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DEMONSTRATION PROGRAM ON USE OF INDIGENOUS BIOMASS RESOURCES FOR MEETING ENERGY NEEDS

US/SUD/26/026/11-51/J 13424

SUDAN

Technical Report*

Mission 6 April to 20 May 1987

Prepared for the Government of the Democratic Republic of the Sudan by the United Nations Industrial Development Organization acting as executing agency for United Nations Development Program

Based on the work of Mr. Albert Zorge,
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690

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TABLE OF CONTENTS

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SUMMARY

The summary of the Technical Report, dated December 1985, concerning the author's mission 1 November to 31 December 1985 within the UNIDO-sponsered project RP/RAF/85/627/Sudan, ended quote [...] to proceed without delay with a number of fieldtests in a simple pilot project [...] unquote.

In this report the above mentioned follow-up, now in the UNIDO-sponsered project US/SUD/26/026/11-51/J 13424, is recorded in all details.

Sections 2 gives information on the characteristics of the area where the fieldtests were carried out.
Section 3 analyses the irrigation structure, previous to the harvest season.
Sections 4 and 5 describe the uprooting of the feedstock, i.e. the cotton stalks, being a bottleneck in a process proceeding the carbonization.
Section 6 gives details about the feedstock, as it was carbonized during the fieldtests.
Sections 7 and 8 are dealing with the kilning equipment as wel as the manpower involved in the tests.
The extensive Section 9 presents the planning and preparation for both the Carbonization- and the Briquettingproject.
In Sections 10 and 11 accomodation for the consultants and the communications between all organizations involved are recorded.
In the following sections nos. 12-17, details of the fieldtests are presented.
Sections 18 and 19 are giving Results and Data.
Sections 20 and 21, Conclusions and Redommendations finalize this report.

1. Introduction

In December 1985 a few carbonization tests were carried out at the site of the testcentre of the Sudanese Renewable Energy Research Intitute, situated at Soba, some 25 km. south of the capital Khartoum.

Objective of these tests was to learn if cotton stalks could be carbonized operating simple kilning equipment, that was locally manufactured.

Why?

A number of starting points was a good reason.

A. An enormous waste of potential biomass resources in the Sudan as annually between 1 and 1 1/2 million tons of cotton stalks have to be burnt in order to prevent spreading of pest infestation.

B. Steadily rising prices for wood charcoal and fuelwood, as these most common domestic fuels had to be produced in still more distant areas, causing higher transportation costs.

C. Together with large-scale landclearing for mechanized farming the production of wood charcoal and fuelwood caused deforestation and desertification, thus reducing heavily the already low forestry resources of the Sudan.
   - Report in the Sudan Morning of May 1987:
     Dinder National Park, the pride of Sudan, is bound to disappear within 5 to 6 years due to large-scale deforestation.
     Every day 40 to 50 lorries are loaded, each with 7 to 15 tons of illegally chopped wood. Destination: the populated areas in the midbelt of the country -

It has been the merit of the United Nations Industrial Development Organization (UNIDO) not only to identify this grave situation, but also to act accordingly.

In the UNIDO-sponsored project RP/RAF/85/627 consultants were fielded in November and December 1985 to fabricate in local workshops suitable kilning equipment for the carbonization of cotton stalks.

Furthermore to introduce simple kilning techniques when demonstrating this carbonization equipment.

These tasks having been succesfully accomplished, fieldtests were strongly recommended as to disseminate the kilning technology when established in a large production organization.

The tests, originally intended for the 1986 harvest season, had to be postponed one year.

Although time for ample preparations was not available and operations started with a 5-weeks delay, yet the results of the fieldtests justify the undertaking of this important project.

Considered to be a replacement for wood charcoal, cotton coal (charcoal from cotton stalks, was not found suitable because of its different burning characteristics.
The Biomass Technology Group of the University of Twenthe therefore designed and developed a simple but efficacious briquetting equipment, using molasses as a binder.

As a logical follow-up of the carbonization fieldtests the produced cotton coal will be briquetted during fieldtests of the briquetting equipment.
After that an extensive marketing and monitoring program aimed at the acceptability of the charcoal briquets will be executed.

In this report the carbonization fieldtests are recorded in details. Operating up to 22 kilns - 8 of them provided from Unido-funds- in daily runs, a smooth running organization was established delivering ample cotton coal supply to the briquetting plant.

2. The carbonization site

2.1. Explanation of terms

CARBO LINE	: Row of kilns on one site of the hawasha
FEDDAN	: 0.42 ha
HAWASHA	: 11 feddan = 5.04 ha, measuring 280 x 180 m.
CARBO LINE OPP	: Row of kilns on opposite side of hawasha
CREW no. 1, 2, etc.	: Team consisting of 1 charcoal maker and 1 assistant
CC	: Cotton Coal = charcoal from cotton stalks
COLLECTORS	: A. assisting in filling of the kilns at beginning of the day B. collecting stalks on the field and transporting these to the carboline(s)
FIELD COURSE	: digged ditch, ca. 40 cm. wide, on both ends of a hawasha. Until mid April filled with muddy water.

2.2. The area

A farmer in the Rahad Scheme cultivates cotton on 11 feddan. Such an area, measuring 280 m. length and ca. 180 m. width, surfacing 5.04 ha., is called a hawasha. Generally 8 hawashas in one row are grown with cotton, thus covering ca. 40 ha., the smallest side being 280 m., the largest side ca. 1430 m. (Table 1.).

The 8 hawashas form a number or a plot. On both - smallest- sides are so-called minor irrigation canals, connected with each other by a ditch, called field course, which runs along both the largest sides of the plot.

Between the cultivated hawashas and one of these field courses is a 14 m. wide path, with good accessability for the transport of necessary supply as fertilizers, insecticides etc.

This supply road is considered very suitable as a carbo-line.

The irrigation canals mostly have water throughout the year. The shallow field courses however can hold their muddy water, after the second and last irrigation is stopped, only until mid April, drying then very rapidly as daily temperatures just above the surface rise normally soon over 50^{o} Centrigrade.

2.3. The soil

The soil of the cottonfields is very hard and crusty, consisting of smaller and larger earth lumps and also a lot of holes and cracks, partly invisible and sometimes up to 1 m. deep.

Due to the nature of this soil carbonization of the stalks in the fields is not possible, notwithstanding that most of the larger heaps of piled stalks would be within several meters distance of the kilns.

The difficulties to be cleared before carbonization in the middle of a hawasha could start, are obvious.

A. all soil on the carbo-spot must be removed, being absolutely unsuitable and appropriate soil from elsewhere must be supplied;

B. like detecting landmines on a battlefield, all invisible holes are to be dermined with an iron stake or knife and then carefully filled;

C. water and mud necessary for the sealing of the kiln after the completion of the carbonizatio. are not available unless at considerable great distances,

D. guarding the kiln(s) during the cooling-off time - mostly at night - encounters real problems as the charcoal burners have to do their surveillance stumbling over the uneasy surface of the field.

The soil however on the supply road is considered suitable. Sometimes just a bit granulated, it can be used to shut off air-inlets and smoke-outlets at the bottom of the kiln. Also this soil can be turned into a clayish mud when wetted with water from the nearby irrigation canals or ditches, from the latter if available. Mud from the same sources can be used to seal the rim of the cover as well as the lid on the top.

This mud however, tends to crack easily, caused by the extreme sunradiation and the hot wind. The charcoal makers must therefore watch the kilns continuously during the cooling-period, sprinkling water on the mud, thus trying to prevent cracking, which causes air leaks.

3. The irrigation

When the sow of the cotton seeds has been executed, irrigation aimed at the crop of the plant is started. At the end of November the irrigation is stopped and beginning around mid-December the first picking is harvested. Then in the middle of January a first additional but shorttime irrigation starts, aimed at the opening of the late balls of the cotton plant. A second and at the same time last irrigation, also for a short period, starting mid February and intended to stimulate growth of the last balls as well as to facilitate the root cutting after the third and last picking, is stopped at the end of February or in the early days of March.

4. The uprooting

After the last pick of the cotton, the removal of the stalks theoretically would start within 10 to 14 days. This harvest generally is at the end of February resp. in the early days of March, soon after irrigation is stopped. Soil and plants then dry rapidly in this climate.

The removal consists of several stages, to begin with

1. root cutting. This mechanized stage is done by tractor, cutting the pen roots at 10 cm. deep, leaving just a small end of the roots in the soil.
2. pulling. Now the stalks must be pulled out of the soil, which is done manually.

3. collecting. The stalks are picked up from the soil, put together in small, loose bundles, which for the time being are left wide-spread all over the hawasha.
4. piling. When all the stalks in the hawasha are pulled and bundled, the bundles are brought together and piled in large stacks.
5. burning. The final stage, when the stacks are fired and the stalks are burned according to the law.

   On June 1st. of every year all stalks must have been destroyed in this way.

Stages 1 and 2 however, are more and more replaced by manual uprooting, due to the fact that

A. only a small number of tractors (April 1987 : 100 tractors out of the original total of 600*) is available for mechanized root-cutting

B. officials of the Rahad Scheme, being aware of this grave situation, decided, resp. advised, to use the remaining tractors for other, more urgent and/or important work, such as ploughing, seeding, etc.

C. the alternative for mechnized root-cutting, being manual uprooting, can easily be establisehed for presently manpower is more or less abundant (refugees, day-to-day labourers, women, youngsters, etc.).

* Source: a 4-week very thorough investigation by Mr. Charles Rogers For Massey Ferguson intending to set up a large rehabilitation program.

In the event of manual uprooting, this is carried out by using a simple tool, the kamasha. In one move the stalks are pulled and laid aside to be picked up later.

A major disadvantage of this tool is its weight, which exceeds - because constructed from solid iron - probably five kilos. Consultant watched and timed several labourers and calculated that by continuous uprooting every minute, a total weight between 50 and 60 kilos is lifted, be it only 15 to 20 cm., above the surface of the soil.

Thereafter stages 3 to 5 follow as described earlier.

Having explained the several stages of the land clearing, it must be remarked that generally only the word "uprooting" is used for all activities concerning the removal of the cotton stalks from the fields.

4.1. The cost of uprooting (land clearing)

Farmers in the Sudan, neither in the Gezira Region nor in the Rahad Scheme are farmers like their colleagues in the developed countries. They are more or less entrepreneurs attending their activities - which could be diversified - as businessmen. If they possess goats, camels, cattle or even donkeys, they hire boys to direct and guard these herds.

Cotton growing farmers hire labourers to do the heavy and monotonous uprooting.

After the inevitable bargaining the farmer closes a deal with one or more labourers to uproot his hawasha. The costs involved vary from £S 200.= to £S 400.= depending on the density of the stalks (p.e. two or three stems per plant), the distance between the plants as well as the length of the stalks.

To finance the uprooting the Rahad Scheme will credit the farmer an advance or a small loan, which is determined to be every year. This advance can also vary depending on several factors. At all times the farmer is paying a considerable sum to have his hawasha prepared for the next crop.

4.2. The duration of the uprooting

As soon as a deal is settled between farmer and uprooter(s) - seldom more than 2 uprooters are involved - the latter is completely free to begin at a time convenient only to him.

Knowing from experience, that it takes 14 days or even less to clear a hawasha completely, he can decide to start immediately - he might need the money soonest - or spread his work over a longer period for reasons only known to him, or he might even start the clearing 14 days before the new crop is seeded.

The consultant noticed, that still in the beginning of May with only two weeks to go before groundnuts will be sowed or one month before D-Day (Disappearing Day, 1st. June, when all cotton stalks must have been disappered from the fields), large areas are still covered with cotton stalks, so that uprooting of these areas will be indeed a last-minute-work.

5. Uprooting and carbonization

Any organized carbonization is hence solely dependable on the availability of the raw material, i.e. cotton stalks. Carbonization could begin on one hawasha but could have to move then to another hawasha, problaby some miles away, since the bordering hawashas are not cleared yet and even will not be for some time as there is still no deal between the farmer(s) and uprooter(s) or the latter takes his time. Both the possible long duration as well as the irregularity of the uprooting on bordering hawashas makes a scheduled and undisturbed carbonization difficult and highly uncertain.

6. Feedstock

Compared to the small quantity of khaki-coloured cotton stalks, used during the test at the site of the Research Centre at Soba in December 1985*, the sight of the tremendous plains in the Rahad Scheme covered with reddish cotton plants is simply overwhelming. To a Westerner, living in a industrialised and highly mechanized world, the thought that plant for plant - and there are millions and millions - must be pulled manually, is really terrifying.

The characteristics of the cotton stalks now on the hawashas differ from the "test stalks" not only in colour. Those stalks appeared to be very dry, quite thin and relatively fragile, due possibly to a long storage.

The cotton plants now under cultivation in the Rahad Scheme muster a new variety, delivering short staple cotton. The stems of the plant can reach a length up to 1 m., are more robust and stronger, being quite fresh and containing an almost double moisture content of that of the test stalks. This moisture has to be eliminated in the carbonization process, requiring more endotherm energy, so a loss of nett yield. This however, could, under improved circumstances, among them better kiln filling resulting in higher bulk density, be compensated.

* Technical Report Demonstration Program on use of indigenous Biomas Resources for Meeting Energy Needs RP/RAF/85/627 Sudan by Albert Zorge. December 1985; photographs on pages 7 (fig. 1), 9, 22 and 29.

7. Carbonization equipment

7.1. Kiln design

The REKI kiln, introduced in November 1985, was developed by Unido experts, who also designed improvement of some technical details. Construction became easier as well as sturdier, manipulation more simple, enabling a better operational technique to achieve higher results.

Especially the improved cover made a more secure sealing after carbonization possible, thus preventing air leakage.

Learning from last year's experience*, the lid on the cover was designed in the short chimney not over it (Table 2.). Sealing of this part became 100 percent effective.

7.2 Manufacture of the kilns

During a preliminary meeting in Paris, the Unido-experts agreed that the counterpart would identify the workshop, where the kilns should be manufactered.

The Gilas Engineering Workshop in El Fau, who had already experience in kiln-production when delivering five kilns last year for fieldtests of a Sudanese briquetting team, again was ordered the manufacture.

Production of 18 kilns started early in April and delivery followed, in spite of some delay, between 6th and 29th April.

Some minor details had to be improved. Furthermore it must be regretted that a less heavier type of steelangle for upper and bottom rings, to be procured in Khartoum, was available. This resulted in one twisted section when unloaded - apparently rather roughly - at the site.

* Briquetting of Carbonized Cotton Stalks for Household Utilization by Dr. El Sheikh el Magzoub, Dr. Ahmed Hassan Hood a.o. October 1986, page 25, 26.

During the entire production some labourers of the workshop seem to have suffered from a kind of poisoning as the drums that where used for the construction of the kiln section, having contained insecticides, were not sufficiently cleaned before. Also it was observed that those labourers who were contaminated, did not take any of the prescribed precautions. Fortunately, they recovered within a few days from their illness, but this event must be considered as a sincere warning towards future kilnproduction when using this type of drums.

Price of the kiln came to £S 473,= ex workshop. No charge of £S 150,= for three drums was presented from the side of the Rahad Scheme authorities.

7.3 Tools

As no carbonization is possible without the necessary tools, consultants decided to supply every carbonization group with a carbokit. This outfit consisted of shovels, headers, buckets, aluminium cups, water drums and a rake.

Shovels to be used to open, resp. close air-inlets and/or smoke-outlets.

Headers, actually seldom used, to equalize the soil at the carbo spot; buckets for transport of canal- or ditchwater from the drums to the kilns, where sealing mud was made.

The cups intended for drinking water, were from time tot time gratefully used to extinguish burning charcoal on the next morning after the nightly cooling-off period.

After the site was left, rakes were supposed to care for cleaning.

The collectors who transported the cotton stalks to the carbolines, were given nylon rope to tie and carry large bundles.

7.4. Personal care

Empty barrels, carefully prepared by using burning charcoal to destroy any trace of insecticide or pesticide and thereafter painted on the inside, were intended to store drinking water for crews and collectors.

Because of the suspected lead in this paint, thought as a protection against corrosion, this idea was immediately abandoned.

As Ramadan began, soon after the start of the fieldtests, no further need for drinking water existed.

Operators and collectors used to take a rather long breakfast - up to 90 minutes, which was sometimes inevitable because most labourers had to walk for a mile or more to reach their homes, where breakfast was waiting. Fortunately the operators could be persuaded to take their breakfast in shifts.

From the beginning of Ramadan all labourers stayed at the site.

Supervisors and their assistants had the luxury of a cooling box.

For treatment of minor injuries a first aid kit was at hand.

8. The labourers

8.1. The operators

Expected, at least hoped for, was that farmers, being informed about these large-scale fieldtests long before and also having witnessed previous short-term tests in 1986, would participate largely.

As in last year however, they showed only little interest and were mostly concerned about the removal of the stalks from their hawashas.

Yet at the start of the operation there was a considerable offer of labourers and the eldest and most-eager-to-work men were chosen to become operators, leading the filling and charring of the kilns and the sacking of the yield on the next morning.

These operators as well as their assistants are professional labourers. They came into this region at the start of the Rahad Scheme more or less as "emigré's", offering themselves as a paid labour force.

Being employed in this project, they can be considered very reliable, loyal and skillful.

Among them were several men who said to have been working in the professional production of wood charcoal elsewhere in the Sudan.

These men took the lead of their teams, showing skill, selfconfidence and knowledge. They were willing to train their assistants and share their know-how. Being real professionals they started to disagree with each other about the best kilning techniques.

8.2. The assistants

As shown in Table 3 and explained later in this report, each operator should be assisted by a hand or assistant. These men, also professional labourers, were willing to do any work, to rake and equalize the former carbospots as well as to carry bundles of cotton stalks to the kilns.

They also did the sacking of the yield on cotton coal and assisted whereever it was required, not in the least in the charring. After a week and dozens of kilnruns they were "promoted", at least financially, to operators.

8.3. The collectors

To transport the cotton stalks, lying in small bundles spread all over the hawashas, to the kilns, labourers should be hired to do this job.

At first many youngsters participated, being paid on a daily basis. This system however, succesful when employing operators and assistants, seemed to run out of control. The suppliers - as so many other youngsters everywhere in the world -, started enthusiastically, eager to earn some pocket money. After only a few days they lost interest and their efforts dropped accordingly. They did not manage to deliver the required daily quantity of stalks, so did not keep up with the operators and their assistants. The latter had to be put in on every morning to help with the supply.

As the system was changed - a bargained and agreed amount for each hawasha - many of these students being sons of farmers themselves, did not return and only a small group, also students but more mature, remained.

Professional labourers to do this work could not be discovered in or around Village 10.

8.4. Supervisors

Consultants were in the intended operational scheme to be assisted by two young staff-members of the counterpart agency.

Later on especially the Unido expert did regret that not more staff-members could be made available.

Certainly with regard to the hundreds of kilnruns, that were executed during the fieldtests from which they should have learned almost everything valuable for future full-scale operations.

Each of these supervisors should after a while organize and direct the operations of a division of nine kilns with supporting operators and collectors.

9. Planning of the Carbonization and Briquetting Project

However not mentioned in his Job Description UC/SUD/86/026/ 11-51/J 13424 under Duties, the Unido consultant should take over all intended activities from a special carbonization planning expert, who was to be assigned if available.

The extension of his duties involved all necessary planning and preparations for the fieldtests of both the Carbonization Project and the thereafter following Briquetting Project.

He was informed that an agreement on these matters was reached between the Industrial Operations Department of Unido and the coordinating organization, the Biomass Technology Group of the University of Twenthe, who also was in charge of the pilot briquetting plant.

Consultant was expected to make all necessary arrangements to start up and conduct the carbonization project.

At he same time he was requested to prepare a smooth start of the briquetting project.

N.B. It must be remarked that the only financial document available to him at the Unido office in Khartoum was a Project Budget (Annex 1) from probably August 1986, totalling US$ 102.773.

Only several weeks after his arrival in the Sudan, having already perfected most of the necessary preparations based on this budget and having already started up the carbonization project, a telex message from Unido HQ in Vienna was submitted to him, mentioning the approved project budget totalling US$ 66.950.
Thus he was confronted with a budget decrease of some 30 percent of the total amount.

In the meantime he had dealt with:

9.1. Project travel (Buli 15-00)

Travel in and between duty stations should be made with an Unido provided vehicle (buli 49-00). As this project vehicle was not available a purchase order was released within ten days after consultant's approval. Delivery however, of (project) vehicles for international organizations takes up to eight months after ordering. Unless purchased in Jeddah (Saudi Arabia) or directly flown in from Europe.

In both cases a vehicle is at users' disposal within two to three weeks, sometimes even less.

Meanwhile a 1980 Peugeot Break had to be used after necessary repairs had been arranged.

Also negotiations took place as a used 4 WD could be obtained within a few days, price of which however turned out to be beyond budget limits.

9.2. Calculations on and purchase of required fuel (Buli 15-00 and 51-00)

Having to deal eventually with the use of three different project vehicles, the required fuel for project travel as well as for running expenses concerning the briquetting project was calculated as shown in Table 4.

For project travel until 20/5 about £S 3311,= was spent.

Apart from gallons petrol bought in Khartoum on CD-coupons all fuel was transported to and stored in El Fau (Rahad) at Scheme HQ premises.

9.3. Vehicle repairs and maintenance (Buli 51-00)

As mentioned in 9.2. a Unido vehicle could be used for the time being but as the car was not in running condition, maintenance and repairs were needed. These were skillfully carried out by a "street mechanic", as the offical Peugeot dealer had no spare parts whatsoever.

Thus, £S 724,= was spent on this barely suitable item.

9.4. Calculations on labour costs (Buli 51-00 running expenses)

In the proposed formation as shown in Table 3, 22 labourers would be employed, operating and supplying with feedstock 21 kilns in 45 daily runs.

Labour costs per man/day were estimated at £S 9,=. So a total of £S 8.910,= was calculated (Table 5).

Not accounted for, as no exact knowledge existed concerning the real labour situation, was an increase of labourers or a double payment on Friday, the Muslim holiday.

9.5. Calculations on and purchase of kilning materials (Buli 51-00)

As can be seen in Table 6, purchase of materials for carbonization was estimated at £S 1.020,=

Actually only £S 943,= was spent.

The headers were not or seldom used. Purchase of this item could be considered unnecessary.

9.6. Table 7 shows an estimation of the number of jute bags per ton product, based on information from the coordinator. If only 5 percent binder would be used in the briquetting operations, the total number of bags would decrease with about 15 percent. The jute bags, the same as used for packing of wood charcoal, were not purchased up until now but such is scheduled before 20th May. A local supplier is willing to deliver used bags of very good guaranteed quality - intended for packing of sesame, a very fine granulated grain - at a price of £S 2,= per bags ex store. New jute bags rate £S 4,= to 5,= each.

For sacking the voluminous cotton coal, thus facilitate the transport of the yield from the sites to the briquetting plant 400 very large sacks for cotton packing, measuring 2 x 1 m., were received from the branch of the Rahad Scheme at Village 10.

These sacks, however of poor quality, torn with holes, were still found suitable for this part of the fieldtests. A total of 400 were charged at £S 600,= ex store.

The better sacks could eventually be used on the drying tables at the briquetting plant. The rest of the sacks were repaired and can be used several times over.

9.7. <u>Inquiries and calculations on wood charcoal prices 1987/88</u>

From several sources* reliable information was received about todays' charcoal prices. These are given in detail in Table 8.

Comparing best case 1987 with worst case 1988, a situation not imaginary, prices will be doubled in about 18 months time.

* Sources: Mr. Gerassimos Pagoulatos, co-proprietor of Acropole Hotel, Khartoum.
Sudan Renewable Energy Program.

9.8. Briquetting Project

The Biomass Technology Group of the University of Twenthe, Netherlands, requested consultant to take care of as many preparations as possible for the Briquetting Project.

Also he would execute the Carbonization Project according to submitted Terms of References.

For the fieldtests of this Briquetting Project he effected:

9.8.1. Customs clearance and transport of briquetting equipment

In several meetings at Her Majesty's Netherlands Embassy at Khartoum, it was agreed that the Chancellor or his deputy would prepare and execute customs clearance of the equipment at Khartoum airport.

Such a clearance, would take 10 to 14 days.

Immediately after consultants arrival in El Fau (Rahad) on 15th April he had a meeting with the authorities of the Scheme. It was arranged to send a lorry to the Embassy or depot at Khartoum after receipt of a radio message of this extent from consultant. Costs of this transport being about £S 1.000,= are likely to be paid by the counterpart agency from funds of other projects.

9.8.2. Briquetting plant

To accomodate the briquetting equipment in Village 10, an extension of the already existing briquetting plant - used by the Sudanese briquetting team - was necessary.

To enable this extension building materials as steelangles, corrugated sheets, nuts, bolts, etc. were ordered in El Fau, estimated totalling about £S 4.000,= As on Buli 49-00 the equivalent in Sudanese currency of only US$ 500, being £S 1.225,=, was approved, the remaining £S 3.775,= will also supposedly be paid by the counterpart agency from other sources.

9.8.3. Additional briquetting equipment

9.8.3.1. Drying tables

As the pelletized briquets should be dried by the heat of sunradiation (estimated between 45 and 55° C) as well as by a continuously blowing warm wind, natural in these areas after noon, a simple drying table, measuring 2 x 3 m. was designed (Table 9).

The Rahad Scheme Central Workshop, for a change, was ordered to manufacture 20 of these tables. The costs roughly estimated between £S 3.000,= and £S 4.000,= are also supposed to be paid by the counterpart agency from other sources.

A first serie of three tables was delivered on 5th May. Arrival at the plant of the remaining tables is scheduled before
20th May.

9.8.3.2. Water basins

Before the cotton coal is grinded, the coal is to be weighed and moistened in some special but simple constructed basins, each made from a drum, cut in half over the full length.

This equipment was also manufactured at above mentioned workshop and delivered at the plant on 30th April.

So far no costs were calculated, but these are supposed to be paid as mentioned above.

9.8.3.3. Binder

The grinded coton coal will be mixed with molasses, serving as a binder. From the newly established Sugar Coordination Office at Khartoum permission was obtained to dispose at a quantity necessary for the fieldtests. Around 20th May a lorry of the Scheme will be sent to the Western Sugar Refinery at Sennar, a trip of over 500 km. to pick up 5 tons of molasses.
The costs for this transport also are supposed to be paid from other sources.

1Ø. Accomodation for national and Unido experts

Consultants are for the duration of the fieldtests accomodated in the official guesthouse of the Rahad Scheme at El Fau. According to national standards a suitable but simple lodging with three double bedrooms, toilet and shower, kitchen with sink, refrigerator and electric cooking stove, a large sitting room, plus another large room, however not available because used for storage of furniture.

An elderly servant was detached for cleaning and serving.

Occupying these facilities by the experts meant a real problem to the Scheme authorities, since this is the only guesthouse in the whole area and therefore exclusively reserved for official guests of the Scheme.

Such was experienced on 22nd April. When VIPs from Khartoum were welcomed and accomodated in the guesthouse. Consultants had to spend the night in a former camp for road-construction engineers, now deserted and desolate, without adequate cooling and deprived of water, nightly temperatures reaching 37° C.

Fortunately this housing problem could be solved the next day and an agreement was made that for the duration of the project, experts can stay in the guesthouse using two out of the three bedrooms.

However, in case of emergency they still have to move over to the McAlpine camp, where facilities should be largely improved. In the meantime simultaneously Scheme authorities would also impose some restrictions as far as visits of important guests were involved, at least during the fieldtests of the project.

11. Communications

Between Rahad Scheme an the world outside, no - apart from the slow postal traffic - daily communication exists but by radio, as it is between Scheme HQ at El Fau and the branches in the 44 villages.

For communication with the coordinating organization, Biomass Technology Group at Enschede, Netherlands, consultant used the telex facilities of his hotel, a reliable and fast line of communication.

To communicate with his backstopping officer at Unido HQ in Vienna, normal channels through UNDP telex could be used.

During the fieldtests in the Rahad Scheme the communication with Unido office in Khartoum was established through the radio channel of the Scheme between El Fau and Rahad Scheme office at Khartoum. Messages to El Fau could be sent any day, and fro only on Wednesday and Saturday.

12. Organization of carbonization

As already shown in Table 3, a formation would be established, divided in groups (crews) and divisions, depending on the available number of kilns. Calculated were 21 kilns, but in fact only from 19th May on this number was daily operated.

Between 20th and 30th April the number of kilns in daily operation was varying from 10 to 7.

Thus the proposed formation was soon to be changed and adapted to the number of operational kilns.

Starting April 30th every day 18 kilns were in use, 17 newly made plus one kiln from last years tests.
Two divisions of nine kilns each, operated by three crews with a total of six operators, were formed. At each division a Reri staff-member was detached, supervised by one of the consultants, who were in control of the fieldtests as a whole.

This system worked out reasonably well and was maintained for the duration of the fieldtests. From 19th May on both divisions rose from 9 to 11 kilns, totalling 22.

The scheduled Division C was abandoned from the beginning for several reasons. Reri staff-member Miss Amal was not available for the job as was the number of kilns. Beyond that no extra supervision by consultants was possible as the counterpart representative Dr. A.H. Hood had to negotiate most of the time with farmers and/or their hired uprooters concerning delivery of cotton stalks and price of uprooting.

Having concluded these negotiations, he had to bargain with the group of collectors/suppliers about their share in the supply of raw material.

The other consultant or a Reri staff-member took over Dr. Hoods supervision.

The eight suppliers, as scheduled in the organization, were not hired anymore after the first week. As already stated in 8.3. a new system for these labourers was introduced, a bargained and agreed amount for the clearing of each hawasha. The collectors soon became professional suppliers, managing to bring to the kilns at the carbonline each day a quantity large enough to run all kilns on the next day and more important, to start carbonizaton on the scheduled time. i.e. between 06.00 and 08.00 hours.

After almost three weeks, 17 to 18 operators/assistants were still on the weekly payroll. Succesively this number was reduced but became never less than 15. To lower this number was considered irresponsible, as carbolines along both sides of the hawashas were already streched out over great distances, operating in groups of two, three of four kilns.

And not in the least the rapid carbonization, especially due to the sometimes fierce breeze (6-9 m/sec) required all attention and skill in order to obtain the highest possible production of a fair quantity in the first place.

This was judged more important than to employ a minimum number of operators.

13. Selection of carbonization sites

In fact, there was nothing to select, since the authorities of the Rahad Scheme had already, after reaching an agreement on these matters with the farmers of these areas, selected a row of eight hawashas between Minor Canal 36 and Minor Canal 37, north of the tarmac Feeder Road, which ends at Village 10. The row is situated west of this little community, roughly at a distance of 1.5 km. (Table 10).

As to the carbolines, the soil of the root-cut first four hawashas was not suitable for kilning, for reasons explained in 2.3. Also the soil of the second four hawashas, where the stalks were manually uprooted and so the surface was less damaged, was found unsuitable.

But the tracks on both sides of the fields, in fact workroads near the ditches, were considered solid enough. Sealing clay could be obtained abundantly mixed with water either from the nearest Minor Canal or from the ditches in which on our request irrigation was resumed for the time being.

Selection of the carboline on hawasha 9, some 2 km. from the row of 8, proved - at least for the first three runs when operating nine kilns simultaneously - to be a failure.

The stalks of this small area - 2/3 of the normal size - were collected on one side, a great advantage to the intended carbonization. Also this spot was spacious and accessible.

But after the said three runs, all kilns were moved to the original nearby work road. Every morning it was discovered that in the majority of the kilns the yield had partly burnt away, caused by subsurface, invisible holes and channels, through which oxygen could flow freely to the inside of the kilns.

The site next to the briquetting plant at Village 10, where the yield of the last two hawashas are to be carbonized after June 1st, was chosen with extra care, as the surrounding areas seemed to be full of holes and channels.

14. Supply of raw material (cotton stalks)

The uncertainty in the supply of cotton stalks endangered for a larger period the entire fieldtests.

As already mentioned in previous sections the stalks on hawashas 1-4 were root-cut, then pulled and collected in small bundles spread all over the hawashas.

These bundles had to be transported to the carbolines on both sides of the hawashas, as the soil of those tracks was found solid enough for carbonization.

Youngsters were easily found to do the carrying of these bundles but as this system, based on daily payment, was soon becoming too expensive compared to the quantity delivered, it was dropped. The new system was based on an agreed amount per cleared hawasha.

Hawashas 5-8 still had to be uprooted, this time manually, using the kamasha. As the carbonization would reach these fields already after a few weeks and uprooting had not even started yet and if so, should take considerable time, measures were to be taken to secure the necessary supply of the raw material.

From this moment on it was decided to split up the work on the top, being the supervision of both divisions and the control of all stages of the carbonization, such as supply of the feedstock, the filling of the kilns, the carbonization itself, the sacking of the yield and the transport of the cotton coal to the briquetting plant.

His share in these activities taken over by his partner, the counterpart now became involved in a everlasting struggle to secure the continuous supply of cotton stalks for the entire operation. Every day he fought a real battle, first trying to persuade every individual farmer to order their hired uprooters to transport the collected stalks to the selected carbolines. As this meant extra work for the uprooters, the counterpart had to bargain with them when most farmers withdrew from this problem.

When such a bargain could not pressed home, the consultant started negotiations with the collectors, who were already engaged in the transport of stalks on preceeding hawashas.

With great skill and never ending patience Dr. Hood managed to reach a successful result at acceptable costs over and over again, thus securing a continuous flow of feedstock and by doing so enabling a continuous production.

The unit of "professional" suppliers can be honoured for a loyal attitude once a deal with them was made.

The yield on cotton stalks on two more hawashas situated next to the first row could also be obtained.

Finally the Scheme authorities gave permission to transport the stalks of another two hawashas to a site near the briquetting plant, the carbonization there to be continued after June 1st.

This gesture - really an exception regarding the law-prescribed deadline of June 1st - will contribute largely to produce the ca. 25 tons of cotton coal needed for the fieldtests of the briquetting plant.

15. The carbonization

Carbonization started each morning before sunrise at Ø5.ØØ hours with a control on fire in the kilns due to air leakage most of the time caused by cracked sealing.

In the beginning of the fieldtests this occured too often, so guards, being operators themselves, stayed overnight in a tent at the carboline. They made suveillances just before sunset, after some 6 to 8 hrs. cooling time, and also at about 22.ØØ hrs. They inspected sealing, renewing it when necessary. After less than three weeks fire in a kiln in the morning became very rare.

When no fire was detected, as the metal of the kiln was feeling cold, the sealing was removed with a shovel, lid, cover and kilnsection lifted and rolled to the next carbo spot.

The filling then started, with storing the stalks in the periphery of the kiln until a full cirlce was built up. Then the middle of the kiln was filled with bundles all positioned in the same direction, the first layer with the roots all in the same direction, the second layer in reversed direction.

In this way the highest possible density, however not measured, could be obtained (Table 11).

When the stalks in the kiln thereafter were lit by setting collected debris of stalks in the chimney afire, at almost the same time the cover and the lid were sealed with clay. Also the circumference at the bottom of the kiln was covered partly with sand, thus constructing air-inlets and smoke-outlets and forcing the hot woodgases to do the charring in the inside of the kiln.

Carbonization started slowly with large yellow/brownish clouds, containing tar and escaping from the smoke-holes at the bottom of the kiln. Sometimes also a white cloud appeared due to the still present moisture in the in fact fresh stalks.

The lowest moisture content in the stalks can be obtained when the stalks after pulling have been lying on the hawasha in the scorching sun for 10 to 14 days.

Carbonization was conducted by hired operators, some of whom said to have worked in the professional production of wood charcoal in the Blue Nile Region.

These operators showed skill, selfconfidence and a professional pride to deliver a good quantity of charcoal and the highest possible yields. Also they were willing to train their assistants and to share their know-how. During the first run a few started interfering with each other, arguing and debating about the best method to operate the kiln(s).

Most of the time, carbonization being started at around 07.00 hrs., about one hour later a considerable breeze and sometimes even a fierce wind began to blow, speeding up the carbonization by supplying more oxygen than intented. Air-inlets were narrowed and control of the process was doubled or tripled.

Operators used to look around for a long stalk, which they shuffled just above the surface of the carbospot under the bottom ring of the kiln. In this way they felt wether the stalks inside the kiln were carbonized or not.
If they met resistance they considered a still insufficient carbonization. When not, they closed the air-inlet.

The sealing clay at the rim of the cover, consisting of thoroughly wetted granulated soil, soon began to dry due to the intense heat from both sides. From below because of the hot metal of the cover, from the top by the growing heat of the sunradiation intensified by the hot wind.

Clay had to be renewed several times over to prevent carbonizationgases from escaping the kiln.

After 2 1/2 to 3 1/2 hrs. carbonization could be considered complete, all in- and outlets being closed, thin blueish smoke rising slowly upwards.

Again sealing was renewed, inspected all over again, the bottom of the kiln secton abundantly covered with sand.

Guards, themselves being operators, took care of the necessary surveillance in the afternoon and night during the cooling-off period.

When unfortunately the next morning fire in the kiln was detected, it immediately was extinguished with water. Normally charcoal makers do not use water, they use sand to fight fire as charcoal and water are natural foes. But, keeping in mind that the sand for extinguishing was not reliable unless wetted, the next run was waiting and last but not least to the charcoal water should be added anyway during the briquetting process, this way of fire-extinguishing was considered the least harmful method.

16. Training staff-members of the counterpart organization

As can be seen in Table 3, showing the inteded organization involved in the fieldtests, a staff-member of the counterpart agency, the Renewable Energy Research Institute, was detached at each division.
They were appionted as assistants to both consultants and thoroughly trained in conducting and supervising the kilning operations.

Arrived at the carbonization site every morning - be it later than the consultants - they were taken all along the carbolines. They were told to pay attention to every aspect of the carbonization, such as the carbospot, the filling, the ignition and charring, the sealing of cover and lid, and to watch closely the preparation of the mud for the sealing: not too dry causing easy cracking, not too wet, resulting in slipping away from the cover. Futher to the sizes of air-inlets and smoke-outlets, the different colours of rising smoke clouds, as well as too many other major and minor details, all aimed at the highest possible yield of a good quality of charcoal.

They were encouraged to discuss all aspects of the kilning techniques with the operators, in order to become convinced of a practical manipulation. But also to convince sometimes the operators, their arguments being based on the scientific behaviour of a pyrolysis process.

It was not the intention to train the staff-members to become skilled charcoal makers, but to teach them to follow closely the carbonization by supervising the crews, issueing directions and stimulating all members of their division.

Already after three days they were left alone as consultants were called back to Khartoum for urgent matters.

Their assistants kept the carbonization going, increasing the number of runs every day. They also secured the supply of raw material and arranged for the transport of the sacked charcoal to the store.

Results of their first independent conduct was considered promising, but many details had to be improved.

Their second independent supervision between 7 and 12 May was a success. Except for one day, when one 9 kiln division was transported from hawasha no. 9 to hawasha no. 4, the assistants directed every day a full scale carbonization, including supply of feedstock and preparations for the transport of charcoal from the site to the briquetting plant.

But above all, staff-members were of great value when acting as interpreter for the Unido-consultant, translating his views, intentions, directions, approval and disapproval, encouragements direcdly to the operators.

Consultants are preparing an examination for the staff-members at the end of the carbonization project.

Some 2Ø questions have to be answered and reasoned (Appendix 1.).

The Unido consultant is convinced that his pupils will pass this exam cum laude.

17. Supervision and troubleshooting

From the beginning of the fieldtests the consultants directed the entire carbonization operation. When staying in El Fau, they woke up every morning at Ø4.ØØ hrs., arriving at the site 22 km. away about one hour later, just before sunrise. The first day they organized the supply of the raw material and did not interfere with the carbonization but preferred to see and watch closely the work of the operators, some of them having been involved in professional production of wood charcoal and/or last years' small scale field tests. Back at their quarters, consultants exchanged views, opinions and suggestions after having examined their findings.

The second day they became involved in the process, because now they gave instructions and directions for the filling and charring, explaining why the Sudanese charcoal makers method had to be adapted to the consultants' views.

On the next morning they already could show the operators the difference resulting in higher yields with better quality.

However, although follwing loyally the given instructions, operators after a while considered themselves experts and started to lean on their routine.

At this moment troubleshooting began. Apparently some operators just sat down, did little or nothing until the moment that all around blue smoke escaped, which was, as they enthusiastically explained, the result of a perfect charring. In fact, it was just burning charcoal causing the loss of a considerable part of the yield as could be seen the next morning. These, fortunately few, operators, were warned and several of them were soon after transferred to the supply group.

The others were shown that very small air-inlets, necessary due to the fierce wind, could not be constructed by using a shovel but by using their hands with spread fingers, when shoveling earth to the bottom ring of the kiln, just leaving openings of a few millimeters.
But when closing an air-inlet they continuously were instructed to shovel sand at least 10 cm. above the bottom ring in order to prevent any oxygen supply. The bottom ring was not welded to the kilnsection all around, but only here and there with corsiderable intervals, thus creating a lot of small openings through which oxygen would enter the kiln, however the lower part of the bottom ring itself was covered with sand (Table 12).

Again and again operators were told to watch the effiency of the mud sealing of the cover and lid, as these sealings soon began to crack caused by kiln heat and sunradiation. The hot woodgases were supposed to circulate <u>in</u> the kiln, not to escape <u>out</u> of the kiln.

Every morning the foreman of the charcoal makers went along the carboline, inspecting and commenting the yield of every single kiln. The accompanying Unido consultant pointed out where charring should have been continued - uncharred stalks - and where not - ash or ash-covered stalks. He showed that it was possible to estimate the yield. The height of the pile of the charred stalks too high meant uncharred stalks, too low would indicate a lot of ash.

The operators were taught how to identify the quality of the cotton coal: charred stalks with blue flames on the outside could be considered 100 percent. Stalks on the top of the pile were mainly covered with a thin layer of loose tardust, but also 100 percent charred. Weak stalks with white spots indicated too long a carbonization, but brownish, tough stalks - though still breakable - were an indication of a too short charring.

Consultants throw in all their experience, all their know-how, all thinkable inventiveness, all gimmicks and tricks of their knowledge.

At the last day of his stay at the carbonization sites, the Unido expert could proudly show to his successors - the consultants of the Dutch briquetting team - fine examples of excellent carbonization, executed by the operators and assistants of the entire organization.

18. Results

The author wishes to distinguish the results of these fieldtests as follows:

A. result in figures
B. result in notions
C. result in socio-economic meanings

A. As a logical follow-up to the very few carbonization tests in December 1985 these fieldtests were established on a much larger scale, operating up to 22 kilns every day.

15 to 18 labourers - operators - were employed, working 7 days per week, each of them earning about £S 67,= in that period.

Numerous other labourers were involved in this operation. Those employed in the manufacture of the kilns or the supply of all kind of materials and equipment, but also a considerable number of collectors, taking care of a continuous flow of feedstock to the kilns.

On the hawashas further on teams of uprooters - each team consisting of one man using the kamasha and two women collecting and bundling the stalks - were busy clearing the land.

A team with a horsecart - driver and 2 hands - were engaged in transporting the yield of cotton stalks of two hawashas to a selected site near the briquetting plant.

The Rahad Scheme provided a lorrie for the transport of the kilns when necessary and of the sacks with cotton coal from the sites to the briquetting plant. This lorrie was also btainable for the transport of molasses. Crew: 3 men.

The counterpart agency provided a pickup van for the transport of empty sacks from the depot to the sites and for the transport of barrels with water from the canals to the carbolines. Also occasionally labourers were transported after finishing the carbonization from the sites to their homes with this vehicle.

B. Already before the carbonization started, great interest could be observed from both the village people, farmers and the Scheme authorities.

Clearly visible for everybody large quantities of formerly considered useless stalks were converted into a valuable charcoal, the raw material for the briquetted charcoalballs, for which these people were looking for already for such a long time. So carbonization became well-known to all spectators.

To carbonize however the yield on cotton stalks from one hawasha after another, possibly totalling 140.000 kg., it was necessary to design, to build up and direct a smooth running organization. This also could be showed to all parties involved.

This carbo-organization, however largely designed and as far as kilns and tools were concerned constructed and procured elsewhere, could not operate without the cooperation of the Scheme officials, without the understanding and cooperation of the farmers involved or without the manpower of the labourers.

So cooperation had its full share in enabling these fieldtests.

C. The consultants, who were in charge of the carbonization fieldtests, believe that the impact of these operations - both the carbonization and the briquetting - could be tremendous from several points of view.

Later on to be described in details in Sections 20 and 21, Conclusions and Recommendations, the results of these tests justify a commercial follow-up as soon as possible, i.e. next season.

It can be expected that a number of workshops in the Scheme will get considerable orders for the manufacture of the kilns, tools and all necessary equipment.
There is reason to believe that these workshops will have to employ more labourers to meet such an enlarged production capacity.

A future organization could of course bring in its own manpower but could also hire local workmen. In this case labourers will come forward from the lower income-class among the village people. At least during the carbonization period, estimated from mid March till end of May, a larger number of these inhabitants could be employed in the field operations. A smaller number of them could be engaged in the briquetting plants, but for a longer period, as these plants will briquet the entire production of cotton coal from hawashas around several villages.

It can be expected that this lower income-class, involved in such an annually returning activity, can - by enlarging with hard but honest work its earnings - achieve a better life and a socially more acceptable and desirable "place in the sun", however hot, the sun over this part of the Sudan is already shining.

It also can be expected that carbonization of cotton stalks, followed by briquetting, will boost economic activities on several other levels, in and outside the Scheme, especially when carbonization will expand every year.

19. Data

During the author's mission from 6 April to 20 May 1987 follwing data could be obtained:

19.1. Kilns

Total number of kilns: 23

1	original RERI-kiln: condemned as not appropriate
4	kilns ex SREP/USAID fieldtests 1986: to be repaired and modified
18	kilns brandnew
23	

Costs of repairs and modification of the 4 SREP kilns were not available before 20.5.1987.

Price per kiln as stated in 7.2. £S 473,= off workshop El Fau. Transport- and handling costs of 18 kilns from workshop to the sites and between hawashas £S 240,= thus per kiln £S 13,33.

The total costs per kiln of £S 486,= could eventually rise to £S 636,= as an amount of £S 150,= - the price of 3 empty drums - was not charged so far by the Rahad Scheme.

It is still not certain that such a payment will be necessary, but it is recommended to calculate this amount in future manufature costs.

19.2. Kilnruns

Until 6.5.1987 a total of 243 kilnruns was executed. A number of 738 kilnruns was scheduled between 6.5.1987 and 15.6.1987, so a grand total of 1081 runs will be executed during the fieldtests.

Starting on 20.4. with 10 runs, on 21.4. 16 runs, on 22.4. 17 runs, on 23.4. 15 runs, on 25.4. 11 runs, on 26.4. 13 runs, on 27.4. 15 runs, on 28 and 29.4. daily 17 runs were performed. From 30th April on at least 18 runs per day (3rd May 21 runs) were made, except for one day as one 9 kilns division returned from a remote site.

Available information indicated that starting on 23rd May every day 22 kilns were operated.
Number of runs supervised 369
Number of runs prepared 712.

19.3. Yield

At 6.5.1987 a rough but conservative estimation learned that 8.815 kg. cotton coal was produced.

As an appropriate balance was not available the weight of the sacks was calculated by measuring the height of the contents of the sacks. This figure was multiplied by an observed formula, i.e. 75 cm. height = 28.5 kg. cotton coal.

The average yield per kilnrun came on 36.2 kg. From this it is estimated that a total production of 35.530 kg. cotton coal can be achieved from 12,5 hawasha, delivering a calculated 137.750 kg. cotton stalks.

All exact data of the produced quantities of cotton coal will be determined by the briquetting team.

19.4. Packing

For packing of the cotton coal at the site and for the transport from the site to the briquetting plant sacks had to be purchased.
The branch of the Rahad Scheme at Village 10 delivered 450 former cotton sacks, sizes 200 x 100 cm., at a price of £S 600,= off depot.

As these sacks can contain up to 60 kg. cotton coal when completely filled, it is assumed that this number of 450 will be sufficient as at the briquetting plant from 23 May on the already stored sacks will be emptied and become available again.

The cotton sacks, being of poor quality, were generally repaired at the site when filled with cotton coal.

19.5. Labour costs

The costs on labour during the fieldtests must be divided in
a) weekly payments to the operators and assistants
b) payments to the collectors and/or uprooters.

19.5.1. Operators/assistants

These men were on the payroll at £S 50,= per week of 6 days, so £S 8,33 per day. When working on Friday, the Muslim day-off, payment had to be doubled according to a Sudanese law, so total pay per man per week of 7 days came at £S 66,64.

Total payments on kiln operating costs were £S 2.331,= from 20.4 - 8.5.1987.

As a minimum of 15 operators and a maximum of 18 operators are employed during the fieldtests it can be estimated that the operating costs will come out on £S 2.331,= + (£S 5.430,= or £S 6.513,=) = £S 7.761,= or £S 8.844,=.

19.5.2. Collectors/suppliers

When starting at 20.4 these labourers also were paid on a daily basis, being £S 6,66 per day, with also a double payment on Friday.

This system, costing £S 373,39 in the first 3 days and £S 291,25 in the then following week, was abandoned and replaced by a bargained amount.

Total costs for collecting from 20.4 - 8.5.1987 were £S 1.140,= for 5 hawashas, including the 2/3 hawasha nr. 9.

The representative of the counterpart who was involved in concluding the necessary deals with the uprooters and collectors, stated following figures:

Hawasha	1	£S 373,29	+ £S 1ØØ,= paid by SREP
Hawasha	2	£S 15Ø,=	+ £S 1ØØ,= paid by SREP
Hawasha	3	£S 15Ø,=	+ £S 1ØØ,= paid by SREP
Hawasha	4	£S 3ØØ,=	(uprooting included)
Hawasha	5	£S 125,=	
Hawasha	6	£S 15Ø,=	
Hawasha	7	Not available as the stalks were burnt	
Hawasha	8	Not available as the stalks were burnt	
Hawasha	9	£S 175,=	(2/3 of normal size)
Hawasha	1Ø	£S 125,=	
Hawasha	11	£S 125,=	
Hawasha	12	£S 1ØØ,=	(transport to a site near the plant)
Hawasha	13	Amount not available. The stalks of this hawasha will also be transported to the site near the plant.	

In the row of hawashas 1Ø and 11 options on two more hawashas were obtained.

19.6. Kilnlife

The manufacture of the 18 kilns was considered of good quality. During the fieldtests no - at least till 15.5.1987 - shortcomings were discovered.

The author ordered in cooperation with his colleque an overall inspection of every single kiln after the fieldtests.

Each kiln will be numbered on lid, cover and section, then thoroughly inspected on the welds and seams, with control on fitting covers and lids.

Damaged kilns are to be transported to a workshop for repairs. Finally all kilns must be stored at a fenced place, preferably the briquetting plant.

From the findings of the consultant it can be estimated that kilnlife, provided the above mentioned maintenance, will be at least 4 years.

However, if future production is speedened up by making 2 runs per 24 hours, kilnlife may be shortened, as the metal will be forcibly cooled.

20. Conclusions

However the time available to prepare the on preceeding pages described fieldtests was considered hardly sufficient, the consultants of the cooperating organizations, United Nations Industrial Development Organization and its counterpart agency the Renewable Energy Research Institute, managed to start the field operations just in time, i.e. at the end of April 1987.

20.1. A carbonization organization, dealing with the complete conversion of cotton stalks to charcoalbriquettes, is bound to start the production in the field immediately after the last pick of the cotton, at the latest round mid March of every year.

20.2. The fieldtests demonstrated that a huge production organization, operating dozens of kilns and employing a considerable number of labourers, can work continuously and successfully.

20.3. They also demonstrated that the equipment used in the operation is appropriate and at least for the time being the only suitable equipment.

20.4. It appeared possible to train within a reasonable short time, numurous kilnoperators and to transfer to them the necessary know-how.
This is also applicable to the staff-members of the counterpart organization.

20.5. Notwithstanding several setbacks the production capacity proved to be large enough to enable extensive fieldtests in a pilot briquetting plant.

20.6. It is beyond doubt that local workshops in the Rahad Scheme either private enterprises or governmental, are capable not only to manufacture charcoal kilns, but also to deliver this equipment on a determined time.

20.7. Finally these fieldtest program made it possible to collect many more facts and data necessary to build up a large-scale commercial organization.

21. Recommendations

With reference to that which has been stated in the Introduction, more specifically that the produced cotton coal has to be briquetted to obtain a marketable domestic fuel, following steps are recommended:

21.1 To design a commercial operated carbonization organization operating 200 (twohundred) kilrs and including all manpower and all necessary tools and/or other equipment among them also means of transportation.

21.2. To design, in connection with above mentioned organization, a commercial operated briquetting plant with sufficient capacity to briquet the expected quantity of cotton coal, being about 1200(one thousand two hundred) tons gross.
The plant is to deliver its entire production within a reasonable time - say at the most 6 months - after the start.

21.3. To contact through the proper channels the Rahad Scheme authorities in order to identify with their cooperation the village(s) where above mentioned operations will be carried out in 1988 and thereafter.

21.4. To submit clear-cut proposals, holding the design of such an organization, along with all financial details as investment costs, operating costs, obtainable selling prices, profits etc. to:

a) Sudanese (charcoal) entrepreneurs
b) Sudanese government
c) all organizations involved, who eventually are willing to support procurement of initial costs.

21.5. To start preparations of a plan for conversion into domestic fuel of <u>all</u> available quantities of cotton stalks in the entire Rahad Scheme.
This plan should mainly be concentrated on a time schedule to achieve this goal - in the author's opinion within 10 years when starting in 1988.

21.6. To set up and maintain during this period a small (emergency) organization, consisting of a national and international charcoal expert, a national and an international economist assisted by one or two national administrative employees.

This unit is meant for immediate support at all levels, technical troubleshooting, technical and economical improvements, evaluation of results and assistance in the preparations of future operations.

21.7. To supply annually a (small) fund from which tests at the testcentre of the Renewable Energy Research Institute at Soba can be paid.

These tests should be aimed at the research of improvement of kilning techniques, considering the circumstances in the Rahad Scheme such as soil specifications at available sites, working conditions (Ramadan) and speeding up the production. Also to obtain reliable results when operating an enlarged kiln with a bottom and topsection.

A further research should eventually be concentrated on the improvement of the briquetting techniques and/or epuipment.

21.8. To focus all appropriate means of public relations on these activities, in order to:

a) draw total attention to this, initially by Unido designed and financed, project.

b) show how a developing country can still contribute largely by solving its problems.

c) interest both government, entrepreneurs and consumers for a case that will benefit them all.

The consultant did already some thinking on these matters by preparing a slide-documentary concerning all stages of this project. He also ordered to organize an "Open Day" at the end of the fieldtests. Of the latter he refers to his notes in Appendix 2.

22. Appendices

22.1. Questionnaire for test RERI staff-members

1. Determine conditions when selecting a carbo spot; Name 5 aspects of your selection.
2. Describe preparation of the sealing-mud and how to assure that any leakage by cracking is prevented.
3. Give all stages of uprooting from the last pick to the storage of the feedstock near the carbo-line.
4. Calculate production time and quantity of one uprooting team.
5. How to minimize an air-inlet.
6. Name the different colours and their significance of various carbonization smokes.
7. Important details to prevent air leakage during kiln manufacture.
8. Name tools to be used during carbonization.
9. Describe the role of water before, during and after carbonization.
10. After opening the kiln, what indicates a good carbonization?
11. And what a poor one?
12. How to examine the quality of the charcoal and to what standard?
13. Give a detailed description of a 6 kiln unit with manpower and all tools involved.
14. Do you consider cotton coal as it is a good substitute for wood charcoal?
15. Give short description of the briquetting process.
16. What are brands?
17. Make a drawing of how to achieve a maximum filling capacity.
18. What measures are to be taken - at the end of the kilning operations - to assure readyness of the kiln for the next year.

19. How to react, once a kiln is lit but combustion is slowing down.
20. Give suggestions to improve carbonization.

22.2. Appendix 2.

Idea's for "Open Day" to be held at the end of the fieldtests.

Place : Village 10 next to the briquetting plant
Date : between 15th and 20th June
Time : between 10.00 and 14.00 hrs, eventually earlier
Duration : 2 to 3 hours.

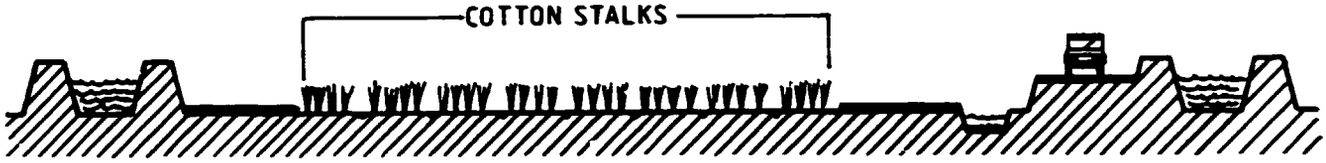
Introductions: - NOT LONGER THAN 10 MINUTES FOR EVERY SPEAKER!! -

Dr. A.H. Hood	: organization of carbonization
Mr. R. Schuuring	: production of charcoal briquettes
Dr. El Tayeb	: coordination of both projects
Ir. R.V. Siemons	: Unido-share and Degis-share in the projects
Gafar El Faki	: prospects of the product

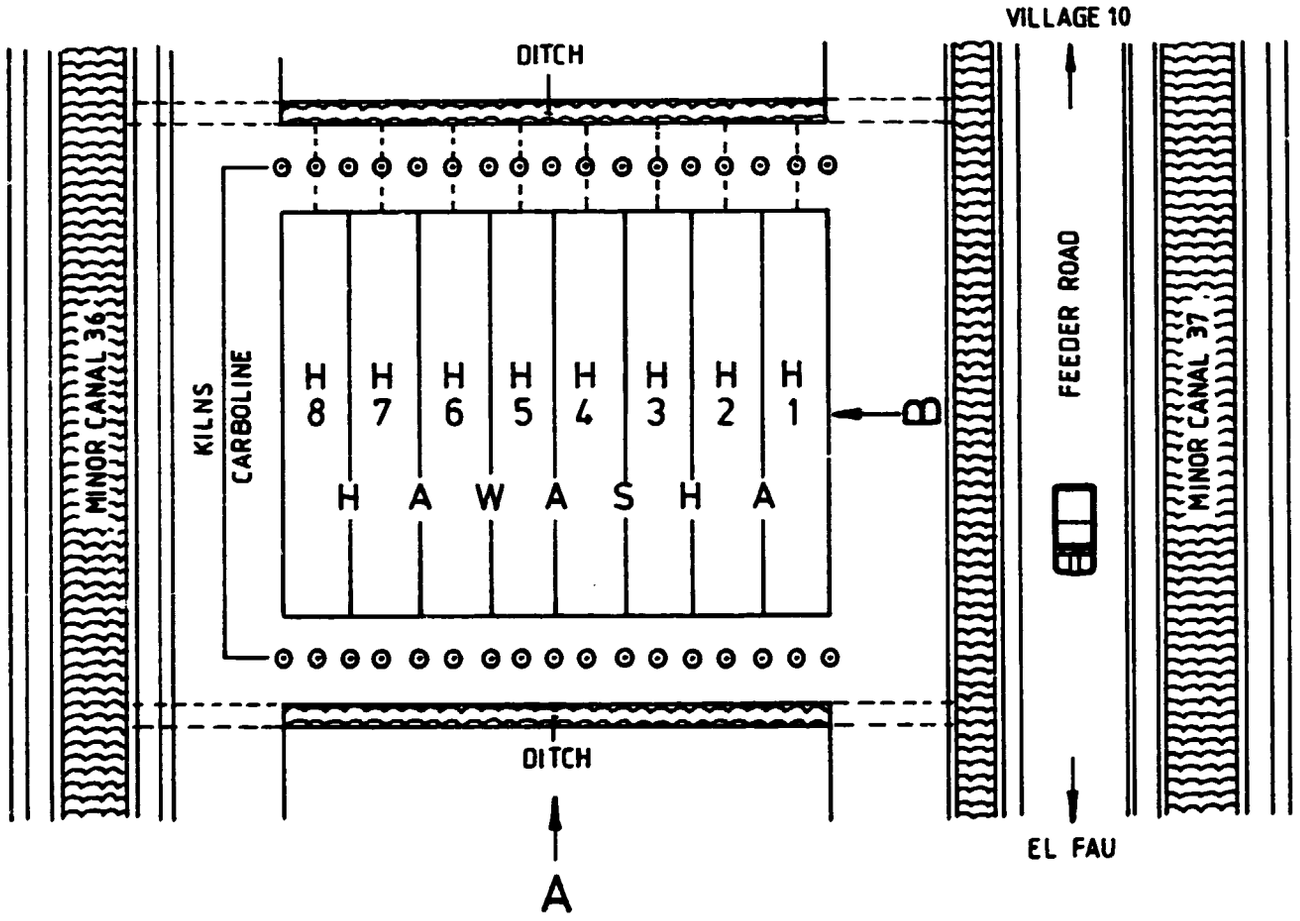
Exposition:
- 1 kiln; dismantled with clearly numbered section, cover and lid, bricks, test stalk, waterbucket with water, shovel, rake.
- 1 kiln; open filled with cotton stalks.
- 1 kiln; at some 50 m. distance. Demonstration of kilning and start of carbonization.
- 1 kiln; in the originally row, with carbonized stalks. This kiln to be operated on a previous day.
- 1 cotton sack; completely filled with cotton coal.
- completely running briquetting plant, operating 1 cement mixer and 1 drying table.
- demonstration of preparation of meals on cooking stoves, rising charcoal balls.

Invitations to send to:	- Rahad Scheme authorities
	- Delegations of farmers, inhabitants of Village 1Ø and representatives of other villages, labourers and of course entrepreneurs.
	- VIP's of Sudanese Government, Unido and Netherlands Embassy
	- Media
Publicity:	- to be recorded in newspapers by journalists
	- photographers
	- Sudan TV
Requisites:	- flags (Sudan, United Nations, Netherlands)
	- soft drinks (Pepsi, lemon, karkadieh etc.)
	- chairs and/or benches
	- awning or parasols

TABLES



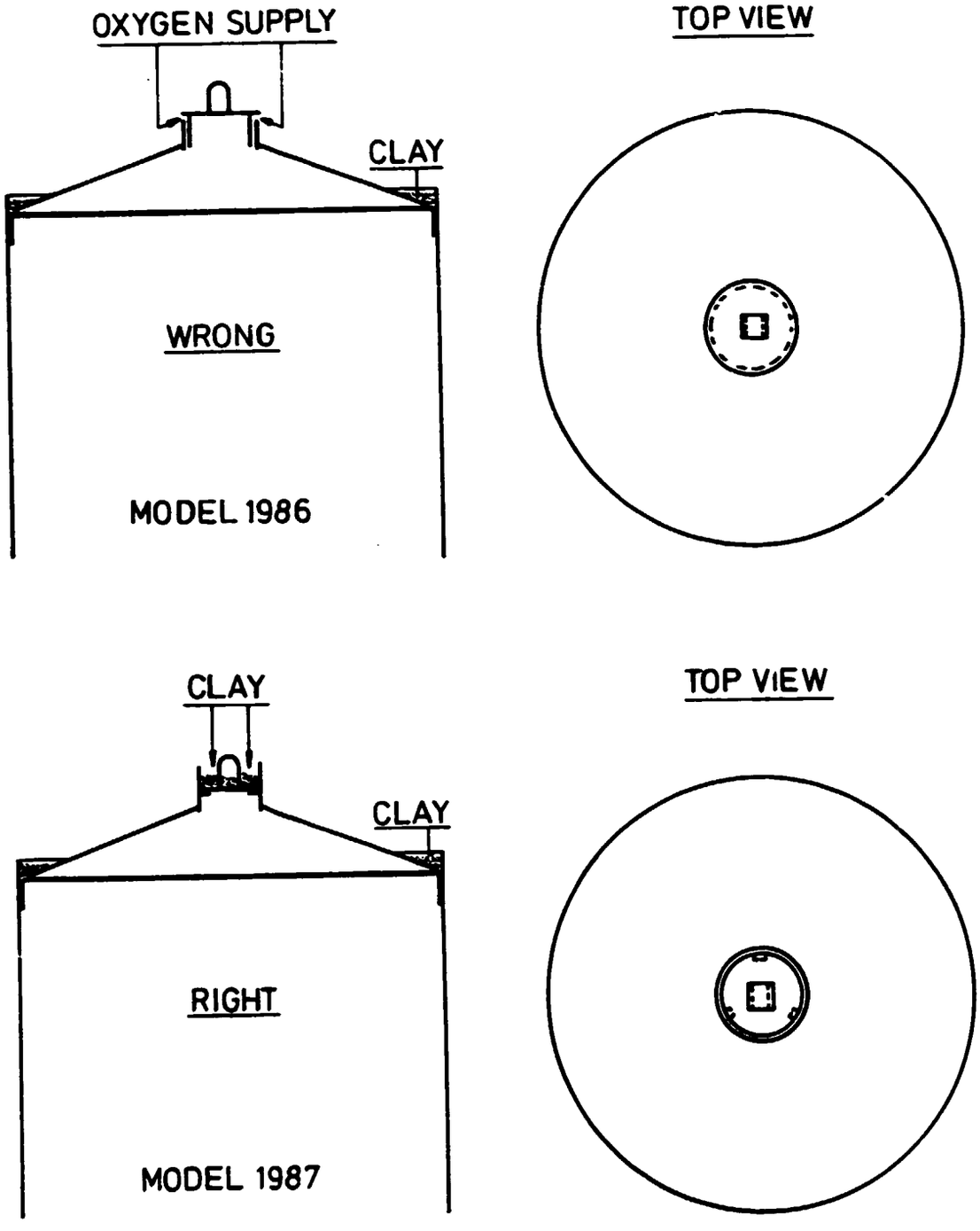
VIEW.A



VIEW.B

GROUND_PLAN

TABLE 1



KILN MODIFICATION

TABLE 2

Table 3.

ORGANIZATION CARBONIZATION

Experts:

Dr. A.H. Hood

Mr. A. Zorge

Division A

Supervisor: Mr. Abdelmawla
RERI Staffmember

Group 1: 1 op 1 ass 3 kilns

Group 2: 1 op 1 ass 3 kilns

Group 3: 1 op 1 ass 3 kilns

Supply Group I: 3 labourers

Division B

Supervisor: Mr. Elwaleed
RERI Staffmember

Group 4: 1 op 1 ass 3 kilns

Group 5: 1 op 1 ass 3 kilns

Group 6: 1 op 1 ass 3 kilns

Supply Group II: 3 labourers

Division C

Supervisor: Miss Amal
RERI Staffmember

Group 7: 1 op 1 ass 3 kilns

Supply Group III: 2 labourers

Required Labour:

Division A	3 operators	3 assistants	3 suppliers	
Division B	3 operators	3 assistants	3 suppliers	
Division C	1 operator	1 assistant	2 suppliers	
Total	7 operators	7 assistants	8 suppliers	= 22 labourers

Table 4.

CALCULATIONS on required fuel for carbo - briquetting project UNIDO

1.	TRAVELS		DISTANCES
1.1.	Khartoum - Rahad	VV	600 km.
1.2.	Rahad - Village 10	VV	50 km.
1.3.	Village 10 - Sites	VV	50 km.
1.4.	Rahad - Wad Medani	VV	200 km.

2.	REQUIRED FUEL		
2.1.	Peugeot 504	Petrol Super	1 ltr. - 6 km.
2.2.	Toyota Landcruiser	diesel	1 ltr. - 6 km. (4WD)
2.3.	Nissan Patrol	diesel	1 ltr. - 6 km. (4WD)
2.4.	Briquetting mixers	petrol regular	3 ltr. per hour

3. KILOMETRAGE

Car	Owner	Availability	Travel no.	Sorties	KM	Total KM's.	Total ltrs.
504	UNIDO	16/4-6/5	1.1	3	1800		
same	same	same	1.2	20	1000		
same	same	same	1.3	20	1000		
same	same	same	1.4	2	400		
						4200	700
Toyota	UNIDO	7/5-30/6	1.1	3	1800		
same	same	same	1.2	24	1200		
same	same	same	1.3	24	1200		
same	same	same	1.4	28	1400		
						5600	934

	Nissan	N.Embassy	16/4-30/6	1.1	5	3000	
	same	same	same	1.2	45	2250	
	same	same	same	1.2	45	2350	
	same	same	same	1.3	28	1400	
	same	same	same	1.4	2	400	
						9300	1550

4. TRAVEL COSTS

4.1.	504	154 gallons a £S 8,=/gallon	£S 1.232,=
4.2.	Toyota	205 gallons a £S 3,50/gallon	£S 717,50
			£S 1.949,50
		7 empty barrels a £S 80,=/barrel	£S 560,=
			£S 2.509,50

OR

4.3	Nissan	341 gallons a £S 3,50/gallon	£S 1.193,50
		7 empty barrels	£S 560,=
			£S 1.753,50

5. RUNNING COSTS Briquetting mixers

4 mixers with 4-stroke engines

estimated per mixer: 3 ltr/hr 6 hrs/day 28 days 504 ltrs.

111 gallons regular a £S 7.5/gallon	£S 1.032,50
3 empty barrels	£S 240,=
	£S 1.072,50

6. MAINTENANCE

Engine oil: 5 gallons a £S 30/gallon	£S 150,=

7. TOTALS

7.1	Travel costs: 504 + Toyota	£S 2.510,=	
7.2	Maintenance	£S 150,=	
			£S 2.660,=

OR

7.3	Travel costs: Nissan	£S 1.753,50	
7.4	Maintenance	£S 150,=	
			£S 1.903,50

11.11.1987	UNIDO requested authorization asap	3 barrels super
12.11.1987	UNIDO advised to purchase the fuel on the free market, which will increase the calculated totals with ca. 35%.	3 barrels regular 7 barrels diesel

Table 5.

LABOURCOSTS

Operational period	: 16/4/1987 - 31/5/1987
Operational days	: 45
Nr. of runs kiln/day	: 1
Total runs	: 45
Labour costs man/day	: £S 9,=

Total: 22 X 45 X £S 9.= = £S 8.910,=

Note: suppliers have to: eventually uproot the c.s.

They will be employed until required quantity of c.s. is secured.

Table 6.

CALCULATIONS on required materials UNIDO Carbo - & Briquetting project

1. Materials for carbonizations

1.1	Shovels for operators	1 per group	+ 2 (reserves)
		9 a £S 2Ø,=	£S 18Ø,=
1.2	Headers (patjols)	same	+ 2 (reserves)
		9 a £S 2Ø,=	£S 18Ø,=
1.3	Waterbuckets	same	+ 1 (reserves)
		8 a £S 2Ø,=	£S 16Ø,=
1.4	Cooling boxes	1 per division	
		2 a £S 25Ø,=	£S 5ØØ,=

		Total:	£S 1.Ø2Ø,=

Table 7.

1. Packing for cotton coal transport and briquetted cotton coal

1.1 estimated contents of jutebags: 45 kos briquets

1.2 estimated amount of jutebags per 1000 kos: 23

1.3 Calculated yield of cotton coal: 37.800 kos
add: 20% binder 7.520 kos

45.320 kos X 23 = 1.043 sacks

2. Costs

Prices for empty jutebags are ranging from £S 2,= to £S 3,= per bag
Required for the project: worst case 1.043 X £S 3,= = £S 3.129,=
best case 1.043 X £S 2,= = £S 2.086,=

packing per ton worst case £S 3.129 : 45.32 = £S 69,04
best case £S 2.086 : 45.32 = £S 46.03

Table 8.

CONSUMERS PRICES FOR WOOD CHARCOAL

1.1 Time: April 1987

Contents per (jute) sack 40 kos less 5 kos/Fines usable 35 kos

Prices per sack range from £S 19.= to £S 22.=

Price per ton usable wood charcoal: best case £S 542,=
worst case £S 628,=

1.2 During rainy season - June, July and August next - transportation of wood charcoal from production areas to populated areas is considered difficult, which will lead to higher prices.

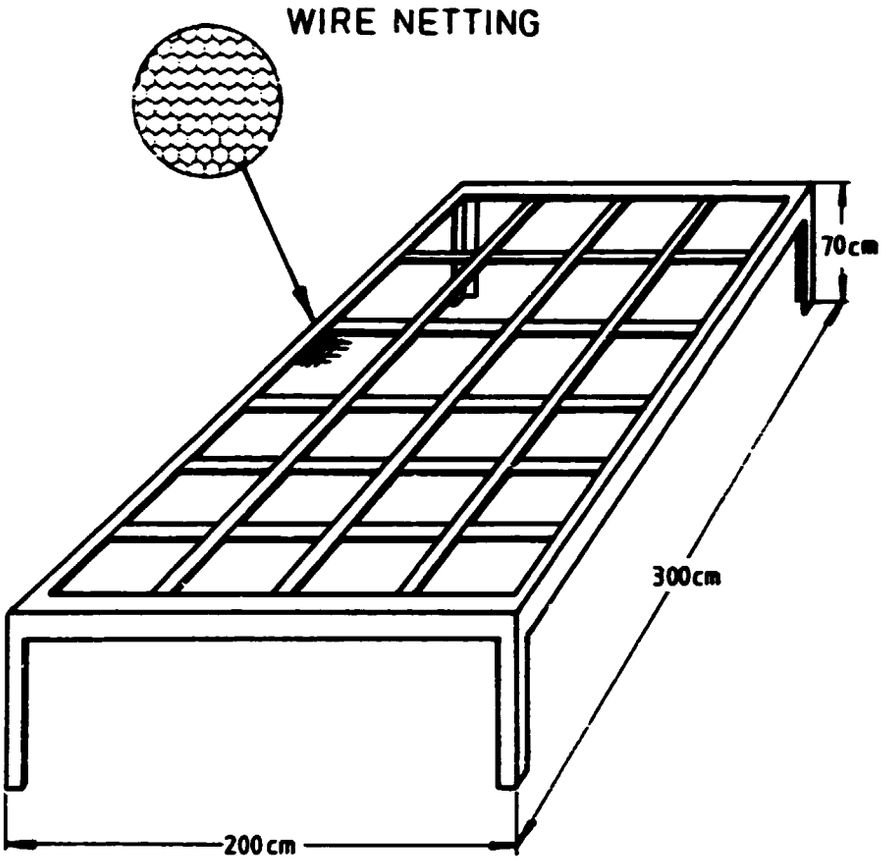
During this period prices per sack range from £S 25,= to £S 30,=.

Price per ton: best case £S 714,=.
worst case £S 857,=.

1.3 Expected prices for 1988: £S 25,= to £S 28,= per sack

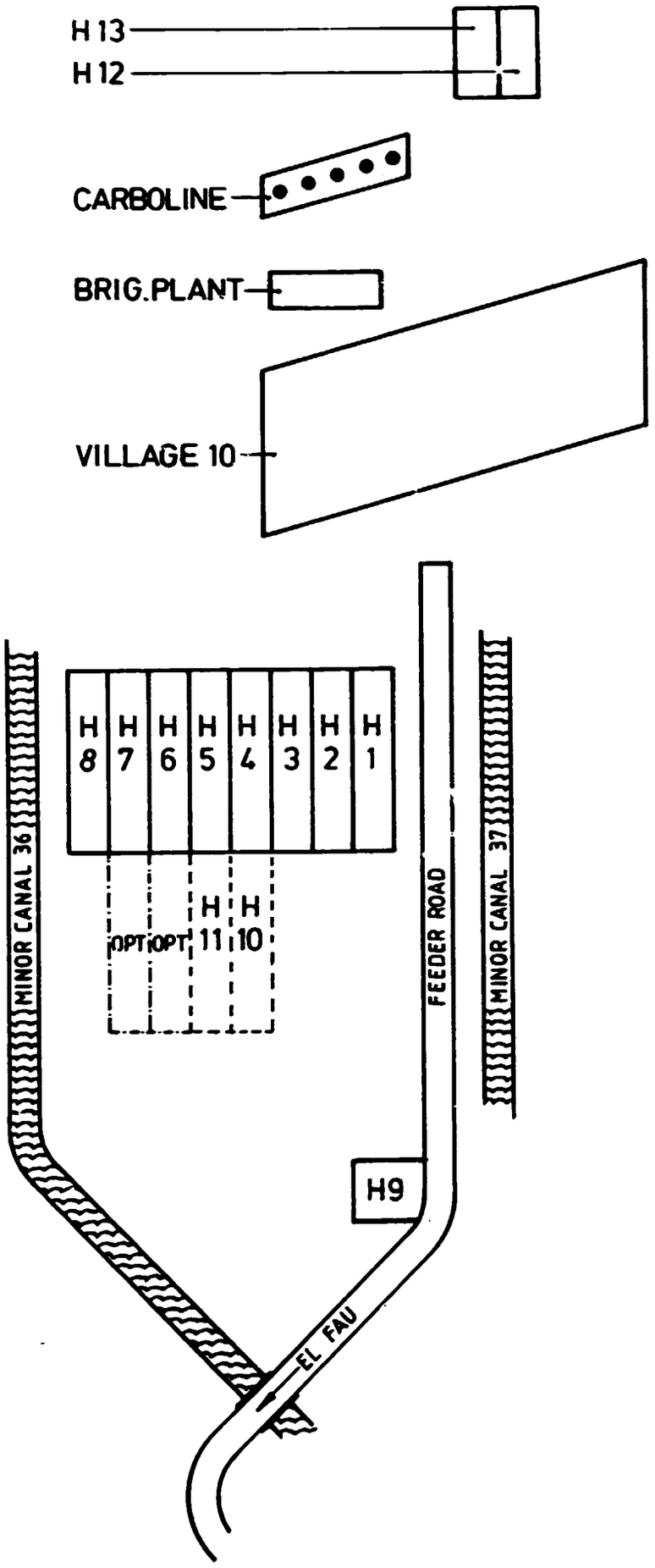
in June until August £S 33,= to £S 37,= per sack

Prices per ton will vary from £S 714,= / £S 800,=
to £S 942,= / £S 1.057,=



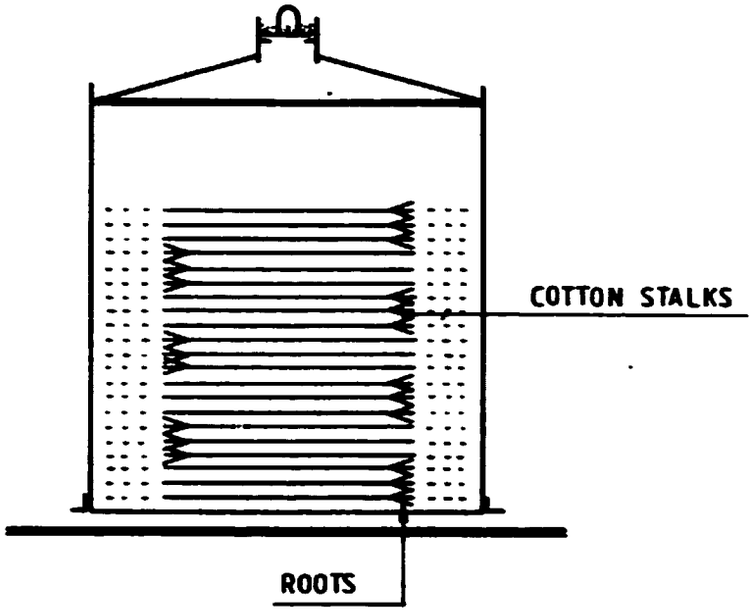
DRYING TABLE FOR CHARCOAL BRIQUETS

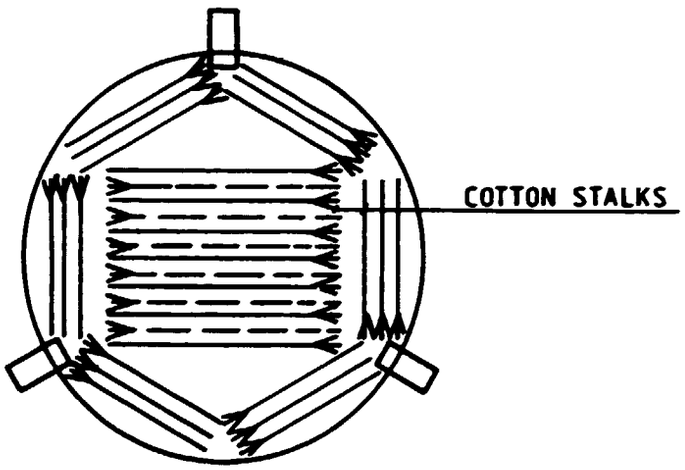
TABLE 9



MAP OF VILLAGE 10 & SURROUNDINGS

TABLE 10

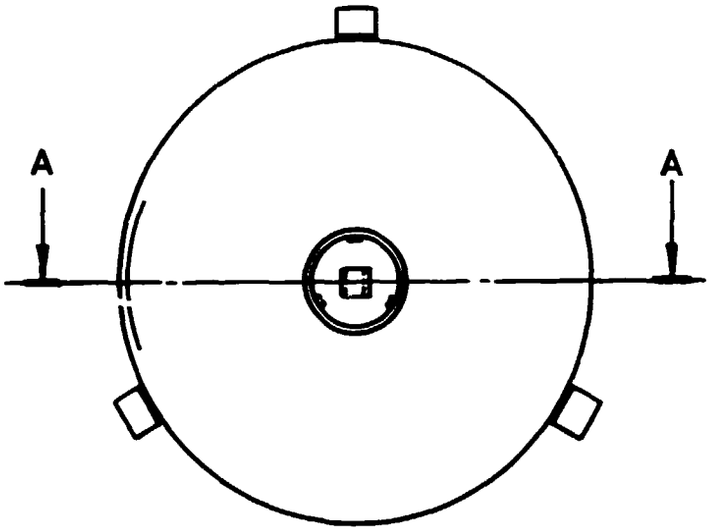




KILN FILLING

TABLE 11

TOP VIEW



CROSS SECTION A_A