khaya senegalensis sawmill waste)

10/11

- 09.10 Cylinder in position on 6 vents.
- 09.15 Because of previous difficulties re fitment of lid:cylinder, some time spent offering lid to cylinder and measuring both pieces of equipment. Lid seems to be circular and cylinder oval (diameter variation 2260-2320 mm). Notes taken for recommendations re minor adaptations of the design for further kiln manufacture..
- 09.55 Stringers placed and central cone of grass+kindling formed and grass laid in radial design for thru-vent lighting. NB with only 6 vents in use, it may be necessary to add an extra inter-vent stringer to facilitate concentric circle mattress structure of wood and brands, while maintaining air access at the base.
- 11.10 Cylinder full - top being shaped to take the lid. (Lid tried once more to ensure it fits).
- 11.25 Moist sand seal applied to top horizontal 'U' track in order to take the lid. Lid manoeuvred into position with difficulty. Filling continued through the ports.
- 11.45 Lid fitting poor despite not overloading. Further moist sand seal applied to try and seal air space between lid and cylinder.
- 11.46 Kiln lit on leeward side, then on windward side; not pulling very well, vertical vents blocked to increase draught.
- 12.03 Kiln going better. Soil dug in preparation for air control.
- 12.07 Initial reduction of air intake started.
- 12.15 Copious smoke through ports but some sections of the kiln still cool.
- 12.20 Inter-vent air intake sealed, then horizontal vents sealed.
- 12.25 3 chimneys positioned. Draught reversing satisfactorily.
- 12.28 Ports closed. 2 chimneys smoking well, 1 poor.
- 15.20 All chimneys smoking well.
- 20.30 Chimneys smoking well - air intake restricted for safety overnight.

11/11

- 08.30 1 chimney with a small amount of blue smoke. Port inspection

indicates charcoal. Kiln sealed for cooling.

12/11

12.00 Kiln cold - bagging commenced.

Charcoal yield 424 kg (11 bags of approximately 38.5 kg per bag).

E. Firing No 5

Guinea-mini (Charge: Pterocarpus erinaceus in the round)

Three men were detailed to work on this kiln.

11/11

09.25 Cylinder in place and 6 vents put under it.

09.40 Stringers and base mattress + cone being laid by the foreman from material supplied by the labourers.

09.55 Loading with wood commenced. Interstices filled with small sawmill offcuts (mainly Khaya senegalensis).

10.20 Cylinder two thirds full.

10.55 Top cone being shaped from sawmill waste to take the lid.

11.10 Moist sand seal applied to horizontal 'U' track.

11.17 Lid manhandled into position.

11.25 Final moist sand seal being applied over the periphery of the lid. Small pieces of sawmill waste posted through the ports to completely fill available space.

11.30 Loading completed.

BREAK

11.50 Loose soil round kiln prepared, and pieces of wood for closing the base inter-vent spaces placed near the kiln.

BREAK

16.50 Kiln lit thru-vents; some vents blocked with too much grass.

17.25 Base and horizontal vents closed, 3 chimneys in position - smoking well, ports closed.

21.50 All chimneys going well. Chimney positions changed. All vertical

vents open.

12/11

- 08.45 One chimney not smoking, the other 2 going well. Thick tar + heat indicating exothermic reaction.
- 09.00 3 chimneys smoking well.
- 10.00 Strong exothermic reaction almost complete - smoke thinning.
- 10.05 All vertical vents open, 1 chimney not smoking.
- 11.15 A hot spot developing, therefore air intake in that region restricted.
- 17.15 2 chimneys stopped with a small amount of blue smoke. Port inspection revealed mainly charcoal. Chimneys removed and kiln sealed for cooling.

13/11

- 08.30 Kiln still slightly warm. Extra sand/water seal applied to the lid periphery.
- 11.00 Unloading.

Charcoal yield 450 kg.

F. Firing No 6

Guinea-mini demonstration firing (Charge: Khaya senegalensis sawmill waste).

NB Two men from Contuboel Sawmill were present for training in kiln operation by the chief charcoal trainee, Bambadinca Sawmill.

12/11

- 10.00 Two trainees arrived, inspected Guinea Mini (3) which was smoking well, had an introductory talk about the kiln, its composition and method of firing. They manhandled a top cylinder into position for

loading and inserted vents.

- 11.15 Stringers, kindling and brands in place.
- 11.25 A mixture of wood and brands added to complete the base mattress. General loading commenced. (Two pieces of Prosopis africana, tied with wire for identification purposes, were placed centrally about two thirds up the charge; this is to be sampled for analysis.).
- 12.00 Interstices being filled with small pieces.

- BREAK Firing delayed until 13/11 as the chief charcoal trainee is ill.

13/11

- 12.35 Lid in position, loading completed and fresh sand/water seal applied to lid/cylinder joint. Wind direction tested and kiln lit.
- 13.15 Half the inter-vent spaces at the base closed.
- 13.20 All inter-vent spaces closed as well as horizontal vents.
- 13.25 3 chimneys positioned. Ports closed.
- 13.27 One chimney giving off blue smoke; it was placed on an adjacent vent and its original station temporarily sealed.
- 16.30 Smoke/draught established and rogue chimney returned to its original position.
- 19.15 Chimneys smoking well; their positions were changed and one very hot vent was part closed to allow for safe overnight burn.

NB Mr Brandao was asked to (1) arrange for the kiln to be unloaded on 17/11, (2) for the weight/volume details of that firing to be telexed to Devon and (3) for a sample of the Prosopis africana charcoal to be sent to Devon for analysis.

ITINERARY

20/10	Kingsbridge - Vienna
21/10	Briefing UNIDC HQ
22/10	Vienna - Lisboa
23/10	Collecting visa and volunteer assistant
24/10	Lisboa - Bissau
25-27/10	Briefing Government and UNDP
28/10	Bissau - Bambadinca
29/10	Testing kilns
30-31/10	Modifying chimneys at Bafata
1-2/11	Testing and training
3/11	Visit to plantation area (assistant to kilns)
4/11	Visit to Gambiel sawmill (assistant to kilns)
5/11	Bissau - market survey, stores & UNDP
6-8/11	Training
9/11	Visit to forest concession area
10/11	Final firing of modified Guinea Mini
11/11	Visit to Contuboel sawmill and concession (assistant to kilns)
12/11	2 students from Contuboel sawmill arrived for training
13/11	Final training session
14/11	Bambadinca - Bissau
15/11	Bissau - Kingsbridge

PEOPLE CONTACTED IN GUINEA BISSAU

(In order of meeting)

MIGUEL DA GRACA	Resident Representative, UNDP, Guinea Bissau.
CARLOS NEATE	Chef du Departement d'industrie et Matériaux Construction.
CARLOS BRANDAO	Bambadinca Sawmill.
JOSTA HALLBERG	Socotram (Silviconsult)
MARLENE TRAVELLA	UNDP i/c UNIDO projects in Guinea Bissau.
CIPRIANO CASSAMA	Direccao Servico Florestal e Laco
MANUEL GOMES BRANDAO	Owner, Bambadinca Sawmill
NUNO MIQUELINO	Timber Buyer.
ALBANO NEVES SILVA	Managing Director, Contuboel Sawmill.
JOAO GOMES JUNIOR	Guimetal, Bissau.