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

RP/RAF/85/627

SUDAN

Technical Report*

30/11/85 - 16/12/85

Prepared for the Government of the Democratic Republic of the Sudan
bv the United Nations Industrial Development Organizaation,
acting as executing agency for United nations Development Programme

Based on the work of Ton Zijp
Expert in Small-scale Charcoal Manufacture and Briquetting

United Nations Industrial Development Organization

Vienna

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SUMMARY AND RECOMMENDATIONS

Within the UNIDO sponsored project RP/RAF/627 (Demonstration Programme on the Use of Indigenous Biomass Resources for meetin Energy Needs) a feasibility study and field testing programme for the production and use of carbonized cotton stalks in Sudan was prepared.

Cottonstalks which at present are burned in the field, have since long attracted attention as a source of domestic fuel that could alleviate the pressure on Sudanese wood resources. UNIDO and the National Council of Research, Sudan have therefore initiated a programme to evaluate the feasibility of decentralized cottonstalk carbonization.

So far a 5 m^3, transportable metal kiln has been developed by an UNIDO expert. This equipment produces a reasonable quality of cottoncoal. However, no field tests have been executed. Therefore the actual operational performance in terms of yields, cotton coal quality and technical lifetime is therefore only tentatively known.

This report presents a first assessment of the feasibility of decentralized carbonization of cottonstalks. It states also the uncertainties and missing information, which has to be gathered during a feasibilty study. The report ends with a detailed workplan to be executed in the Rahad scheme for the next period (april and may 1986) in which cotton stalks will be available.
The objectives of the workplan are:

- field tests of the metal kiln in order to gain operational experience,
- field tests with earth type pits in order to assess its appropriatness for cotton stalks carbonization,
- evaluation of the feasibility of decentralized cotton coal production,
- preparation of a plan of action, (in case cotton coal production is attractive) to further develop and implement the production and marketing of cotton coal. This plan shall include the inputs required both for the local as well as for the foreign components, in terms of manpower, capital and institutional and governmental support.

The main observations in this report are:

- Cotton coal can substitute a maximum of 3 % of the yearly cuttings of forestry recources,
- Cottoncoal can be marketed in local, home markets or in remote, urban markets. The latter markets makes densification of the cotton coal necessary.
- Granulation of cottoncoal with molasses is a promising

densification option,

- Granulation is an option as well to lower the reactivity of the cotton coal and hence to improve on its burning characteristics,
- In order to penetrate the markets cotton coal must be made available at a lower market price tan wood charcoal,
- Cottoncoal specific stove development cannot be recommended,
- Low wood prices to charcoal manufacturers impede the implementation of cotton coal production. In case real wood production costs are taken into account the economics of cotton coal and/or cotton coal briquettes appear much more attractive.
- A feasibility study with field experiments and monitoring is needed to better establish the cost structure of cotton coal production and marketing, as well as to analyse the attitude and reactions of potential cotton coal producers, traders and users.

1 INTRODUCTION

1.1. Energy situation in Sudan

Domestic fuel use of wood and charcoal amounts to almost 75 % of the total annual Sudanese energy consumption (lit.2, 1980:2.9 10^8 GJ/year). This wood or forestry based energy pattern poses a high pressure on the Sudanese wood reserves.
Cotton stalks have been identified as a potential source of domestic fuel. which could substitute for wood or charcoal. Almost all cotton stalks (more then million ton per year) are burned due to Government regulations to be burned in the field before the 1st of june. The energy content of those cotton stalks equals 7 % of the Sudanese yearly domestic energy consumption.

1.2. Programme-background

Previous consultants (lit. 4, 5 and 6) have recommended thermochemical technologies, particularly carbonization as suitable for the conversion of cottonstalks into an useful, domestic fuel.

The programme which stems from these recommendations aims at the introduction and dissemination of equipment suitable for the decentralized production of charcoal from cotton stalks.
The overall objectives of this programmme are:
- to alleviate the current, acute shortage of domestic fuel,
- to encourage rational utilization of forestry resources.

The Energy Research Institute and UNIDO decided on the initiaton of a detailed feasibility study. A charcoal manufacturing expert was therefore fielded in November and December 1985 for the identification and construction of equipment for simple carbonization procedures.

1.3 Scope of this report

This report presents a first assessment of the feasibility of the carbonization of cottonstalks. It states also the uncertainties and missing information which is to be investigated and collected during the feasibility study.
A detailed workplan is developed for the execution of the feasibility study after the coming cotton harvest.

Execution of this workplan must generate the following information:

- technical feasibility of the design of the kiln introduced by the UNIDO expert,
- possibility of incountry manufacturing of the kilns,
- acceptability of the cotton stalk charcoal (cotton coal) to the potential user,
- economics, including cost of fabrication and purchase price of the kiln, operating costs, potential markets and price of cotton coal,
- impact of a briquetting stage on the feasibility of the charcoal making process,
- identification of potential binders for use in briquetting of the cotton coal,
- optimum size of charcoal making and briquetting equipment
- need for modification of existing stoves when burning cotton coal.

II COTTON STALKS AS AN ENERGY SOURCE

II.1. Availability of cotton stalks

General profile: The Sudan is a major exporter from cotton. It is after Egypt, the world's second supplier of long staple cotton (Taweel Eltyla), the majority of which is produced in artificially irrigated areas. Large cotton growing schemes are the Gezira, Managil and Rahad schemes (64 % of the cotton production) with the first 2 growing long staple and Rahad medium staple cotton.
Although cotton is a perannial plant, it is treated as an annual one; i.e. cotton is planted again every year, as quality and quantity of the cotton is highest that way.

Cotton stalks as residues: Cotton stalks are an agricultural residue from the cotton production. Immediatly before harvesting, irrigation of the cotton fields is stopped. As a result, the plant begins to dry which is required for the picking of the cotton. After the picking, cattle is allowed to graze in the cotton fields, eating the left over green parts and small twigs.
Preparation of the land for the next crop requires uprooting of the stalks and finally burning of the cotton stalks before the 1st of june . The latter is regulated by law, because of the sensitivity of the cotton plant to diseases.

Description of cotton stalks: Typical* features of the stalks in uprooted state are:
moisture content: 10 - 20 %,
length including roots: average 60 - 110 cm,
diameter : average 0.8 - 1.5 cm,
weight: 30 - 50 gram @ stalk
yield: 1 - 1.5 ton stalks per Feddan (0.42 ha),
heating value: 18.200 kJ/kg (dwb)

Cottonstalks available as domestic fuel: 1 Million Feddan (420.000 ha) have been under cotton cultivation as an average for the last 10 years in the whole of Sudan. Hence 1 till 1.5 million ton of cotton stalks are each year produced in Sudan.
Part of this is used before the 1st of june as a domestic fuel and some of it illegaly after the 1st of june. However this practice is limited and at least 75% of the cottonstalks are burned in the field each year.

* Samples taken in December 1985 from cottonstalks stored from the 1985 harvest had a moisture content of only 8 % (w.b). Other sources (lit. 4) give a moisture content from 10 -20 % just after uprooting.

The conclusion is therefore that on the average 1 million ton of cottonstalks are available as an energy source each year. If converted into cotton coal (yield 25 %) 6.7 10^6 kJ becomes theoretically available as domestic fuel. Which is 9 % of the 1980 consumption figure of charcoal in Soedan (lit. 3).

II.2 Energy conversion and demand

Scope of this report: The scope of this study is to prepare a feasibility study for decentralized, labour intensive and low capital intensive carbonization of cotton stalks to be used as a domestic fuel.

The reasoning for this restriction is discussed in detail in lit. 4,5 and 6 but can be summarized as follows:

why carbonization:

- carbonization provides a way in which a part of the energy content from the cotton stalks can be stored, transported and used after the 1st of june without phytosanitary problems.

why decentralized carbonization:

- the phytosatinary risk is reduced since cotton stalks are not to be transported and stored,
- organisation of a major transport effort of cotton stalks within the two months after harvesting at high costs is avoided,
- the short allowable carbonization period per year allows only for low capital intensive and hence high labour intensive technologies. This condition coincides with characteristics of decentralized carbonization technologies.
- the decentralized approach allows for a gradual introduction of both the technology as well as the new domestic fuel, with all kind of possibilities of adaptation with respect to the technology, the production factors and the end use and the end users.

Cottoncoal* demand: The demand for cotton coal as a domestic fuel is still unknown. The demand depends on the quality of the charcoal, the price and the potential number of users.
The potential demand equals at least the amount of charcoal energy now used for domestic use. However in case an attractive marketing mix for cotton coal can be realized also people using other domestic fuels, such as wood and kerosine might be attracted to the cotton coal market.

* Carbonized cotton stalks will be referred to as cotton coal, better would be cotton stalk coal; but other authors used already the short version.

The cotton coal market can be distinguished in the direct local home market where charcoal is produced for own use or directly sold and the production for the further remote markets, which requires a more organized marketing and transport activity.

Limitation of area under study: Study of the feasibility of cotton stalk carbonization is limited to the provinces Khartoum, Gezeira and the White Nile. This is justified by the following reasoning.

- 71% of the cotton production is grown in this area, which is equal to a potential cotton coal energy content of 4.7 10^6 GJ while the 1985 consumption of charcoal in the same area is calculated at 24.1 10^6 GJ and for wood at 20.4 10^6 GJ (lit. 3). The maximum attainable production of cotton-coal can therefore easily be absorbed by the total charcoal market in the same area.

  The direct home market in the main cotton production centers can also absorb a considerable part of the maximum cotton coal production. An example of possible direct home markets are the Gezira and Rahad cotton growing schemes.

The Gezira sheme with 500,000 feddan under cotton can produces 3.4 10^6 GJ cotton coal per year, while 1 person requires 2.8 GJ of charcoal in the same area (source lit. 5) meaning that a home market of 1.2 million persons could be served with a substitute for charcoal. At least 100,000 tenants and 500,000 workers do live in the same area with an unknown number of relatives and migrant workers. A considerable part or possible even all cotton coal could therefore be sold in this home market. Moreover part of the wood users might also shift to cotton coal use.

- Implementation of cotton coal production in this area is expected to generate a higher return on project inputs then in the other 29 % of the Sudanese cotton producing areas with a much lower population density.
- Deforestation pressure is highest in the Northern provinces where more then 78 % of population lives and which have only 33 % of the forestry resources.
- 2 major cotton growing schemes are situated in this area with a relatively, high degree of organization and a well developed technical infra structure.

III PRE FEASIBILITY CONSIDERATIONS

On basis of available data a number of comments on different aspects of the feasibility of cotton coal production is given. This discussion indicates indirectly the data that are still missing.
Chapter IV presents a workplan for the execution of a feasibility study to establish better and more reliable data.

III.1 Decentralized carbonization

Choice of carbonization technology: In principle cotton stalks can be carbonized in earth pit or moulds systems or in metal kilns.
Choice of the metal kiln for the cotton coal production has a number of advantages above a pit or mould system.
- The carbonization proces is easier to control, which is important because of the dry and thin cottonstalks which otherwise could burn easily.
- The product is normally cleaner because of less direct contact with the soil. However contamination with cottoncoal under the dry Sudanese conditions is not seen as a major problem, especially since charcoal for domestic cooking does not require high standards of cleanliness.
- Shorter production cycle time because of faster cooling. This is an important factor because of the limited period available for carbonization.

However pit or mould systems do require almost no capital investment.

At present no preference can be recommended for either the pit or mould system, since relative advantages and disadvantages tend to be site specific.
Differences will exist in:
- the amount of work involved in burning preparation,
- usable and locally available residues for covering (e.g. woven carpets of leaves),
- ease of control,
- the weight yield.

It is therefor worthwile and recommended to initiate field experiments with pits and moulds, in parallel with the more proven metal cotton coal kiln technology.

An UNIDO charcoal expert (lit. 8) developed a 5 m^3 transportable metal kiln, which can be used for the decentralized carbonization.
Unfortunately only a limited number of trial burning have been executed with the metal kiln. The main characteristics of this equipment are:

Kiln characteristics: The kiln consists out of 3 parts:
- a cylinder shaped main part; diameter 2.30 m and a height of 1.22 m,
- a conical cover with lighting hole at the top; diameter .30 m,
- a lid to cover the lighting hole.

No provisions are made for air inlets and smoke outlets or chimneys. Air and smoke draught is regulated throughout the proces an arrangements of channels in the soil used to seal the kiln at the bottom.
The main part and the cover are reinforced with flat and angle irons.
The manufacturing techniques necessary are available in many local workshops. Economics of scale can play a major role in the manufacturing technique used; it is expected that development of standards, moulds and other devices can reduce the margin for labour costs with about 50 % as compared to single unit production.

Yield: During 3 trial runs yields of 32% (weight basis) were achieved.
However yields of 25 % weight are probably a better and more realistic figure as a base for economic analysis, because of the combined effect of the following observations:

- Proximate analysis of the yielded charcoal showed high volatile contents (d.w.b) of 21 till 34 %. Domestic fuel users prefer moderate volatile contents of 10 till 25 % giving good combination of acceptable smoke conditions during cooking and ease of ignition. Lower volatile contents can be obtained by higher carbonization temperatures and/or slower carbonization. Both have the effect of decreasing the yield.
- The trial runs are executed with cotton stalk samples with a moisture content of 8 % (dwb), while higher moisture contents (10 -20%) are mentioned for cotton stalks in the period direct after harvesting.
- There is a normal tendency of have better results during trial runs as compared to normal field runs.

The best assessment of the actual yield can only be obtained by additional carbonizing trials over longer periods in real field conditions.

Quality: Cotton stalks do keep their original shape during carbonization. The carbonized stalks (cotton coal) are brittle and can easely be broken in pieces. Cotton coal can be used directly (without briquetting) in standard charcoal cookers and is easy to ignite, but has a reduced burning time compared to wood charcoal.

Chemical characteristics The characteristics of cotton-coal are given in table 3.1.

ash	11 - 13 %
moisture content	3 - 4 %
volatiles	21 - 34 %
C	62 - 68 %
H	2 - 3 %
N	nihil
S	.20 - .24 %
S^{-2}	.13 - .16 %
CL^{-}	.24 - .29 %
Caloric value	26,300 - 26,500 kJ/kg (dwb)

Table 3.1.: Characteristics from cotton coal production trials

Capital investment: The materials for the 5 m^3 kiln have costed LS 600. This kiln type can be manufactured in workshops in the cotton growing areas, avoiding high transport costs. The margin required for labour costs and profit is estimated at another LS 600. This estimation is based on interviews with 3 potential manufacturers, costs of the production factors and the production time required.
The total capital investment amounts therefore to LS 1200.

Technical lifetime: The technical lifetime of the metal kiln is limited and determined by the following factors:
- corrosion: the corrosion rate in Sudan is very low because of the low humidity and the pure, un-polluted air.
- thermal stress: high thermal stresses occur during the cottoncoal burning cycle. The technical lifetime will therefore depend largely on the number of burning cycles per season and the carbonizing temperature. It is already suggested that the carbonization temperature should be increased (see quality) which has a possible negative effect on the lifetime.
Extremely high thermal stresses can occur in case the kiln is not well attended and overheated.
- mechanical stress: the kiln can be transported by rolling of the cylindrical part and the round cover. Mechanical stress during rolling can influence the lifetime considerably. Rolling durability tests showed problems with the reinforcing rivetted flat and angle irons.
- manufacturing: the kiln design and manufacturing technique shows certainly room for improvement. This can best be done in coordination between manufacturers and kiln users.

Based on experience the lifetime of a comparable transportable Ugandese Mark V metal steel kilns (200 cycles per year) is normally taken at 3 year.

Operation characteristics: The following operations are required for cotton coal production:

A - placement of the kiln on flat ground,
- collection of cotton stalks,
- filling of cylindrical part with cotton stalks,

Manpower requirement for this first phase are 4 - 6 man hours (2 men for 2 - 3 hours).

B - firing of the kiln,
- sealing of the kiln with dry soil and mud,
- attendance of the kiln and control of the carbonization proces.

This latter phase takes 5 man hours (5 hours for one man).

C - cooling down of the kiln for a period of 10 - 12 hours.

Emptying of the kiln by lifting and removal of the kiln structure.
This phase takes 2 men for 5 minutes.

The whole cyclus fits into 24 hours; emptying and refilling in the morning, followed by carbonization during the afternoon and cooling overnight.

III.2 National-considerations

National objective: Carbonization of cotton stalks has no direct importance for the nations foreign currency oil bill. It can substitute a maximum of 3 % of the yearly cuttings of forestry resources. In judging the importance of this 3 % one should realize that most of the saving of forestry volume is attained in the area with the highest deforestation pressure (e.g. Blue Nile Province).

Program capacity: Given the scarce government resources in fighting deforestation, the cotton coal program should be compared with other programs with the same objective (f.i. improved wood and charcoal stoves) and valued on results and use of government resources. Clearly higher savings in forestry cuttings can be attained with higher domestic stove efficiencies (see lit. 10), however has not yet been realized.

Execution of the cotton coal program requires a decision of the government, which decision has to be prepared in terms of resources required and results to be expected.

Employment: Based on the theoretically possibility to install a total number of almost 60,000 kilns; creation of employment can vary from nihil in case that the cotton coal will be used as a substitute for charcoal to a maximum of $2.8\ 10^6$ mandays or 10,000 man years in case the coal is used as a substitute for domestic wood fuel. However most of these man years will be short seasonal jobs (2 months).

Local manufacturing of a maximum of 15,000 kilns (kiln life time 4 years) yearly could be an incentive for the start up or improvement of a number of local mechanical workshops with its expected spin-off the rural development.

III.3 The cotton coal producers

Production figures: Typical cotton coal production figures data can be summarized as follows:
- a maximum of 60 cycles per season or year,
- input: 21000 kgs of cotton stalks per year or season (net residues from an average of 21 feddan or 8.8 ha),
- output: 5250 kgs of cotton coal per year or season.

The demand for labour in march, april and may necessary for cotton coal production coincides with a relative low labour demand in the prevailing agricultural crop rotation system.

Producton of cotton coal: Production of cotton coal should be profitable.
In principle 3 types of commercial set ups are possible,
- production could be done or organized by a cotton growing farmer (tenant), who owns the kiln as well. Each farmer can produce enough cotton coal for supplying for his own household and 6 others with domestic fuels (lit. 5, village surveys in Rahad and Gezira).
- the same as above, but kiln capital investment is secured by the tenant union.
This set-up can be helpful during the implementation and dissemination stage of the technology by reducing the financial risk of the farmer by means of a hire-purchase financing system.
- the production is organized by the same people , who are running the existing well organized commercial charcoal manufacturing business (lit. 9).

III.4 The users

The attitude of women to the use of cottoncoal in cooking is not well known.

Cotton coal-cooking: The cotton coal burns clearly differently from normal wood charcoal: a cotton coal fire burns faster and is less easy to control. Preparation of food on a traditonal charcoal stove requires therefore more attention and frequent refilling.
The different cooking behaviour and the probably lower social status of cotton coal as compared to wood-charcoal could well result in a negative attitude towards cotton coal use. It needs investigation whether the cottoncoal can be produced and/or marketed at a price low enough to countervail this attude.

Economic choices of users: Difficulties in the implementation of improved charcoal stoves with payback periods of less then a couple of months are often used to argue that people do not make their choices in an economic way.
The same arguing can not be applied to use of cotton coal, because no initial investment and lengthy time period is required before actual savings can be assessed. The financial advantage of cottoncoal use can therefore be realized without any prior investment. Acceptance of cotton coal depends of course very much on the trust people have in the fact that the amount of usable energy of wood charcoal (on a weight basis) does not differ much from the usable energy in cotton coal. Or, in other words, that lower kilogram prices for cottoncoal are conceived as direct savings.
Acceptance of cotton coal requires therefore a certain period of promoting and experimenting.

III.5 Improved uses of cotton coal

If the financial advantage of cottoncoal use does not outweigh the lower burning characteristics of cotton coal one may try to improve those characteristics by briquetting or by development of a cotton coal specific stove.

Briquetting: Briquetting is one of the options which can improve on the burning characteristics of cotton coal in stove use as well as on the costs in storage and transport. Burning characteristics are considered unfavourable not only because of the low density, but also because of the high reactivity of the cotton coal due to high micro-porosity. The ideal briquetting process should therefore densify and decrease the microporosity at the same time.

The Energy Research Council, National Council for Research has started a program for the development of a briquetting process for charcoal fines and cotton coal.

The binding material so far used is paper pulp (made from soaked newspaper), no market study or economic appraisal has been made and the technology itself seems far from ready.

Other materials which could be used as binders are cement, molasses and residues of arabic gum. Experiments with charcoal and molasses at Twente University, Biomass Technology Group could give the basis for the development of a low energy intensive granulation proces, producing a lower reactive cotton coal briquet. Since molasses from beets and charcoal from beech wood was used during the experiments, results are to be valued for cotton coal and molasses from sugar cane as well. Moreover the briquets produce during lighting a light, caramel flavour. Not unpleasant and acceptable according researchers, but whether the users are of the same opinion has also to be checked during fieldtests.

The total expected amount of molasses to become available after the rehabilitation programme of the sugar industry is estimated at 266,600 t/yr (lit. 1). Though the best weight ratio between molasses and cotton coal in briquetting yet has to be defined, ratios from 0.20 till 0.30 are likely. The maximum of 117,500 ton of cotton coal that can be produced in the same area indicates that sufficient molasses could be made available for granulation.

Stove development: A programme aiming at the development of special stoves for easy, comfortable and efficient use of cottoncoal as a domestic fuel may be started. However, chances for the development of low-cost stove which could also succesfully be implemented must be considered slim, due to the low cottoncoal density and the above mentioned problems (see III.4) in the implementations of improved charcoal stoves. Stove development special for cotton coal is therefore not advisable.
Comparative stove tests between wood charcoal and cottoncoal burning stoves, however are considered as useful for a better understanding and judgement of the cotton coal burning performances.

III.6 Cotton coal markets

Local or home market: Cotton coal can be used directly for cooking in the home market.
Transport and storage requires probably sacking of the cotton coal, but actual handling procedures are to be investigated during fieldtests.

Remote or urban market: Cotton coal marketed as a domestic fuel to the urban area.

Marketing of cotton coal to urban areas implies transport. The low bulk density of sacked cotton coal 125 kgs/m^3 (or 13 kg per sack) prohibits costwise in transport, therefore densification or briquetting is necessary. This procedure increases the apparent density to about 460 kg/m^3 (own measurement for ground and compressed - 1N/m^2 - cotton coal). Transport costs at those densities are determined by weight and not any more by volume. Therefore in this case the transport costs of charcoal and cottoncoal are of the same magnitude.

III.7 Economics of cottoncoal production

Inputdata: Inputdata for the economic assessment are:

- Average weight of 1 sack charcoal at the market 39.6 kg.
- Net effective weight of usable charcoal after transport of 1 sack 32 kg, (Average loss of fines after transport 20 % of original weight).
- Net heating value of cotton coal is 90 % of the net heating value of wood charcoal.
- Average yield of cottoncoal is 25 % of weight of cotton stalks, that is 87.5 kg cotton coal per burning cycle for the 5 m^3 UNIDO kiln.
- Cost of kiln is 1200 LS; technical life time 4 years; straight line depreciation of 300 LS per year.
- 50 carbonization cycles per year .
- 9 - 11 manhours labour per cycle (day) at a cost of LS 4 per day. Labour demand is generally low in april and may, due to the labour requirements in the agricultural crop rotating system (lit. 5).

The production costs of 1 kg of cotton coal comes then to LS 0.11/kg for unsacked coal (LS 4.27 10^{-6}/kJ). Wood charcoal is available in the Rahad and Gezira scheme at market prices depending on the season of LS 8 - 13 per sack, or LS 0.25 - 0.40/kg usable charcoal. Or in other words wood charcoal is marketed at LS 0.22 - 0.36 for 0.9 kg (LS 8.18 - 13.3 10^{-6}/kJ), which represents the same amount of energy as in 1 kg cotton coal (price LS 0.11/kg).

Annual savings of LS 480 till 1090 per kiln (average capital investment of LS 600) can therefor be obtained from cotton coal production for the home market. It is however not predictable whether these high internal rates of return on capital investment (80 - 180 %) do suffice to:

- arrange for a direct financial incentive for the women to use cotton coal in cooking,
- cover for costs (if necessary) of storage, sacking and transport,
- to accept the risk of initial capital investment in

an unproven technology.

The costs and attitudes related with these questions are to be answered during further field experiments.

III.8 Organisation and economics of briquetting

Reasons for briquetting: Briquetting may be a prerequirement for the acceptance of cotton coal as a domestic fuel. This may be true for both the local/home market as well as for the remote/urban market. Briquetting or densification is also required for lowering of the transport costs if the cotton coal is to be used inthe remote/urban market.

Briquetting for the local/home market: Molasses is brought at bulk to a central place in the cotton growing and cotton coal producing area. Mobile briquetting units are used for decentralized briquetting. Estimations of labour, transport, storage and capital costs can not be made in this stage, because only little is known of the actual briquetting technology, labour requirements and production capacity. The technology envisaged, however consists out of crushing, mixing and granulating followed by air or sun drying. The absence of high pressures and external heating and the possibility of natural drying makes the technology a low energy intensive one. Besides the above there is energy consumed in transport of the mobile unit itself. Tentatively (and as a target) the costs of production and transport will be set at LS 0.040/kg briquet or LS 1.50 10^{-6}/kJ.

Material costs: Molasses is to be transported from the sugar factories, where ample amounts are dumped in the field adjacent. The economic value of the molasses can therefore be taken as zero or even below zero. Molasses exports options are possible, but in all cases will be restricted to minor amounts. The costs of the molasses at the cotton production sites is therefore largely determined by the transport costs.
With an average distance of 80 km from the sugarfactories (e.g. Gunaid and Sennar) and a ton-kilometer price of LS 0.30 - 0.40 ton-km, the cost price of molasses at the cottoncoal production site can be taken as LS 24 - 32 /ton molasses, or LS 3.2 - 4.3 10^{-6}/kJ. This cost is in the same magnitude as the cost for cotton coal (see III.7); weight ratios of both components do therefore not influence the material cost of the briquet per kJ, which can therefore be taken at an average of LS 4 10^{-6}/kJ. Taking into account the above mentioned material and transport costs, the minimal costs of briquetted cotton coal (excluding labour, capital costs will amount to about LS 0.150/kg or LS 5.7 10^{-6}/kJ.

Briquettering for the remote/urban market
In case cottoncoal/molasses briquets are to be made for the Khartoum market, a different organisation of the briquetting proces is required. The situation of the Gunaid sugarfactory along the way from the main cotton schemes to Khartoum and the high transport costs makes it necessary to produce the briquets near the sugar factory.
The cotton coal has in this case to be crushed at cotton coal production sites in order to obtain bulk densities of more then 300 kg/m^3 in order to minimize on transport costs. Cotton coal tranport in bulk to the sugar factory over about 80 km and a ton-kilometer price of LS 0.30 - 0.40 results in a cotton coal costprice at the Gunaid sugarfactory of about LS 5.3 10^{-6}/kJ or LS 0.143/kg; molasses is available at no costs.

The ideal compositon of the cottoncoal/molasses briquet is still to be determined by experiments but will also depend on the economic trade-off between the differences in material costs of both components as well as on transport costs to Khartoum per kJ. The latter are ofcourse proportional to the specific heating value of the briquettes.

A tentative estimate of the lower heating value of an usable briquet is 20,000 kJ/kg and results in an indicative cost for transport to Khartoum (200 km) of LS 3.5 10^{-6}/kJ.
The material and freight prices of briquets in Khartoum, excluding production costs of briquetting and taking into account a zero cost of molasses do therefore reach a total of 8.8 10^{-6}/kJ. This figure should be compared with net charcoal prices of 10.4 till 20.8 10^{-6}/kJ.

Conclusion: For both markets under examination, given all uncertainties of the production process, the composition and burning characteristics of the briquets and the attitude of the potential users towards briquet use, as for now no definite answer can be given as to the economic feasibility of briquetting.

III.9 Economics of wood charcoal

Descripton of charcoal branche: The National Council of Research, Energy Research Council has published 2 reports giving a very detailed description of the charcoal marketing and production (lit. 7 and 9). The summary of one of these reports gives the main characteristics of the wood charcoal business and is therefore copied in Appendix A.

Production and marketing costs: Table III.9 is also based on the above report and gives the costs of different production and market activities. Market prices of charcoal in Khartoum are very fluctuating, but reached values as high as LS 20 per sack (LS20 10^{-6} kJ)in december 1985.

	1984	1986*	% of total 1986
Production costs			
Labour	1.520	2.190	23
Water	0.220	0.315	3
Foremen	0.170	0.245	3
Agent	0.106	0.150	2
Burial	0.070	0.100	1
	2.078 +	3.000 +	
Marketing costs			
Royalties & taxes	0.300	0.430	5
Sacking	0.558	0.805	9
Packing & handling	0.296	0.425	4
Transport to depot	0.440	0.880	9
Guarding	0.063	0.090	1
Losses & depreciation	0.070	0.100	1
Transport to Khartoum	1.800	3.600	39
	3.527 +	6.330 +	+
Grand total in LS/sack wood charcoal	5.605	9.330	100 %

* all costs have been increased with 20 %/yr, to take inflation into account, except for transport costs which have been doubled for the 1984 - 1986 period.

Table III.9 Marketing and production costs in LS/sack

Transport costs: Almost half of the costprice of wood charcoal stems from transport activities (LS4.7 10^{-6}/kJ). The bulk density of charcoal of about 300 - 350 kg/m^3 indicates that full use is made of the lorry's weight transport capacity. Lower transport costs can not be attained by a better weight capacity utilization of the lorries.

Implications for the cotton coal branch: This implies also that other fuels in order to be cost competitive should have:

- a comparable or higher bulk density than woodcharcoal,
- a comparable or higher heating value than woodcharcoal,

- a shorter transport distance between production centre and users market than for woodcharcoal.

The first requirement emphasizes the need of crushing or briquetting before transport in order to realize bulkdensities above 300 kg/m^3.

The heating value of cotton coal is about 10 %, of molasses 70 % and of molasses/cotton coal briquets about 35 % lower than charcoal. Transport costs per kJ are therefore higher for all these materials.

The last requirement is advantageous for cotton coal and molasses which are in all cases produced closer to the users market than wood charcoal. Moreover this effect will increase with the shifting of available wood resources away from Khartoum, which at present occurs with a a speed of about 15 km/yr.

Material costs: The wood costs per sack charcoal (LS 0.4 10^{-6}/kJ) paid in royalties and taxes are low considering the replacement costs of wood (US$ 25.- per ton dry wood, LS 8.3 10^{-6}/kJ of charcoal) under the Sudanese conditions.

Unfair price-competition: The low price setting for wood is a major restriction in fighting the deforestation by promoting of other domestic fuels. Addition of the wood replacement costs to the price of charcoal increases the production and marketing costs with LS 10/sack charcoalup to LS 19/sack charcoal. Resulting in Khartoum market prices of LS 20 - 30 per sack charcoal. By taking the latter into account a better competitive scope for cotton coal c.q. cotton coal/molasses briquets both for the home/local as well as the remote/urban market, becomes apparent.

III.10 Conclusions

A start has been made with a program to answer the long existing question whether cottonstalks could be used as a substitute for other domestic fuels. Carbonization trials with cottonstalks gave promising results, but further field tests are needed to develop the kiln design and to determine the manpower requirements as well as the yield and quality under field conditions.

It is not clear yet whether it is financial attractive to become a cotton coal producer. The same is true for potential users. Again field tests are needed to determine the actual production and marketing costs and the cotton coal price at which people are willing to use cotton coal with its different burning characteristics as a replacement for their normal domestic fuel. Table

III.10 gives an overview of a number of site specific material and market costs, calculated under a large set of assumptions given in this chapter. The table can only be used for a tentative analysis and indication for further studies required.

Description of material or activity	LS 10^{-6}/kJ
Cotton coal at production centre	4.27
Transport crushed cotton coal to Sugar factory	0.88 - 1.18
Cotton coal at sugar factory	5.15 - 5.45
Molasses at Sugar factory	nihil
Transport molasses to cotton coal production centers	3.20 - 4.30
Molasses at cotton coal production centers	3.20 - 4.30
Wood for charcoal	0.40*
Wood for charcoal against replacement costs	8.30**
Charcoal at cotton growing schemes	8.18 -13.30
Charcoal at Khartoum	10.40 -20.80

* On charcoal energy basis
** Based on 25 US $ for 1 ton dry wood production

Table III.10 Material costs for charcoal and cotton coal production

Briquetting - especially with molasses as a binder - is a possibility to improve on the burning characteristics of cotton coal and to create transport costs comparable to those of charcoal.
A distinction is made between the local/home and the remote/urban market because of differences in marketing structure, such as handling, storage, transport and briquetting requirements. Each market has sufficient potential clients to absorb the whole cotton coal production.

Use of cotton stalks as cotton coal can substitute for a maximum of 3 % of the yearly woodcutting in Sudan. Whether this figure can be realized is largely dependent on the costs of transport and of the materials involved. The current availability of wood for charcoal manufacture, at almost zero-price is a very restricting factor for a succesful implementation of cotton coal. The proximity of cotton stalks to the users market represents a major costs advantage.

A feasibility study with field experiments and monitoring during the coming cottonstalks harvest is needed to better establish the cost structure of cotton coal production and marketing, as well as the attitude and reactions of potential cotton coal producers/traders and users. The results of the study will give the

Sudanese government sufficient information to decide whether a cotton coal implementation program is attractive enough in terms of counteracting deforestation to justify active government support. The latter could express itself in subsidizing of kiln manufacturing costs or even more appropriate in increasing of wood prices for the wood charcoal burners.

IV WORKPLAN FOR FEASIBILITY STUDY

Use of cotton stalks as an energy source in Sudan has been an often returning idea. However prefeasibility studies on the same subject have never been conclusive, because of the vast number of uncertainties with go with the unproven cottonstalk carbonization technology and the attitude of users towards its product - cotton coal -.
The National Council for Research, Energy Research Council in cooperation with UNIDO has developed a cottonstalk kilning technique, which is to be tested and further developed under field conditions*.
The time period of field testing, technology development and assessment of the overall feasibility is restricted to a period of 2 months per year of cotton stalks availability. Sequencial execution of activities is not recommended, because of unwanted division of programme efforts and considerable delay of the possible implementation of cottoncoal production and use.
A detailed workplan for the execution of a complete feasibility study for the coming cotton stalks harvest period (april and may 1986) has therefore been developed with the Energy Research Council, Biomass Technology and Technology Development and Dissemination Units.

IV.1 Missing and uncertain information

Chapter III presents a first discussion of the feasibility of cottoncoal production and use. It indicates also a number of uncertain and missing data which are to be determined during the feasibility study. These data are elaborated and classified below leading to the design of a workplan and a check-list for execution of the feasibility study.

Data required for the technical feasibility:
- establishment of field operation procedures,
- kiln performance by potential users in terms of cotton coal quality,
- training requirements,
- experiments with pit type carbonization technologies,
- use of cotton coal as domestic fuel by potential users,
- experiments with decentralized briquetting technologies,
- use of cotton coal briquets as an domestic fuel by potential users,

* The Energy Research Council plans to have fieldtests with drumsized cotton stalks carbonization equipment based on the work described in lit.11 as well.

Data required for the economical feasibility:

- cotton coal prices at which the different type of producers are willing to take the entrepreneur risk of production,
- cotton coal prices at which potential users do start using cotton coal in relation to prevailing charcoal prices,
- cost of labour and labour requirements,
- capital cost of kiln and economics of scale of kiln manufacturing,
- actual maxixum number of carbonisation cycles which can be realised per season, this should be related to the actual period cotton stalks are available,
- assessment of the local and foreign currency components of the cotton coal production and marketing,
- assessment of kiln lifetime,
- identification and assessment of size of different users markets:
  : for cotton coal which can be sold directly without sacking and storing,
  : for cotton coal which has to be stored and sacked before selling,
  : for cotton coal which is briquetted, stored and hence sold,
- production and marketing activities in terms of labour and capital requirements and costs required for supply to the above markets.

Data required for the social feasibility:

- willingness to directly use cotton coal with its different burning characteristics,
- willingness to use cottoncoal briquets as a domestic fuel,
- attitude of people towards cotton coal production, especially with respect to expectations as to further limitations on illegal use of cotton stalks (after the 1st of june).
- supportiveness of the labour force involved in cotton coal production and marketing,
  Related questions are:
  - which people will deliver the extra labour for cotton coal production and marketing,
  - is the workload involved supplementary to their normal work and are they properly payed.

Data required for the implementation feasibility:

- assessment of the potential attainable substitution of wood based fuels,
- attitude of the established charcoal branche towards cotton coal production and willingness of those businessmen to enter the cotton coal production business,
- which subsidy on kiln capital investment or increasement of wood royalties is needed to improve on the financial feasibility of cotton coal production,

- assessment of the programme inputs required for a succesful implementation and dissemination programme, in terms of manpower, capital and government support (separated in local and foreign components),
- assessment of available credit facilities for the initial capital investment,
- (any) foreseeable and important changes expected in the cost structure of cotton coal production and marketing or other related conditions, which could hamper the implementation. If any, can they be avoided.

IV.2 The workplan

The workplan itself is presented in Appendix B together with a summary of the required inputs for labour, transport and funds. The workplan consists out of a list of activities with its related objective and the department responsible for its proper and timely execution. Planning of the activities is presented in a barchart.

Rahad cotton growing scheme: It has been decided by the National Council for Research, Energy Research Council to execute the feasibility study in the Rahad cotton growing scheme 280 km from Khartoum.

Number of kilns: The experiments will be executed with 10 kilns, 1 for demonstration, additional testing and training and the 9 others will be operated under different commercial settings. The kilns will be provided at no costs to the producers, under condition that the kiln can be bought at the end of the season against rest value. The number of kilns bought will be a measure for the attractiveness of the production process to the producer.

Different commercial settings: Three kilns will be provided to individual cotton growing farmers. Based on average yearly incomes of LS 3 - 4,000 for the least profitable cotton crop only, it is assumed that a considerable number of farmers have enough credit facilities to enter into the cotton coal production business.

Three kilns will be provided via the Rahad Tenant Union to lower income farmers which can normally not pay the initial capital investment. The Tenant Union can act as a financing source for those producers if they want to keep in cotton coal business. Involvement of the Tenant Union in this early stage can ease dissemination of the technology. The Tenant Union can be the appropriate institution for initiation of a hire-purchase scheme for the provision of kilns to farmers.

Three kilns will be provided to wood charcoal traders. These traders are well-known for their efficient charcoal production organisation, which may be advantageous in the organisation of cotton coal production as well. They have also ample credit facilities. It is therefore very worthwise to include them as potential producers in the feasibility study.

Manufacturing: The 9 kilns are to be ordered from at least three different mechanical workshops. The manufacturers should be forced to generate competitive prices and to pay attention to improvements in the kiln design. Moreover quotations for larger serial production should be obtained from those manufacturers.

Improved cotton coal use: Briquet and stove development activities are already existing program activities within the Energy Research Council and will run parallel with the feasibility study.

Artificial market: The producers are free to market their cotton coal produced at any price they want. However an artificial market will be created with a weekly fixed price for cotton coal, depending on the going charcoal prices in the same region. Reactions of the producers in terms of sales of cotton coal and production efforts will provide information as to the market value of cotton coal and will keep producers in business, even when no direct sales of cotton coal are forthcoming.

Monitoring scheme: An intensive one man one kiln monitoring scheme will be developed. Each kiln and its relevant environment will be closely monitored. The monitoring people will be trained prior to the fieldwork to observe the subject relevant aspects. The actual field work itself will be for 3 periods of 2 weeks with reporting and evaluation of tentative results in between. During fieldwork intensive supervision is required for the gathering of reliable and comparable data and information. Relevant issues are:
- the yield and labour requirements of carbonization,
- production and marketing activities, including storage and securing,
- classification of the cotton coal users, with respect to: reasons of cotton coal use, normally used domestic cooking fuels, distance to home, means of transport, attitude towards cottoncoal use and experience with cotton coal use.
- attitude of labourers towards cotton coal production implementation,
- estimate of number of potential users,
- alternative use of cotton stalks after the 1st of june
- any aspect which could hamper introduction of the cotton coal production

Manpower and institutions: The Dissemination Department will be responsible for the manning of the monitoring scheme. It is suggested that it is best to hire students from the Forestry Instiute, because of their capability to camp or to accommondate themselves near to the kiln sites.
The Biomass Department from the Energy Research will be responsible for most of the activities as indicated in the workplan.
Two UNIDO experts are to be fielded:
- a carbonization expert for the demonstration of the kiln technique, training of the producers and further experiments with the kiln, pit and mould system.
- a carbonization feasibility expert:
  - for training, organisation and supervision of the monitoring team to be composed,
  - for the set up of kiln experiments and organisation of the measurements,
  - for training of a laboratory assistant to operate the field laboratorium at Rahad scheme, thus giving direct feed back on the quality of the cotton coal produced.
  - for the execution and evaluation of the overall feasibility study.

General result: execution of the workplan should give conclusive information as to the scope of cotton coal production and marketing. If cotton coal production is attractive for producers a scope for further development and a plan for implementation of the cottoncoal production/marketing is to be developed as well. This plan should include the inputs required both for the local and foreign components, in terms of manpower, capital and institutional and governmental support.

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APPENDIX A

CHARCOAL MARKETING AND PRODUCTION ECONOMICS IN BLUE NILE

CHARCOAL MARKETING AND PRODUCTION ECONOMICS IN BlUE NILE

Gaafar El Faki Ali

August 1985

SUMMARY

In this study financed by the Sudan Renewable Energy Project, all aspects of the charcoal industry (marketing, production economics and distribution) in the Blue-Nile are analysed. Both records survey and analysis were used to furnish the necessary information.

Discussion of the marketing environment covers the analysis of producers, traders, marketing process, distribution channels and institutional aspects. The analysis reveals the following:

- Charcoal production in the Blue-Nile is a highly commercialized activity comparable to agricultural production both in terms of scale and money involved.
- It is a well organized industry with a high level of competition which is reflected in the conduct, performance and development of the industry.
- Marketing process and distribution show a long, complex chain. Compared to an ideal distribution system, the existing system is very poor (sphagetti structure), perhaps mainly due to the very low trade margins characterizing the trade in the industry.
- Generally on average, of charcoal produced on the kiln site 20% is sold on site (packed or unpacked), 29% finds its way immediately to Khartoum and Gezira markets, 14% is transported to local markets in the Blue-Nile, 34% is stored in storage areas in the Blue-Nile in anticipation of high price periods and 3% is left on site for the next season.
- Charcoal production since the 1960's is a salvage operation that bears no or very little relevance to forest management practices. Of all the charcoal produced in the Blue Nile in the 1984 season, 84.5% was from commercial production zones, defined as areas allocated to agriculture in the future.

The economic analysis of the industry dealt with production economics, prices, price development, investment charcateristies such as profile, profitability (or return on investment) and employment generation. Analysis of these factors indicated that:

- Of all the production and marketing costs, labour and transportation are the highest. The latter however can prove to be a limiting factor for production. Even with high labour costs - labour exploitation is a salient feature of

the industry.

- Prices are stable and show a distrint pattern of low and high price periods. Collusive practice and price rings are rare and very much less than most accusations tend to suggest.

- Charcoal investment is based on an initial revolving capital concept. The initial capital is estimated to be 16% ± 8 of total production and marketing costs.

- Returns on investment are generally high and averaged for the producers analysed in this study 85% ± 48. This is based on returns on initial capital.

- In terms of finance the industry is dependent on a traditional finance system typical of rural agriculture in the Sudan, referred to as the sheit system. Although it has so many drawbacks it is expected to continue to dominate. Very little bank financing is expected to be seen within the industry.

- The industry is a valuable employment generator. In the production phase alone 65,856 man-months employment opportunities were available during the 1984 season.

The future of the industry is constrained mainly by the diminishing forest resource. The supply gap is expected to widen while charcoal demand is projected to rise. Afforestation and demand management policies rate very high in securing the future of the industry. With inadequate wood supplies no technical prescription can provide the charcoal needed.

APPENDIX B

WORKPLAN FOR FIELDTESTS AND FEASIBILTY STUDY

WORKPLAN ASSESSMENT FEASIBILITY OF DECENTRALIZED COTTON STALK CARBONIZATION

Nr.	Activity	Objective	Responsibility	Inputs [1)]
10	Trial run 5.1 m^3 kiln Sampling coal for analysis	Performance scaled-up model Information for manual operation Determining coal quality	Biomass Dept. (RERI)	Analysis Twente University
20	Storage and securing cotton coal yield of trial run	Stock of cotton coal for briquetting and stove development activities	Biomass Dept. (RERI)	
30	Introduction technology and workplan to Rahad Scheme	Arrangements for the organisational setting of the field testing program in April and May 1986	Biomass Dept. (RERI)	
40	Introduction technology and workplan to Tenant Union	Official introduction to farmers, initiation of contract arrangements for the kiln use with the farmer-members	Biomass Dept. (RERI)	
50	Introduction monitoring program to Rahad Scheme and Tenants Union	Creation of understanding of need for such a study and co-operation with all partners involved	Biomass Dept. (RERI)	
60	Arrangements and transport of stalks to Soba	Stock of cotton stalks for further briquetting, stove, kiln development and training, demonstration for the period after June 1986	Biomass Dept. (RERI)	Funds

Nr.	Activity	Objective	Responsibility	Inputs [1)]
70	Design and write up project document, incl. basic info on technology and economics, project name and operation manual for kiln use	Establishment project identity and bulletin for information purposes	Dissem. Dept. (RERI)	
80	Durability test of prototype	Data for product development	Biomass Dept. (RERI)	
90	Product development in co-operation with manufactuers	Optimalization technical lifetime and product quality in relation to the prevailing costs of the production factors	Biomass Dept. (RERI)	
100	Contract arrangements for the kiln use with wood charcoal entrepreneurs in January 1986	Study to use wood charcoal production organization for introduction cotton coal production Time allowances to set up cotton coal production infrastructure	Dissem. Dept. (RERI)	
110	Briquetting development	Enlargement marketing chances and fuel acceptability of stove users	Biomass Dept. (RERI)	
120	Stove development	Enlargement marketing chances and fuel acceptability of stove users	Dissem. Dept. (RERI)	Stove Consultant
130	Set up and build up of stove test capability	Infrastructure required for further stove development	Dissem. Dept. (RERI)	Stove Consultant

Nr.	Activity	Objective	Responsibility	Inputs [1)]
140	Manufacturing of 9 kilns by 3 different manufacturers	Kilns for use by farmers, Tenant Union and wood charcoal entrepreneurs during April, May 1986 Cost price assessment through competition and comparison	Biomass Dept. (RERI)	Funds
150	Transport of kilns to Rahad	Preparation field work	Biomass Dept. (RERI)	Funds
160	Demonstration kilning technology	Introduction of the technology to potential cotton coal producers	Biomass Dept. (RERI)	Consultant A
170	Contract arrangements with "farmer-producers" and "Tenant Union"	Framework for feasibility study	Dissem. Dept. (RERI)	
180	Definition of market conditions and prices on artificial market plus operation of such market	Improvement of risk conditions for producers	Dissem. Dept. (RERI)	Consultant B Funds
190	Job training, supervision and trouble shooting of producers' kilning activities	Technology transfer	Biomass Dept. (RERI)	Consultant A
200	Training RERI-Lab. trainee	Strengthening of charcoal analysis capability	Biomass Dept.	Consultant B

Nr.	Activity	Objective	Responsibility	Inputs [1)]
210	Set-up lab. facilities in Rahad	Direct feed-back on coal quality during field work (proximate analysis)	Biomass Dept.	Drying lab. oven, weighing, balance muffle furnace
220	Test runs with thermocouple equiped kiln	Optimalization of carbonization procedure in terms of yield, fixed carbon and volatiles content Assessment of drying period required after uprooting	Biomass Dept. (RERI)	Consultant A/B Thermocouple Recorder Lab. analysis
230	Field experiments briquetting team	Assessment of production of cotton coal briquets	Biomass Dept. (RERI)	
240	Evaluation of data obtained during technical supervision and test runs	Input data for feasibility study	Biomass Dept. (RERI)	
250	Design of monitoring and observation schemes	Organization of information gathering for the assessment and/or improvement of the feasibility of decentralized carbonization of cotton stalks	Dissem. Dept. (RERI)	Consultant B
260	Selection of applicants for monitoring study	Improvement of quality monitoring work	Dissem. Dept. (RERI)	

Nr.	Activity	Objective	Responsibility	Inputs [1]
)	Training and introduction of monitoring personal to Rahad	Improvement of quality monitoring work	Dissem. Dept. (RERI)	
280	One man one kiln intensive monitoring (3 times 2 weeks)	Information gathering for the determination of the feasibility of the decentralized cabonization of cotton stalks and for information on marketing strategies	Dissem. Dept. (RERI)	
290	Supervision monitoring team	Ensure reliable information gathering and reporting	Dissem. Dept. (RERI)	Consultant B
300	Evaluation monitoring information	Input data for feasibility study and future workplan	Dissem. Dept. (RERI)	
310	Assessment of feasibility	Design of follow-up activities	Biomass Dept. (RERI)	Consultant B
320	Contract arrangements kiln use 1987	Indication of usefulness of kiln for producers	Biomass Dept. (RERI)	Consultant B
330	Arrangements new workplan	Planning of activities and determination of required inputs		Consultant B
340	Ongoing information and technology co-operation between Biomass Dept. (RERI)-Biomass Technology Group (Twente university of Technology)	Ensure access of RERI to project relevant technologies, information and developments	Biomass Dept. (RERI)	

Nr.	Activity	Objective	Responsibility	Inputs [1)]
350	Project co-ordination	Tuning and execution of project activities	Biomass Dept. (RERI)	

1) Inputs given are restricted to additional manpower from outside NCR/RERI and required funds.
The necessary transport facilities are only indicated under "Summary of main inputs"
Consultant A refers to an UNIDO expert on charcoal production
Consultant B refers to an UNIDO expert on feasibility studies with regard to the introduction of thermo-chemical conversion systems.

SUMMARY MAIN INPUTS

Manpower

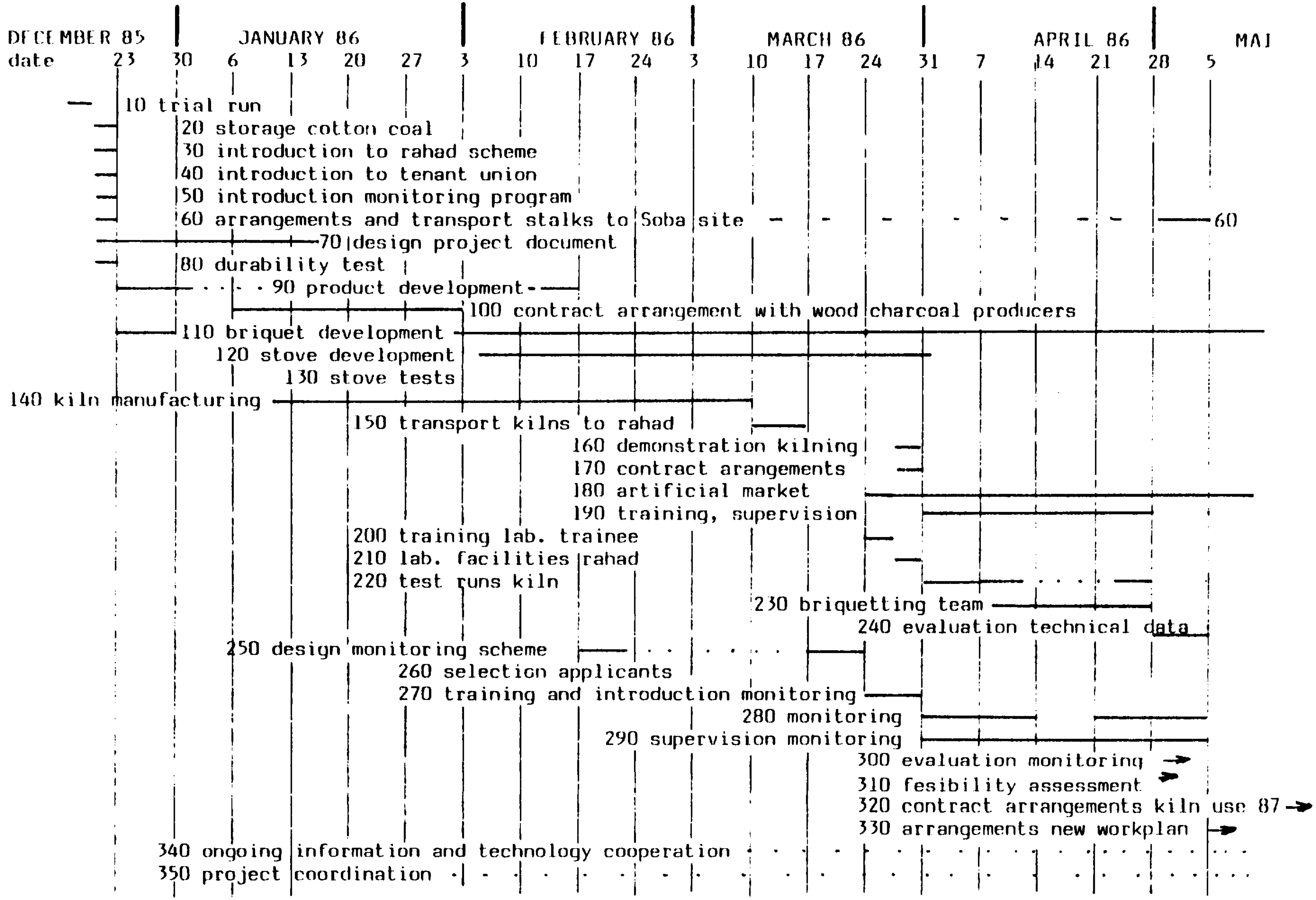
- Biomass Dept. (Dr. Hood),	6 months during period till end of August 1986
- Dissemination Dept. ,	3 months " " " " " " 1986
- Lab. trainee ,	2 months " " " " " " 1986
- Charcoal stove consultant (from NCR,RERI),	2 weeks during February/March 1986
- UNIDO-consultant A (charcoal expert),	6 weeks " period 24 March - 5 May 1986
- UNIDO-consultant B (feasibility expert),	8 1/2 weeks , of which:
	4 weeks in period 17/3 - 14/4
	3 1/2 " " " 1/8 - 24/8
	1 week in total divided over the period till August 1986

Funds for:

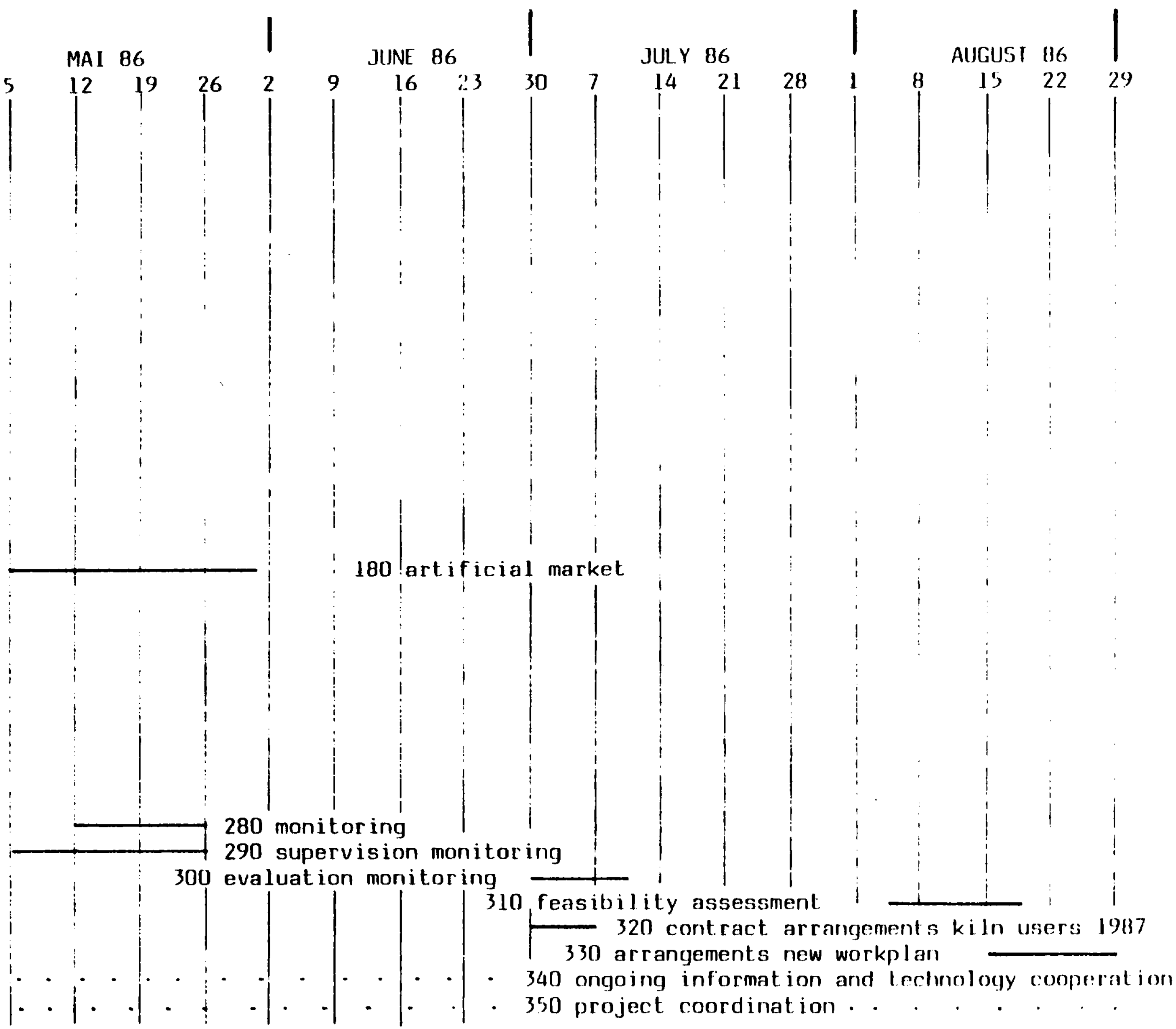
- Counterpart contribution (Topping up, per diem)
- Monitoring team (salaries, per diem)
- Kiln manufacturing (9 kilns, transport)
- Artificial market (costs of cotton coal)
- Project car (initial plus running costs)
- Cotton stalks to Soba
- Working fund local project co-ordinator (manuals, stationeries, secretarial services)
- Supplementary inputs for stove development, kiln testing, training and analysis
- Management and planning course (rural energy)

Transport

- From project car for ongoing project activities
- From NRC/RERI provided four wheel drive during period of fieldwork from 24th of March till 1st of June 1986



TIME SCHEDULE DECENTRALIZED CARBONIZATION OF COTTON STALKS RP/RAF/85/627



TIME SCHEDULE DECENTRALIZED CARBONIZATION OF COTTON STALKS RP/RAF/85/627 (page 2)