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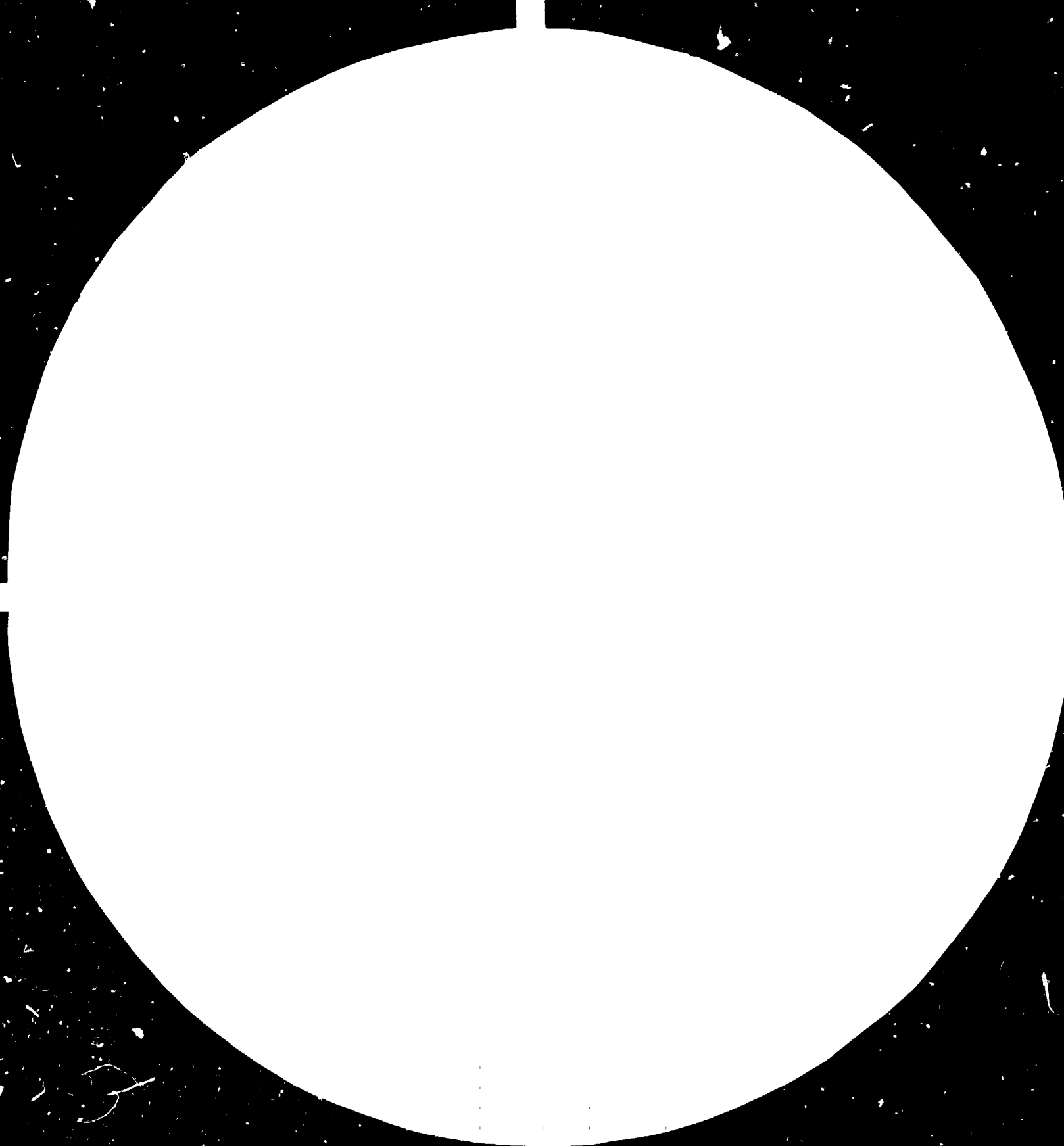
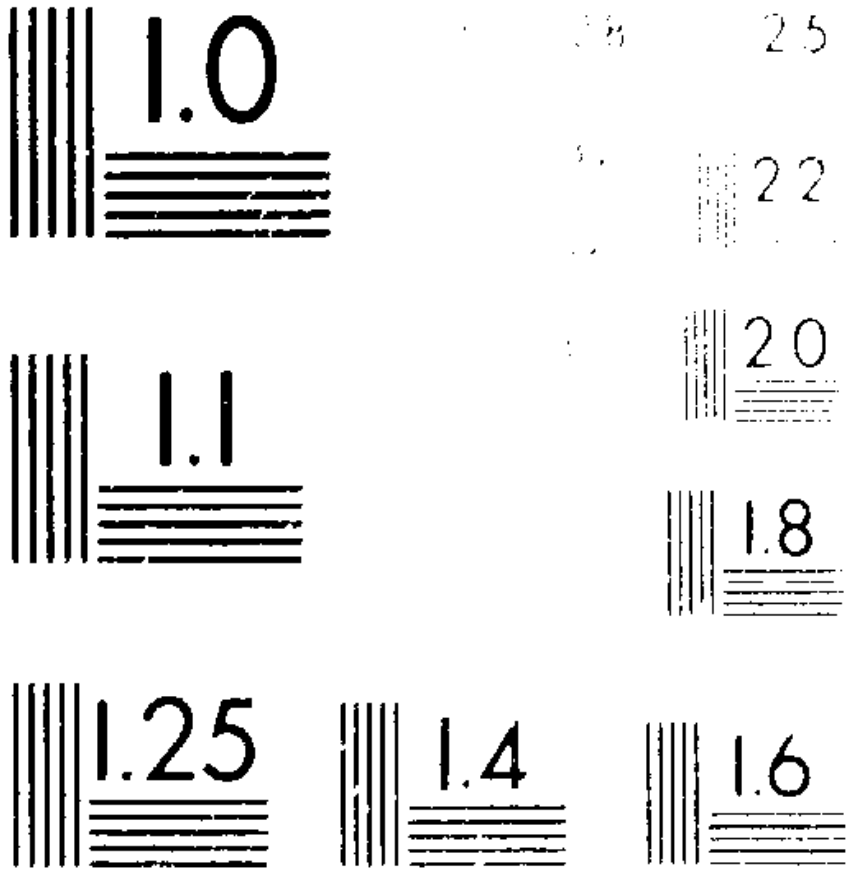
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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CELLULOSE CHEMISTRY AND TECHNOLOGY RESEARCH UNIT
ST/SUD/82/001
SUDAN

Terminal Report

Prepared for the Government of the Sudan by the United Nations Industrial Development Organization, acting as executing agency for the United Nations Financing System for Science and Technology for Development.

Based on the work of HASSAN IBRAHIM,
Consultant of

United Nations Industrial Development Organization
Vienna

ABSTRACT

It goes to the credit of such cooperation between the Government of Sudan and UNFSSTD/ UNIDO/ UNDP Office of Kartoum that the Project " Cellulose Chemistry and Technology Research Unit - ST/SUD/82/001 " has been executed within a reasonable period of time.

Since the project became operational in June 1982 up to August 1984, the establishment of the Cellulose Chemistry and Technology Research Unit, the main immediate objective of the project, has been achieved in respect of the provision of buildings and facilities, delivery of equipment and supplies, international technical expertise and training of research personnel.

The research activity was started in July 1983 on the Animal Feed Project and then followed by the Pulp and Paper and Construction Boards Projects. For the first time in Sudan, paper and particle board sheets were produced from domestic raw materials in March 1984.

In addition, technical services have been extended to the paper industry via quality control, trouble shooting, development of process and product and training of personnel. As a result, the Apex Paper Mill at Gadid El Thawra, Gezira Province was successfully started - up for the first time in May 1984 after having suffered from technical problems that hindered its start - up for more than one year.

It is recommended that the research personnel should be encouraged to continue their work on the research projects as formulated by the Research Leaders and the consultant in order

to achieve the project objectives. Also, close contacts with the industry should be maintained and strengthened for the benefit of both sides.

The Government is requested to approve and support the Project on " Rehabilitation and Modernization of the Existing Pulp and Paper/ Board Mills in the Sudan " submitted by UNIDO in January 1984 with the object to utilize the idle capacity for producing more pulp, paper and board badly needed for the country.

This is the fourth split mission of the consultant for a period of 6 months (March - August 1984) to act as a programme adviser to the National Director in the main fields of research on pulp and paper, construction board, animal feed and energy usage of agricultural residues.

CONTENTS

INTRODUCTION

The Democratic Republic of the Sudan is the largest country in Africa with a total area of 2.5 million Km^2.

The economy of Sudan is based on agriculture and there are vast areas of land suitable for agriculture on the Nile of which only 10 % is now being used.

Natural forests are only found in the Southern region of Sudan and there is also a lot of land suitable for industrial plantations as stated by the ECA/FAO Forest Industries Advisory Group in 1976. Large trial plantations are being carried out with Eucalyptus in Sudan, along the Blue Nile from Khartoum to Er-Roseires and Ed Damazin area has been considered the best place for extensive industrial Eucalyptus plantations.

Sudan, a country endowed with rich natural resources- agricultural, mineral and animal - stands a good chance of becoming one of the largest agro-industrial countries in Africa. Large irrigation schemes and appropriate agro-industrial projects can make Sudan self-sufficient in the short-run and an important exporter in the long-term.

The industrial sector contributed 8.8 % to GDP in 1981/82 and employed more than 200,000 people, about 3.5 % of the economically active population.

When Independance came in 1956, Sudan inherited an industrial sector which had previously played a minor part in the national economy.

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In the 1960's, a separate Ministry of Industry was established in 1966 followed by the Investment Act of 1967 which encouraged growth by giving protection to locally manufactured goods, by a five-year tax-exemption programme for new investors and by expanding private sector activity in canning, edible oil production and grain mills, etc. However, lack of comprehensive planning and scientific and technological research led to the failure of several publicly owned projects such as the Aroma Carton Factory and the Babanusa Milk Products Factory.

Consequently the development plans in the 1970's represented the start of careful planning policy. The major aims were to increase agricultural production by putting more land into production, to process agricultural products to meet local demand and eventually export especially edible oil, leather and textiles, to produce agricultural aids such as fertilizers, insecticides and machinery, to encourage the search for minerals, natural gas and petroleum, and to distribute factories fairly throughout the country to achieve balanced development.

Research institutions were also established such as the Industrial Research and Consultancy Institute, the Food Industries Research Centre, The Sudan Development Corporation, and the National Council for Research (NCR) with its four specialized councils including the Council for Scientific and Technological Research (CSTR) which was entrusted in April 1970 with specific task, among others, of studying the aspects of industrialization and marketing of cellulose.

Accordingly, the Cellulose Chemistry and Technology Research Unit was established and the following steps were taken prior to the project :

- A director for the Unit and three research assistants were appointed.
- Four temporary laboratory buildings with a total area of 130 M^2 were established for the Unit to commence its research activities.

- A part of the required equipment, glassware and chemicals was procured.

- Establishment of a Research Committee of some professers and researchers from the University of Khartoum and the National Research Institutions to co-ordinate and monitor the activities of the Unit.

The assistance for the project was requested from UNFSSTD in 1980 and in February 1982, the project was approved and the document was signed by the representatives of the Government of the Sudan, UNFSSTD and UNIDO (Executing Agency). The project became operational in June 1982 for a duration of two years. However, in view of the protracted installation phase including the extension of the laboratory buildings and the procurement, delivery and installation of equipment, it was agreed at the Tripartite Review Meeting held in Khartoum on 5-6 September 1983 to extend the project by one year to be completed in May 1985.

The total contribution by UNFSSTD for this project is US$ 647,000 and by the Government of Sudan is LS 264,404 (Sudanese Pounds).

The development objectives of the Project are:

- to strengthen and promote industries through utilization of agricultural and forest residues,

- to strengthen indigenous scientific and technological capacity in the area of Cellulose Chemistry and Technology.

The main immediate objective of the Project is the establishment of the Cellulose Chemistry and Technology Research Unit to conduct research work on domestic fibrous raw materials aiming at finding the best economic use of them. This would help in :

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- assisting the Government in formulating its policies for the utilization of forest and agricultural residues.

- advising the industrial sector on assessment, selection, acquisition and adaptation of foreign technology and expertise.

- forming a National trained cadre in the field of cellulose chemistry and technology to serve both the Unit and the industry.

- disseminating the information and findings of research of the Unit to agricultural and industrial sectors to promote and improve their development activities.

RECOMMENDATIONS

1. The equipment and apparatus of the Cellulose Chemistry and Technology Research Unit should be well maintained and operated. It is therefore recommended to add two technicians (one skilled electrician and one mechanic) to look after the maintenance and repair of the equipment.

2. The delivery of the equipment&supplies not yet received should be expedited.

3. Service engineers from the suppliers are required to adjust and calibrate the Hydraulic Heating Press and the Briquetting Machine.

4. The research work on the three research projects; Pulp and Paper, Construction Boards and Animal Feed should be continued and intensified through the following period to achieve the project objectives. Incentives for the research personnel to pay more efforts are highly recommended.

5. The research work on the densification or briquetting of wood and agricultural residues for energy utilization should be carried out jointly with the Energy Research Institute of the National Council for Research.

6. The research work should be oriented towards solving the problems and improving the quality of the end products of the paper and board mills and the converting factories.

7. Close contacts between the Unit and the industry should always be maintained and strengthened for the benefit of both sides. Through the technical services rendered by the Unit to the industry via quality control, Trouble shooting, development of process and product, the research personnel would gain sound technical expertise.

8. The Government is requested to adopt the project submitted by UNIDO in January 1984 for the " Rehabilitation and Modernization of the Existing Pulp and Paper/Board Mills in the Sudan ". The main objective of the project is to utilize the idle capacity at the existing mills to produce more paper and board needed for the Sudan without heavy investment on the part of the Government.

9. Parallel to the technical suitability study being presently conducted at the CCTRU laboratories, economic availabitity study on the domestic raw materials should be undertaken to ensure their continuous supply to the industry at a reasonable cost.

10. At present, if a new pulp and paper mill is to be based on agricultural residues such as wheat straw, it is recommended the mill capacity would be in the order of 20 to 30 ton /day to cope with the small - size domestic market and the local infrastructure and conditions.

11. If a wood - based pulp and paper or particle board mill is to be established in the Sudan, large - scale plantations of suitable wood species like eucalyptus should be first established aiming at providing the raw material for the proposed mill.

12. Surplus bagasse at the sugar factories should be utilized for generating more energy and / or making paper, particle board and animal fodder.

13. Instead of exporting molasses (a by - product of the sugar industry) at a very low profit, it is recommended to be used locally for animal feed and chemical feedstock.

Another alternative suggested by the writer is to use the molasses as a substitute for bagasse to generate steam and electricity (by direct combustion) in the sugar factories. In this way, adequate bagasse could be made available for establishing a new pulp and paper or particle board mill. It is recommended this idea would receive more attention and study from the research institutes and the industry.

I. PROJECT BUDGET

The present status of the project budget as at 30 June 1984 according to the monthly computer run on the project dated 4 July 1984 is as follows :

A. UNFSSTD / UNIDO

Budget Line	Total Allotment	Expend-iture	Uncommitted Balance
19-99 Personnel	242,454	223,590	18,864
39-99 Training	71,000	51,270	19,730
49-99 Equipment	326,546	301,077	25,469
59-99 Miscosts	7,000	3,874	3,126
99-99 Project Total US$	647,000	579,811	67,189

B. GOVERNMENT

Personnel	97,290	65,233	32,057
Equipment	34,154	40,000	5,846 -
Premises	112,960	209,000	96,040 -
Miscosts	20,000	-	20,000
Project Total LS	264,404	314,233	49,829 -

It is to be noted that the contributions of both the Government and UNFSSTD/UNIDO have been fulfilled. The small uncommitted balance of UNFSSTD's contribution will cover the second part of overseas training (2 m/m fellowships + 2 m/m study tours) and the equipment requisitioned in June 1984 as well as international personnel expenditure.

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II. INPUTS

A. UNFSSTD / UNIDO Inputs

1. Assignment of International Staff

(a) Consultant

The Consultant Dr. Hassan Ibrahim was assigned to the Project on 4 split missions for a period of 10 months as follows :

1 st Mission	:	August-September 1982 (2 months)
2 nd Mission	:	January - February 83 (1 month)
3 rd Mission	:	September 1983 (1 month)
4 th Mission	:	Originally scheduled for two months (April-May 1984) but it was extended to 6 months and rescheduled to start from March through August 1984 at the request of the Government.

(b) Pulp and Paper Expert

Mr. Thampoe Jeyasingam was assigned for a period of 18 months from June 1982 through December 1983. The mission was started and completed as scheduled.

2. Training

(a) Local Training

Theoretical and practical Training for the technicians and the research assistants (university graduates) was provided by the Expert and the Consultant through the years 1982 and 1983. Details of the Training course are found in the terminal report of the Expert and the interim reports of the consultant.

A second theoretical Training course coupled with on-the-job training was also given by the consultant through his last mission. This course, based on TAPPI Home Study Course and recorded on cassette tapes, was intended to review and consolidate the knowledge of the research personnel on :

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- Pulping Technology
- Paper making Technology
- Paper and Board Properties and Testing

This course would also be useful as a training material for the new -comers to the Unit as well as for the mill personnel and university students.

Details of the training course is given in Annex I.

(b) Fellowships Training

According to the Project Document, 20 man/month have been allotted to fellowship training of the research personnel. As at the end of August 1984, 18 m/m have been completed as shown in Annex II. Still 2 m/m are left for completing the overseas training of two research assistants in the fields of construction boards (particle board and fiberboard) and animal feed. It is recommended the second part of overseas training for the two research assistants to be scheduled for January - February 1985 as indicated in the Project Work Plan for the extension period, Annex.XVII.

(c) Study Tours

Three m/m study tours for the Director of CCTRU were originally scheduled for January 1983, August 1983 and March 1984. Until August 1984 , only one m/m study tour to China, India, Pakistan and Egypt was completed as scheduled. The second study tour was postponed to June 1984 because it was found advisable at that time to intensify research work upon the delivery and installation of the equipment thmough June 1983 to May 1984.

It is recommended the 2 m/m study tours to take place in December 1984 and March 1985.

3. Equipment and Supplies

The major items of equipment and supplies that have already been delivered to the Unit are listed in Annex III. By the end of July 1984, almost all the items requisitioned for the Project have been delivered except for some few items listed in Annex IV. It should be mentioned that most of these items not yet received have recently been requisitioned in June 1984.

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B- Government Inputs

1. Assignment of National Staff

When the Project became operational in June 1982, there were only the Director of the Unit and three research assistants of whom two were still on mission to the U.K. for M. Sc. graduation in cellulose chemistry and technology.

Thereafter, two research assistants and two technicians were appointed in 1982 followed by two more research assistants and two laboratory attendants in 1983.

The present status of the Unit personnel compared with the original plan is as follows :

	Planned (June 1982)	Actual (August 1984)	Difference
Director	1	1	
Researchers	8	3	- 5
Research assistants	4	4	
Technicians	4	3	- 1
Admin. & personnel	1	1	
Typist	1	1	
Secretary	1	-	- 1
Lab attendants	1	1	
Store Keeper	1	-	- 1
Drivers	2	1	- 1
Total	24	15	- 9

At present, the research team consisting of the Director, 3 researchers and 4 research assistants could be considered adequate for carrying out the research work in the fields of pulp and paper, construction boards (particle board and fiber board) and animal feed. However, it is recommended to increase the number of technicians from 3 to 5 including one skilled electrician and one mechanic to look after the repair and maintainance of the equipment. It is also recommended to add two other lab attendants and one secretary to the Unit.

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2. Buildings

At the start of the project, the minimum requirement for CCTRU buildings was suggested by the Consultant to comprise the following :

- Raw Material Preparation Laboratory: for the preparation of wood and agricultural residues for pulping, board making and animal feed etc.

- Analytical Laboratory : for the chemical analysis of raw materials, pulp, paper and board, etc.

- Digester Room : for cooking the raw materials and treatment of pulp

- Beater Room (Wet lab) : for beating and refining of pulp, making handsheets and fiber classification, etc.

- Paper and Board Testing Laboratory : for physical testing of pulp handsheets, paper and board and packaging materials.

-- 2 Offices for the research staff.

Consequently, the Government agreed to arrange and expand the existing buildings and the first extension was completed in August 1983.

However, in view of the large number of equipment and apparatus already procured for the project, it was decided to extend the laboratory buildings once more so as to house all the equipment procured and to make the laboratories more spacious and convenient for the work.

Taking into consideration that the CCTRU buildings are temporary and the extension should be made with the least possible expenditure, it is suggested to extend the laboratories as follows:

- Paper and Board Testing Laboratory

This would be extended by adding one adjacent room (previously used as an office for the Consultant) for housing the Universal Testing Machine and other board testing equipment. A new room has to be constructed behind the laboratory to house the Air Conditioner which would serve the entire paper and board testing laboratory.

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- Raw Material Preparation Laboratory

This would be extended as shown in Annex V to house all the equipment used in the preparation of raw materials including the Chopping Machine, Crushing Machine in addition to the Briquetting Machine. Besides there will be a room for storing the spare parts and raw materials.

The second extension of the laboratory buildings was started in June 1984 and it is hoped to be completed by end of August or September 1984.

With the completion of the second extension, the floor area of CCTRU buildings will be more than double the original area as can be seen from the following figures :

Buildings	Orignial (June 1982)	1st Extension (August 1983)	2nd Extension (August 1984)
Laboratories	1	4	5
Offices	3	2	1
Total area, m^2	130	220	290

3. Utilities

The utilities provided for the Unit include:

- Water Supply

Two water tanks (one underground and one overhead) with one water pump were installed to ensure adequate continuous water supply to the laboratories.

- Electricity

One line for 220 V and another for 380 V were provided.

- Gas

Two butane gas cylinders were procured for the Bunsen burners.

4. Equipment

The following equipment and supplies were purchased by the Unit before the start of the project :

1 Rotary Digester (10-liter capacity)
1 British Handsheet Machine
1 Dry Particle Classifier
1 Grinding Machine
2 Electric Balances (Mettler)
1 Drying Oven (Heraeus)
1 Set of Mechanical Tools
1 Set of Electrical Tools
Analy tical Chemicals and glassware

III. ACTIVITIES

A. Work Plan of the Consultant

At the start of this assignment, a work plan(Annex VI) was prepared in accordance with my job description and in consultation with Dr. P. Harju, Deputy Resident Representative (Ex. SIDFA), Khartoum.

The work plan was discussed in two meetings attended by Mr. Abd El-Rahman El Agib, Director of CSTR, Dr. P. Harju, Dr. S. Gabir, Director of CCTRU and the writer. The meetings were held at UNDP Office on 6 March 1984 and at CSTR on 21 March 1984. The work plan was approved and implemented.

B. Equipment and Supplies

1. Review and Follow-up of the Delivery of Equipment and Supplies

At the beginning of this mission early March 1984, I checked with the Director of CCTRU the present status of equipment and supplies procured for the project. The items that were not yet delivered up to 10 March 1984 were listed and sent to UNIDO - Vienna to expedite their delivery.

As a result, most of the missing equipment and supplies were received through the period of May-July 1984. The major items of these equipment are the air conditioner, chopping machine, disc refiner, corrugating medium Fluter, muffle furnace, centrifuge, etc.

However, there have been same equipment and supplies still not yet delivered until the end of July 1984 (Annex IV) The most important items of these equipment are the Universal Testing Machine for testing the particle board and fiberboard and the Laboratory Standard Valley Beater for beating and evaluation of pulp. It is to be mentioned that most of these missing equipment have recently been requisitioned on 28 June 1984 when UNIDO-Vienna notified there were about US $ 30,000 still uncommitted on BL 49 Equipment.

2. Installation, Operation and Repair of Equipment

Upon the arrival of the Consultant in Khartoum on 4 March 1984, it was found that most of the essential equipment available at the unit were out of operation and waiting for spare parts that had already been ordered. Of these equipment are the following:

- Rotary Digester : for cooking the raw materials
- Pulp Strainer : for screening of pulp
- Vacuum Pump : for washing and thickening of pulp
- Handsheet Press : for pressing the pulp handsheets
- Hydraulic Heating Press : for making particle board and fiberboard sheets
- Crushing Machine: for reducing the fibrous raw materials into particles suitable for making particle board.
- Fold tester : for testing the folding endurance of paper.

Since the failure of such equipment had hindered the progress of the research work, the Consultant took action to repair and operate these equipment depending on local facilities and materials. This required the contact with the Apex Paper Mill, Khartoum and the Energy Research Institute of the NCR to get the services of one mechanic and one electrician.

Under the guidance and instructions of the Consultant, all the equipment were repaired and put back into operation.

New equipment and apparatus that were received during the period of January-July 1984 were inspected, installed and operated. Of these equipment are the following :

- Laboratory Hollander Beater : for beating and evaluation of pulp.
- Brightness Meter : for measuring the brightness degree and opacity of pulp handsheets and paper.

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- Tensile Strength Tester : for measuring the tensile strength and elongation of the pulp handsheets and paper.

- Air Conditioner : for conditioning the Paper and Board Testing laboratory at constant temperature and relative humidity.

- Chopping Machine: for reducing the agricultaral residues such as straws and stalks into small lengths suitable for pulping.

- Corrugating Medium Fluter : for preparing the corrugating medium specimens for stiffness measurement.

- Disc Refiner : for fiberizing and/or refining of pulp.

Inspection of the Hollander Beater has revealed that this equipment does not conform to TAPPI Standards as specified . It is uncontrolable with respect to the load and the clearance between the roll and bedplate. Furthermore, upon operating the beater in accordance with the manufacturer's instructions, the motor started burning denoting that it is not wired for 220 V, single-phase and 50 Hz as ordered.

Acoordingly, a claim was issued and sent to the Purchase and Contract Service of UNIDO-Vienna for taking corrective actions. The Purchase Department has forwarded the claim to the supplier with a request to satisfy the requirements of the Project authorities. The subject is still under settlement.

As the laboratory beater is a very essential equipment for the research work on pulp and paper, an additional Standard Laboratory Beater (Valley-type) has been requisitioned for the Unit.

The Air Conditioner has been installed in a newly constructed room adjacent to the Paper and Board Testing Laboratory. However, the air conditioner was supplied for 220 V, 3-phase instead of either 220 V, single-phase or 415 V, 3-phase (normal electrical rating in Sudan). A claim was issued and the supplier is requsted to solve this problem.

For the installation of the Chopping Machine and the Disc Refiner, concrete foundation and a lifting device are needed.Contacts with a local contractor to furnish these facilities were made but until the writing of this report these facilities have not been made available.

C. Training

1. Research Personnel

Following the basic training received in the country and abroad, the research personnel were provided with On-the-Job training through conducting research work in the area of:

- Pulp and paper
- Particte board
- Animal feed

Further theoretical training was also provided during the period of March-August 1984 toward the end that overall personnel efficiency will be substantially up-graded in the field of :

- Pulping Technology
- Paper making Technology
- Paper and Paperboard Properties and Testing

2. Mill Personnel and University Students

Upon the start-up of the Apex Paper Mill, Khartoum in May 1984., the mill personnel were provided with elementary Training on stock preparation, papermaking and process and quality control.

This would be followed by a basic training course at CCTRU as soon as the mill personnel are made available to attend the course. The training material is already available at the Unit.

University students will likewise receive a training course in the above -mentioned fields.

D. Research Activity

The major activity of the project is conducting research work on the utitization of domestic cellulosic raw materials (wood and agricultural residues) in the production of pulp, paper, paperboard, particle board, fiberboard, animal feed, energy etc.

At the begining of the project, the research program was formaulated by the research leadars in collaboration with the Consultant in five research projects entitled :

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Project 1 : Pulp, Paper and Paperboard from Indigenous Fibrous Raw Materials.

Project 2 : Construction Boards from Local Fibrous Raw Materials.

Project 3 : Animal Feed from Agricultural Residues and Agro-industrial By-products.

Project 4 : Densification (Briquetting) and Gasification of Agricultural Rasidues.

Project 5 : Fertilizers from Organic Wastes.

At the Tripartite Review Meeting of 5-6 September 1983, it was agreed to concentrate the research work in the present phase on the first three projects as detailed in Annexes VII- IX

The research work was started in the second half of 1983 but it was not progressing at the desired rate up to March 1984. This was due to the following reasons :

- Delayed delivery of some essential equipment such as the chopping machine, disc refiner, air conditioner, universal testing machine and other testing equipment.

- Failure of existing equipment used for pulping, sheet making and testing namely the rotary digester, pulp strainer, handsheet press, hydraulic heating press, vacuum pump, folding tester, etc.

- Non-availability of skilled electrician and mechanic for repairing the equipment.

Therefore, the urgent activity of the Consultant during the first period of his mission was to inspect and repair the idling equipment and put them back into operation in order to conduct the research work. Besides, a detailed experimental research program was prepared for the research personnel to be executed.

The status of research work until August 1984 is as follows :

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1. Project 1 : Pulp and Paper

Up to March 1984, the work done comprised morphological and chemical analysis of some indigenous agricultural residues namely sugarcane bagasse, wheat straw, cotton stalks and sorghum stalks. In addition, one cook of each raw material was made but without complete evaluation of the pulp produced.

After repairing the equipment and putting them back into operation through March-April 1984, the research work was resumed according to the following program :

(a) Preparation of raw materials for pulping

Three raw materials namely sugarcane bagasse, cotton stalks and sorghum stalks were used. The bagasse was wet-depithed in a laboratory Hydrapulper while the stalks were chopped by hand due to the non-availability of the chopping machine at that time.

(b) Pulping

The soda process was applied to all the three raw materials. Each raw material was pulped using five levels of chemical charge. The quantity of chemical used varied between raw materials since the digestion conditions were chosen to give unbleached pulp which would be suitable for bleaching. Each cook was duplicated and the result reported is the average for the two cooks.

(c) Treatment of pulp

The cooked material was washed free of black liquor and defibrated in a laboratory Turbo pulper to simulate the defibration occuring during blowing a commercial digester. The pulp was then screened on a laboratory strainer using a plate with 0.15 mm slits to remove shives. The screened pulp was collected in a cloth bag.

(d) Evaluation of unbleached pulp

The yield of unscreened and screened pulp as well as the screen rejects were determined. The pulp was chemically analyzed. The Kappa number (cooking degree) and the Hypo number (bleach requirement) were determined for each pulp. The pulp was disintegrated in a laboratory Disintegrator for 5 and 25 minutes before making handsheets.

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Standard handsheets were formed on a British sheet Machine and pressed in a sheet Press in accordance with TAPPI Standard Methods for the determination of physical characteristics of the pulp. In addition, the freeness degree and drainage time of unbeaten pulp were determined. Fiber classification of various pulps was also carried out using a Bauer - Mc Nett Classifier.

Unfortunately, beating of pulp could not be done at the present time because the laboratory beater delivered is uncontrollable and not conforming to standard specifications. A claim was made to replace this beater with a Standard Laboratory Beater (Valley-type) in order to study the beating and drainage characteristics of pulps.

(e) Bleaching of pulp

Pulp from each raw material was bleached using a three-stage (CEH) sequence of successive applications of chlorine, sodium hydroxide and calcium hypochlorite to achieve a brightness level of 80 %.

The amount of chlorine consumed in bleaching of pulp as well as the loss of pulp during bleaching were determined.

(f) Evaluation of bleached pulp

The bleached pulp was evaluated for the yield, brightness degree, freeness degree and drainage time. Standard handsheets were made for the determination of physical characteristics of pulp such as the bursting and tensile strengths, tear resistance, folding endurance, porosity, etc.

Details of pulping, bleaching and evaluation of pulps are given in Annexes X - XV

2. Project 2. Construction Boards

This project was lagging behind schedule until the beginning of March 1984. No significant work was done in respect of board making and testing. Even the preparatory work that should have been done for making board sheets was not achieved. For instance, metal moulds and plates as well as urea formaldehyde resin binder required for making board sheets were neither requisitioned from abroad nor locally procured.

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The work done before March 1984 comprised :

- Literature survey on wood-based panels including particle board and fiber-board.

- Sample collection of local agricultural residues such as groundnut shells, sugarcane bagasse, cotton staiks, etc.

(a) Preparatory work

In March 1984, the work on the project was started with the following preparatory work:

- Hydraulic Heating Press

The press used for board making was checked and repaired. Two damaged electric contactors for heating the platens were replaced by new ones.

- Crushing machine (Hammer Mill)

The crushing machine used in the preparation of raw materials for board making was repaired by rewinding its motor at a local workshop.

- Metal moulds and plates

At the beginning, attempts were made to manufacture metal moulds at local workshops but it was found this would take long time. Therefore, wooden moulds were made at the workshop of the Forest Research Institute, Soba, Khartoum. Steel Plates were purchased locally.

- Urea formaldehyde resin

Since commercial urea formaldehyde resin was not available on the local market, actions were taken to procure about 200 Kg resin from abroad.

Meanwhile, trials were made at the laboratory to prepare the resin from locally purchased chemicals (urea, formaldehyde and ammonia). A urea formaldehyde resin comparable to the commercial grade was produced and used in making particle board.

- Collection of wood residues and bagasse samples

Representative samples of wood waste (sawdust) from Singa and Es Suki Sawmills, Blue Nile Province, were collected by the Research Leader and the Consultant during their field visit in May 1984. The predominant wood species in that area is Acacia nilotica.

In addition, fresh sugarcane bagasse samples were collected from Sennar and Kenana Sugar Mills for the investigation.

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(b) Work program

After completing the preparatory work, a work program was set up for execution.

The raw materials chosen for the investigation are:

- Groundnut shells
- Cotton stalks
- Sugarcane bagasse
- wood waste from sawmills

The normal practice followed in these trials to determine the suitability of various raw materials for particle board manufacture is as follows :

Preparation of raw material

- Chopping of the material when necessary.

For example, raw materials such as groundnut shells, bagasse and sawdust do not need chopping while cotton stalks should be chopped.

- Crushing (Hammer - milling) to reduce the material to small particles of suitable size.

- Drying of the particles to a moisture content of 3-5 %

- Classification of the particles into portions of different particle size by means of a shaking classifier equipped with a set of sieves of different meshes.

Boardmaking

Particle board sheets measuring 300 x 300 mm and with varying thickness and density are made by spraying and mixing a weighed quantity of particles with urea formaldehyde liquid resin containing 60 % of resin solids to which is added ammonia / ammonium chloride hardener equivalent in weight to 6 % of the resin used.

The sprayed particles are sprayed by hand into a square mould on a stainless steel caul plate. This mat is then cold pre-pressed and the mould removed. A further stainless steel caul plate is placed on top of the compressed mat. This sandwich is then placed in an electrically heated hydraulic press where it is subjected to specified pressure, temperature and time.

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During the preliminary stages of the investigation, boards were made from particles of different size from which the fines-i.e. that portion passing through a No. 20 ASTM sieve was removed, whilst the resin added to the particles before pressing, remained constant at 10 % of the weight of dried particles used. Pressing conditions were:

Temperature	130°C
Max. pressure	100 bar
Time to max. pressure	6 min.
Time at max. pressure	5 min.
Time to atmospheric pressure	5 min.
Total pressing cycle	16 min.

After testing and evaluation of test results, particles of optimum size to give maximum strength will be used and the resin content will be varied to determine the optimum resin content.

Boards will also be made from particles containing varying amounts of fines to study the effect of fines content on the physical and strength properties of the boards.

The effect of pressing variables regarding temperature, pressure and time will also be studied.

Chemical additives used in the course of board manufacture to impart special properties to the board will be investigated. These additives include preservatives, water repellents and fire retardants.

Board testing

The boards have to be tested for the following properties.

- Moisture content
- Thickness
- Density
- Modulus of rupture (Bending stress)
- Tensile stress parpendicular to plane
- Screw holding
- water absorption
- Thickness swelling

The particle board sheets made from domestic groundnut shells, cotton stalks, bagasse and sawdust for the first time in Sudan were tested for thickness, density, water absorption and thickness swelling. Unfortunately, testing for modulus of rupture, tensile stress and screw holding could not be carried out due to the non-availability of universal testing machine at that time .

With the arrival of the universal testing machine, complete testing of the boards for physical and strength properties would be carried out and the investigation would be continued at a faster pace.

3- Project 3 - Animal Feed

This project has shown good progress since it was started in July 1983. Through the period of July 1983 to March 1984, the following work was achieved :

- Literature review of the utilization of agricultural residues and agro-industrial by-products as livestock feed. This review covers the various uses of ligno-cellulosic materials and the research work done in the Sudan and world-wide. It also summarizes the various physical and chemical treatments which could be applied to these raw materials for upgrading their quality.

- Soda treatment of groundnut shells :

In the light of the information gathered, groundnut shells were chosen for the investigation on account of its availability in large amounts at a relatively low cost as a by-product from oil production.

Groundnut shells were first fractionated into a number of fractions of different particle size by means of a laboratory shaking classifier equipped with a set of sieves of 10,16,20 and 40 mesh (ASTM).

The fraction with large particles retained on 10-mesh sieve was treated with 6 % and 9 % caustic soda based on ovendry material. The treatment was carried out in a laboratory rotary digester of 10-liter capacity for 15 minutes at 125°C and a liquor-to-solid ratio of 3 : 1. After the treatment (cooking), the black liquor was discarded and the cooked material was dried in the open air.

The treated material was then incorporated at a level of 20 % into a balanced ration having the following composition:

Groundnut cake	15 %
Sorghum grains	24 %
Wheat bran	20 %
Molasses	20 %
Groundnut shells	20 %
Common salt	1 %

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A control ration was prepared with the same composition except that the shells were incorporated without treatment.

Feeding trials were run on sheep having an average weight of 25 Kgs. The sheep were harnessed and kept in metabolism crates to allow collection of feaces and urine separately. After 7-day adjustment period, dry matter intake was recorded for 21 days and dry matter digestibility measured during a 7-day period at the end of the trials.

Samples of feed, feaces, urine, rumen fluid and blood were collected and analyzed to study the effect of sodium hydroxide treatment of groundnut shells on the digestibility of dry matter components, nitrogen retention, ruminal and blood constituents.

The results of this investigation were analyzed and reported by the research Leader Dr. M. Maglad and the research assistant Mr. A. Lutfi in a paper entitled :

"The Effect of Sodium Hydroxide Treatment of Groundnut Hulls on the Digestibility of Dry Matter, Ruminal and Blood Components."

The results as reported indicate that although no significant improvements in the digestibilities of the ration components and nitrogen balance, the data tend to suggest that if the treated material were fed for a longer period, the effects of treatment might be apparent. The researchers suggested further studies to be directed towards feeding these rations to sheep in fattening experiments to investigate their effects on animal performance and the economics of feeding.

In March 1984, the Consultant held a meeting with the research team of the project to review the work done and to take measures and steps required to ensure the continuity of progress in achieving the objectives of the project.

Since the research work was hindered in the last few months due to the failure of the laboratory rotary digester, the Consultant took action to repair the digester and put it back into operation.

In addition, specific apparatus like crude Fiber Apparatus and Fat/Oil Extractor needed for the research work have been requisitioned at the request of the rescarchers.

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Regarding the research work, the Consultant has pointed out that although the work done is of high standard from the scientific standpoint, yet the process of fractionating the groundnut shells and soda treatment of only one fraction to improve its digestibility would be far from commercialization and economic viability especially in Sudan. Importing the caustic soda at a high price (over LS 1000 per ton) and the partial utilization of the raw material would considerably add to the cost of the feed product especially no significant improvement in digestibility was proven by the feeding trials conducted. Moreover, the soda process has undesirable ion load in the feed as well as detrimental polluting effect.

It is advisable that low-quality roughages i.e. agricultural residues and agro-industrial by-products should be treated with less costly and non-pollutant process. For this, the Consultant has suggested the following processes to be investigated in the following period starting April 1984.

- Steaming or water hydrolysis at high temperatures, i.e. without any added chemicals

- Ammonia treatment at ambient temperature.

The ammonia treatment is intended to increase both the digestibility and nitrogen content of the material.

Both processes have neither undesirable ion load nor detrimental polluting effect. Besides, the production cost of the feed product would be considerably reduced.

Consequently, it has been agreed upon the following research programme for execution.

- To complete the investigation on soda treatment of groundnut shells for studying the effect of particle size on the digestibility of treated material.

- To study the effect of water hydrolysis of groundnut shells, sugarcane bagasse and other agricultural residues on increasing their digestibility.

- To study the effect of ammonia treatment of the above-mentioned raw materials on increasing both the digestibility and the nitrogen content of the treated material.

Directly after the repair of the baboratory digester in March 1984, the research work was resumed and the following series of experiments were conducted through the period April-August 1984.

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- Soda-treatment of groundnut shells-fraction retained on 16-mesh sieve (ASTM) with 6 % NaOH based on ovendry material under the same treatment (cooking) conditions previously followed. Over 30 cooks were made for the prepartion of the material for feeding trials.

Feeding trials using the treated material at a level of 20 % in a balanced ration having the same composition as above mentioned. Feeding trials were run on sheep to determine the dry matter digestibility of the treated material.

Another feeding trial was run in the same way using a control ration containing 20 % of untreated groundnut shells (fraction retained on 16-mesh sieve).

- Water hydrolysis of groundnut shells-fraction retained on 10-mesh sieve. 40 cooks were made under the same conditions as the soda treatment.

Feeding trials with the treated material at a level of 20 % of the balanced ration.

- Water hydrolysis of groundnut shells-fraction retained on 16-mesh sieve. 40 cooks were made under the previous cooking conditions for the treatment of the material.

Feeding trials with the treated material following the same procedures and techniques.

- Water hydrolysis of the whole groundnut shells at a high temperature 170-180 ^{o}C for 20 minutes and a liquor-to-solid ratio of 3:1. About 40 cooks were made for the preparation of raw material for feeding trials.

- Feeding trial with untreated sugarcane bagasse incorporated in a balanced ration at a level of 20 %. This trial would serve as a control run for the ensuing feeding trials using water-hydrolyzed bagasse.

In all feeding trials, samples of feed, feaces, urine, rumen fluid and blood were collected and analyzed to determine the effect of the treatment on the digestibility of dry components, nitrogen retention, rumenal and blood constituents.

At the time of writing this report, the results of these experiments are being analyzed to be reported next month.

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E. Technical Services to the Industry

In addition to the research activity, it was adopted at the Tripartite Review Meeting of 5 September 1983 that CCTRU has to extend technical services to the existing paper, board and converting industry via conducting quality control of raw materials and end products, trouble shooting, development of process and product and training of personnel.

The services rendered to the industry through the period of March-August 1984 were mainly to the Apex Paper Mill at Gadid El Thawra - Gezira Province.

This mill was built in 1982 for making fluting paper from wastepaper. It was scheduled to start up the mill in 1983, but due to some problems experienced on the paper machine, it was not possible to put the mill on stream as scheduled. Therefore, the mill management requested the Director of CCTRU to arrange for UNIDO Consultant to help start up the mill.

On visiting the mill in March 1984, it was found that the most obvious problem on the paper machine was the web sticking on to the top roll of the first press.

Examination of the problem has revealed that the main reason for the web sticking was the high wetness of the paper sheet from the wire to the press as indicated by its high moisture content of about 86 %. This was due to insufficient drainage of the stock on the wire.

This problem was solved by taking the following measures:

- The drainage characteristics of different pulp stocks made from the various grades of wastepaper available at the mill namely old corrugated, printing and writing and newsprint were studied at CCTRU Laboratories to determine the most easily dewatered furnish for making good quality fluting paper.

- A new suction box with a separate vacuum pump was installed on the wire just ahead of the couch roll to increase the drainage of the stock.

As a result, the moisture content of the paper sheet from the wire to the press was reduced to about 80 % and the sheet could be easily drawn from the wire and through the press without sticking or crushing. Furthermore, it was possible for the first time to increase the press nip pressure by putting weights on the first and second presses to increase the dryness of the sheet for saving energy in the dryer section or increasing the speed of the paper machine for more production.

Another critical problem facing the mill was the lack of trained local personnel or papermakers. In this connection, the Consultant gave a preliminary training to the national operators during the starting up of the mill and helped the management in recruiting three papermakers from Egypt to ensure continuous running of the mill and to further train the local personnel.

Mill trials on converting the locally produced fluting paper into corrugated boxes were also followed up at the converting factories in khartoum. First trials showed good performance of the local paper on the corrugators during making the corrugated boxes. Representative samples of local and imported fluting paper and corrugated board were withdrawn for testing at CCTRU laboratories to evaluate the quality of the local paper in comparison with the imported paper.

From the test results, it was evident that local fluting paper has lower stiftness values i.e. ring crush test(RCT) and flat crush test (FCT) or CMT compared to those of the imported paper. Since stiffness is one of the basic properties of fluting paper (corrugating medium), research work has been initiated at the CCTRU to improve the paper stiffness through the use of chemical additives such as starch and galactomannans. Promising results have been obtained.

F. Future Assistance to the Existing Paper and Board Industry

Based on the recommendations of the Consultant (Dr.IBRAHIM) given in his discussion paper " Proposal for the Development of Paper Industry in the Sudan " in February 1983 and the discussions with UNIDO Expert (Mr. Jeyasingam) in December 1983, a draft project document for the " Rehabilitation and Modernization of the Existing Pulp and Paper/Board Mills in the Sudan" was formulated by UNIDO and submitted to the Government of Sudan through UNDP Office of khartoum in January 1984.

The consultant during his briefing in Vienna in March 1984 was asked to discuss the project with the Government and have it with or without modifications supported by the Government and UNDP Office.

To this end, several meetings were organized by Dr.P.Harju, Deputy Resident Representative and Dr. S. Gabir, Director of CCTRU to discuss the project with the Government Officials at the Ministry of Industry, National Council for Research and the Blue Nile Packing Corporation.

Though the management of both the Blue Nile Packing Corp. and the Apex Pulp and Paper Co. have agreed to the proposal of having the idle equipment of Aroma Board Mill dismantled and transfered to their mills for making more paper and board, however no decision has been made up to August 1984. This is because of contractual and financial problems facing Aroma Mill and the Sudanese Paper Mill being not yet settled.

At the Tripartite Review Meeting of 11 August 1984, the issue was discussed again. Mr. A. Holcombe, UNDP Resident Representative suggested that the Ministry of Industry, Ministry of Finance and Economic Planning and the Cellulose Chemistry and Technology Research Unit should review the Draft Project Document, make the necessary amendments and return it to UNDP for on-forwarding to UNIDO for finalization.

G. Availability of Indigenous Raw Materials for the Industry

A survey of the indigenous raw materials particularly sugarcane bagasse and cotton stalks was made to clarify whether such materials are available in sufficient quantites for the paper and board industry under the prevailing socio-economic conditions.

To this end, the information and data available from the Food and Agriculture Organization (FAO) of the United Nations, the Sudan Forest Administration and Department of Agricultural Economics of the Ministry of Agriculture were reviewed. In addition , short visits to some sugar factories and saw mills as well as contacts with officials of the Ministries of Agriculture and Industry were made.

Recent data on sugarcane bagasse, cotton stalks and other indigenous agricultural residues produced in the Sudan during the last years are presented in Annexes XVI & XVII and the availability of these raw materials for the industry will be discussed in the following pages under Findings.

H. Tripartite Review Meeting

It was scheduled to hold a review meeting through the last month of the Consultant's mission (August 1984). For this purpose, a report was prepared by the Director of CCTRU and the Consultant on the present status of the project budget, inputs and outputs.

UNDP Office of khartoum had arranged for the review meeting to be held at NCR on 11 August 1982 after having been notified that Mr. M. Allahwerdi, Senior Regional Adviser UNFSSTD, New York would visit Khartoum on 10 August 1984.

The meeting was held as scheduled and attended by :

Government :

Mr. Abd El Rahman El Agib	: Director, Counsil for Scientific & Technological Research(chairman)
Dr. S. Gabir	: Directer, CCTRU
Mr. M. George	: Assistant Under-Secretary, Ministry of Industry.

UNDP :

Mr. Arthur Holcombe	: Resident Representative
Mr. Ismail Mohamed	: A., JPO

UNIDO :

Dr. Hassan Ibrahim	: UNIDO Consultant

Unfortunately, Mr. Allahwerdi could not attend the meeting due to work pressure in Sana'a, Yemen which obliged him to postpone his visit to Khartoum to a later date.

Minutes of the meeting will be sent to UNFSSTD, New York and UNIDO, Vienna for their information and comments.

I. Project Work Plan for the Extension Period

It may be recalled that at the Tripartite Review Meeting of 5 September 1983, all parties agreed on an extension of the project for one year to be completed by end of May 1985 instead of May 1984 within the revised budget.

Accordingly, Dr. Gabir and Dr. Ibrahim have worked out a work plan covering the extension period from June 1984 to May 1985 as per Annex XVIII

IV. OUTPUTS

As stipulated in the Project Document, the outputs would comprise:

1. Establishment of a Cellulose Chemistry &Technology Research Unit:

In respect of laboratory buildings, equipment delivered and personnel training, the establishment of the Unit is almost complete.

It is hoped with the completion of the second extension of the laboratory buildings and the delivery and installation of the rest of equipment in August 1984, the Unit would be completely established.

However, the Unit has started its research activities as early as the third quarter of 1983 when the first extension of the lab buildings was completed and a good part of the equipment and supplies was delivered.

The Unit comprises well equipped laboratories for conducting research and development work in the following areas :

- Pulp and papermaking and testing
- Particleboard and fiberboard making and testing
- Treatment of lignocellulosic materials for animal feed
- Briquetting of wood and agricultural residues for energy utilization.

2. Initial Technical Information :

A survey of the agricultural residues in the Sudan and their present utilization was made and updated in accordance with the available recent statistics.

3. Technical Products :

These include the studies of the various local fibrous raw materials (wood and agricultural residues) for their suitability in the production of pulp and paper, construction boards (Particle board, fiberboard), animal feed and briquetted fuel.

So far, the work done covers the following :

(a) Pulp and Paper :

- Morphological and anatomical structure of agricultural residues namely sugarcane bagasse, cotton stalks, sorghum stalks and wheat straw.
- Chemical analysis of the raw materials
- Soda pulping of bagasse, cotton stalks, sorghum stalks to find the optimum conditions for producing bleachable pulps for making fine paper.
- Chemical analysis of pulps
- Bleaching of pulps by a 3 - stage bleaching sequence (CEH) to a brightness level of about 80 %
- Testing of freeness degree, drainage time and fiber classification of pulps.
- Making standard handsheets of pulp for testing their physical properties.

(b) Particleboard :

Local agricultural residues namely groundnut shells, cotton stalks and bagasse as well as wood residues (sawdust from Acacia nilotica species) have been used for making particleboard.

The work achieved included :

- Preparation of raw materials i.e. cutting, crushing and particle classification.
- Preparation of Urea Formaldehyde resin (binder)
- Board making
- Board testing.

(c) Animal Feed :

The work on this project started with the chemical treatment of groundnut shells with caustic soda to improve their digestibility. The results of the investigation have been reported and accepted for publication.

The second phase of the investigation is running on the treatment of groundnut shells with water hydrolysis (without using any chemicals). This is to minimize the costs of the treatment on one hand and to reduce the pollution load on the other. Hydrolysis is being applied to other local raw materials such as sugarcane bagasse, stalks, etc. At the time of writing this report, the results are being analysed and reported.

4. An Information and Data Bank for Agricultural Residues Utilization :

The information and data gathered from the above mentioned items 2 and 3 together with the information extracted from the international research reservoir published in books, journals and periodicals will form the basis for the information and data bank.

5. Formulation of Feasible Residue Utilization Strategies that Reflect Realistic Social, Economic and Technical Goals :

This will be done after completing the studies and investigations on the economic availability and technical suitability of the residues for making pulp and paper, particleboard, fiberboard, animal feed and energy.

6. Trained Technical Cadre at Different Levels in the Cellulose Chemistry and Technology :

A team consisting of the Director, 3 researchers, 4 research assistants and 3 technicians has received theoretical and practical training locally and abroad as well as on-the-job training in the following areas:

- Chemical and morphological analysis of fibrous and non-fibrous raw materials.
- Pulping and bleaching technology.
- Papermaking technology.
- Pulp, Paper and paperboard testing.
- Particleboard making and testing.
- Treatment of agricultural residues for increasing their digestibility and improving their nutritional value.
- Animal feed trials and evaluation of the results.

This team would form the nucleus of a trained cadre to serve both the Research Unit and the industry.

7. Technical Reports on the Fields to be Studied Under the Project:

The first report on Animal Feed (Research Project No.3) which has been prepared and accepted for publication is entitled:

" The Effect of Sodium Hydroxide Treatment of Groundnut Hulls on the Digestibility of Dry Matter, Ruminal and Blood Components ".

By Mahmoud A. Maglad (Research Leader) and
Asim A. Lutfi (Research Assistant).

This report will be followed by other reports in the fields of animal feed, pulp and paper and particleboard.

In addition to the foregoing outputs, new ones were adopted at the Tripartite Review Meeting held in Khartoum on 5-6 September 1983. These new outputs are mainly to serve and strengthen existing industries. They involve the following:

8. Technical Services to the Industry :

The technical services extended by the Consultant and CCTRU to the existing paper industry ccmprised the following:

(a) Quality Control of Raw Materials :

This covered the analysis and testing of the raw materials (various grades of waste paper) used for the production of fluting paper at the Apex Paper Mill, Gadid El Thawra, Khartoum.

(b) Trouble Shooting:

The problem of sticking of the paper web on to the press of the papermachine in Apex Paper Mill was identified and solved. As a result, the machine was successfully run for the first time in May 1984.

(c) Quality Control of End Products :

The locally-produced fluting paper (Apex Mill) as well as imported fluting paper used by the corrugated box factories in Khartoum were tested for their physical and strength properties to evaluate the quality of the local paper in comparison with the imported one.

(d) Training of Mill Personnel and University Students :

A training course is now available on cassette tapes from TAPPI Home Study Library to be given to the paper and board mill personnel and the students.

This course covers the basic technical background on:

- Pulping Technology.
- Papermaking Technology.
- Paper and Paperboard Properties and Testing.

As soon as the mill personnel and the students are made available, the course will be run by the CCTRU staff who are now well trained.

V. FINDINGS

A. Cellulose Chemistry and Technology Research Unit(CCTRU)

1. Equipment and Supplies

By the end of July 1984, over 90 % of all the equipment and supplies requisitioned for CCTRU, through the years 1982 - 1984, have been delivered. The items that have not yet been received (Annex IV) were requisitioned last June 1984. However, it is requested to expedite the delivery of such items together with the other missing items from previous requisitions.

All the equipment received at the Unit have been installed and operated except for the Chopping Machine and the Disc Refiner which are still awaiting the preparation of suitable concrete foundation by the local contractor. The Air Conditioner which has been installed, requires certain electrical arrangement to be furnished by the supplier for putting the equipment into operation.

Also, the equipment and apparatus that had been out of operation before March 1984, were repaired, adjusted and put back into operation. Of these equipment were the Rotary Digester, Pulp Strainer, Handsheet Press, Vacuum Pump, Fold Tester, Tensile Strength Tester, Hydraulic Heating Press, Crushing Machine, ect. In this connection, it is to be mentioned that repair of such equipment and apparatus had taken too much time and effort due to the non-availability of either a mechanic or an electrician at the Unit. It happened that the consultant, through his good contact with the paper industry in Sudan, was able to call on a mechanic from the Apex Paper Mill to help in the repair of the rotary digester.

The Director of CCTRU arranged for an electrician to be hired on a part - time basis from the Energy Research Institute to help repair the electric apparatus.

However, it was a good opportunity for the research personnel to be trained on how to deal with the equipment when they fail to work and how to get them repaired and opearted depending on locol facilities and materials. In this respect, it is needless to say that proper operation and maintenance of the equipment would keep them running efficiently without the need for much repair or spare parts.

The National Council for Research has decided to establish a well - equipped central workshop for the maintenance and repair of all equipment and apparatus available at its various Research Institutes including the CCTRU. This is a good idea and should be encouraged and supported.However, until the central workshop is established, the Unit should be provided with a skilled electrician and mechanic to look after the maintenance and repair of its equipment.

Service engineers from the manufacturers are required to adjust and calibrate the Hydraulic Heating Press and the Briquetting Machine as has been agreed upon by the Government and UNIDO. The Hydraulic Heating Press needs to be levelled and fixed on a concrete base.

It may be mentioned here that some difficulties and problems were encountered during the procurement, shipping, customs clearance, local transport and handling of the equipment and supplies. Though such problems are not unusual and often experienced during the executuon of similar projects,

however corrective actions have been taken by UNIDO in due time to remedy these problems as in the following examples :

- Damaged Equipment

  The Hydraulic Heating Press was partly damaged due to bad handling of the local transport contractor.

  Action was taken to repair the press and new replacement parts for the damaged ones were delivered. The press is now functioning.

  The Photocopier was also damaged in transit. Replacement parts were delivered.

- Equipment Delivered with Missing Parts

  The Elmendorf Tear Tester for measuring the tear resistance of paper was delivered without pendulum due to misunderstanding from the supplier.

  Action was taken to order three pendulums for the tester.

- Equipment **Not Conforming to Specifictions**

  Two Platform Scales were delivered with weights instead of dial. At the request of UNIDO, the supplier has delivered two other dial scales free of charge.

  The Laboratory Beater delivered is a Hollander - type beater. A claim was issued to replace this beater with a Valley - type beater in accordance with specifications.

  The Air Conditioner was supplied for a power supply of 220 V, 3 - phase instead of either 415 V, 3 - phase or 220 V, single - phase (normal electrical rating in Sudan). A claim has been made and the supplier has to take corrective measures.

- Non - UNIDO Delivery

The equipment that had been purchased by CCTRU before the commencement of this project had also suffered from the same problems as the loss of a laboratory beater in transit, damaged laboratory digester and missing of an air compressor for the handsheet press. For these equipment, UNIDO has also supplied replacement parts for the digester and an air compressor for the handsheet press. Consequently, the equipment were repaired and put into operation.

Despite such difficulties, the equipment and supplies procured for the project are generally of good quality and arrived at the project site in good condition. With the arrival of the first shipments starting from January 1983, the research work could be initiated as early as July 1983.

With the equipment and supplies already procured for the project, the Unit has become one of the well - equipped laboratories for conducting research and development work on the utilization of wood and agricultural residues in the production of :

- Pulp, Paper and paperboard
- Construction boards (particle board and fiberboard)
- Animal feed
- Briquettes for energy utilization

With the same equipment and testing apparatus, the Unit could provide valuable technical services to the industry in the form of quality control of raw materials and end products, trouble shooting, development of process and product and training of personnel.

2. Buildings and Facilities

Taking into consideration that the buildings for the Unit are temporary and the area available within the premises of NCR for the extension of the laboratories is limited, it was decided at the beginning of the project to expand the builiding area from about 130 m^2 to 220 m^2. This extension was completed in August 1983.

However, in view of the large number of equipment and apparatus delivered to satisfy the needs of the work in the various fields of research, it became clear in March 1984 that the laboratory buildings have to be more extended. The second extension was started in June 1984 and is due to be completed by the end of August 1984. With this extension, the laboratory buildings will be spaceous enough to house all the equipment and supplies delivered as well as convenient for the work.

As the extension of the laborateries has been made partly at the expense of the office rooms, there is now a need for an office room for the research personnel.

The facilities rendered to the Unit regarding the water supply, electricity, etc. are adequate. However, it is strongly recommended to provide a voltage regulator to protect the equipment and apparatus against the fluctuation in the current voltage.

3. Personnel

The total number of personnel available at present is 15 compared to 24 as originally planned.

The research staff comprising one research leader (Pulp and Paper Project), 3 researchers and 4 research assistants in addition to two research leaders from the Animal Production Department of the University of Khartoum (Animal Feed Project) and the Forest Research Institute (Construction Board) are capable of conducting the research work.

However, there is a shortage in the technicians and laboratory assistants, The Unit is in need to two more technicians with a background in electricity and mechanics to look after the repair and maintenance of the equipment and apparatus. In addition, two other laboratory assistants are required.

A secretary and one store keeper have also to be appointed.

B. Research Projests

The research work is being conducted in accordance with the research projects fromulated by the research leaders and the Consultant.

1 . Animal Feed Project

As has been previously mentioned, the research work on the Animal Feed Project was first started in July 1983 with the chemical treatment of groundnut shells using caustic soda. The test results have been analyzed and reported.

On discussing the caustic soda treatment of agricultural residues and agro - industrial by - products, it was realized that the treatment process would be costly and the price of feed product would be uncompetitive at

the local market. Furthermore, the soda process would have undesirable ion load in the feed as well as detrimental pollution effect. Consequently, it was decided to orient the research work, in the second phase of the project toward less costly and non - pollutant treatment processes. To this end, the water - hydrolysis process and the ammonia process have been suggested for the treatment of these low - quality roughages. The investigation started in April 1984 and is still progressing. The investigation results will be analyzed and reported by the Research Leader Dr. M. Maglad and the Research Assistant Mr. A. Lutfi. The research team of this project has done a very good job and is showing enthusiasm and interest. This should be encouraged and supported.

2. Pulp and Paper Project

The work on this project was started when the necessary equipment, apparatus, glasswares and chemicals had been received and put into operation in the last quarter of 1983.

For few months, the work was interrupted due to the failure of some equipment and apparatus.

However, with the repair of such equipment, the work was resumed in March 1984. Three research groups were formed to work simultaneously on three raw materials under the leadership of Dr. S. Gabir as follows :

- Cotton stalks : Mr. Salah El Siddique and Mr. Eisa El Hilo
- Sorghum stalks : Mr. Abdalla El Magli and Mr. Ali Osman
- Sugarcane bagasse : Mr. Seif El Faki and Mr. Omar El Assum

The work conducted was on the soda pulping and pulp bleaching of these raw materials with the object to determine the optimum conditions for the production of bleached pulp suitable for making fine paper.

Though most of the research workers were new to this field, however they have shown much interest and capability to do the work assigned to them. A part of the results of their work is presented in Annexes X - XV with samples of handsheets made from unbleached and bleached pulps exhibited in Annexes XIX - XXI.

Preliminary test results showed that sorghum stalks was the most easy to pulp and bleach followed by sugarcane bagasse and cotton stalks. Pulps obtained from these raw materials have generally low drainage characteristics which should be considered in the design of washers, thickeners and papermachine operating on these pulps. On the other hand, these pulps would require less refining and consequently less power consumption in the stock preparation for making paper as compared to wood pulps. Moreover, handsheets made from unbeaten pulps have good formation, smoothness and opacity which are desirable for fine paper (printing and writing).

However, it is premature to draw final conclusions from these preliminary results. The project is now in good progress and with continuous work and enthusiasm, more progress could be achieved especially when the air conditioner, disc refiner and laboratory beater are put into operation.

3. Construction Boards

The research work on this project was actually started after the arrival of the Consultant in Khartoum last March

and the return of the research assistant Mr. Fareed Rizgalla from his overseas training

After one - month overseas training in Egypt, planned and supervised by the Consultant, the research assistant was able to conduct the research work on particle board making from indigenous raw materials namely groundnut shells, cotton stalks, sugarcane bagasse and wood waste (sawdust) to determine the technical suitability of these raw materials for making good quality particle board.

Urea formaldehyde resin binder was also prepared at the laboratory when the commercial grade resin was not available at the local market.

The particle board sheets were also tested for the thickness, density, water absorption and thickness swelling. Upon the arrival and installation of the Universal Testing Machine, strength properties of the sheets will be tested and evaluated. Progress reports on the findings will be submitted by the Research Leader Dr. Nasroun and the research assistant Mr. Rizgalla.

C. Availability of Cellulosic Raw Materials for the Industry

The present situation of domestic cellulosic raw materials was reviewed in respect of their availability for the pulp, paper and board industry.

Findings could be summarised as follows :

1. Wood

- Northern Sudan is part of the Sahara desert which expands by about 5 km to the south each year. In the central part of the country, the desert changes first into steppe and then into bush and grass savanna. Natural forests are only found in the southern mountain area.

- At present, there is a shortage of wood for industrial and construction purposes. A considerable portion of sawn timber and all wood - based panels (plywood, particle board, hardboard, insulation board, etc.) are being imported by the woodworking industry and the building industry to satisfy the needs of local market.

- It may be difficult, under the present fuel shortage and infrastructure conditions to secure constant and sufficient wood supply for a sizable pulp and paper mill.

- There is a lot of land suitable for industrial forest planations as stated by ECA / FAO Forest industries Advisory Group in 1976.

-- Large trial plantations are being carried out with Eucalyptus in the Sudan along the Blue Bile from Khartoum to Er Roseires, some of them on irrigated land, some close to the river on " Gerf " land and some further away from the Nile.

- The Ed Damazin area on the western side of the Blue Nile near Er Roseires has been found to be the best place for extensive industrial Eucalyptus plantations and as the site for the first integrated pulp and paper mill in the Sudan. A total of 60 000 ha.has already been reserved for forest plantations.

- If large Irial plantations prove to be feasible, the plantation programme should aim at providing the required raw material for the proposed pulp and paper mill.

2. Sugarcane Bagasse

- At present, there are five operating sugar factories with a total installed capacity of 700 000 ton/ year sugar extracted from about 7 million tons sugarcane (Annex XVI). The largest one is the Kenana Sugar Factory, a joint venture, with a capacity of 330 000 ton / year sugar. The other four factories are state - owned and have the following capacities:/

Guneid Sugar Factory	60 000 ton / year sugar
New Halfa Sugar Factory	90 000 ton / year sugar
Sennar Sugar Factory	110 000 ton / year sugar
Assalaya Sugar Factor	110 000 ton / year sugar

- In the last year 1983 / 84, the factories were running at a capacity utilization of 75 % for Kenana and 38 to 53 % for the other factories.

- A rehabilitation programme is being undertaken to improve the efficiency and raise the output of the state - owned sugar factories.

- Bagasse remains the primary source of thermal energy in sugar factories and is available in sufficient quantities to meet requirements. Consequently, without fuel supplements, only a small portion of the total quantity of bagasse produced is available for the manufacture of partivle board or paper pulp.

- In May 1984, a field visit to three sugar factories namely Kenana, sennar and Assalaya was made to check the availability of surplus bagasse for the particle board and paper pulp industry.

- At Kenana sugar factory, all the bagasse produced is used for the generation of steam and electricity to meet the requirements of the factory operations, housing and utilities, irrigation pump station and the National grid.

  During the grinding season, the electricity generated is 40 - 42 MWh distributed as follows :

  15 MWh for the factory
  17 MWh for the irrigation pump station
  3-4 MWh for housing and utilities
  5-6 MWh for the National grid

- Surplus bagasse is also used during the off - season for generating electricity to satisfy the needs of the factory, housing and irrigation pump station. For example, last season (1983 / 84), surplus bagasse of about 40 000 tons were used in place of furnace oil for generating electricity at a rate of 26 MWh in few weeks.

- In view of the high cost of fuel oil (LS 270/ton furnace oil in 1984), the management of kenana will continue using any surplus bagasse for generating electricity.

  Consequently, there is no surplus bagasse available at kenana for industrial uses.

- AT sennar and Assalaya sugar factories, there was no surplus bagasse in significant quantities until the last season (1983/84). Surplus bagasse in this season was attributed to high fiber content of the sugarcane used, coupled with improved productivity and less down time. Total bagasse produced (with 50 % moisture)was estimated at about 40 % by weight of the cane crushed. About 10 % of this bagasse was left as surplus. This would constitute about 4 % of the cane tonnage crushed. Consequently, 28 000 tons surplus bagasse (50 % moisture) or 14 000 tons ovendry bagasse were accumulated from 700 000 tons cane crushed at sennar factory. At Assalaya factory about 10 000 tons ovendry surplus bagasse were obtained from crushing 500 000 tons cane.

  Surplus bagasse is now creating problems for the management of these factories.

- It is expected with continuous efficiency improvement and increasing the production of the sugar factories more surplus bagasse would be available. Running at full capacity, each factory could crush over one million tons of sugarcane resulting in about 20 000 tons of surplus bagasse (ovendry).

- The management is thinking about producing direct consumption sugar which requires less energy than the 1 st grade refined sugar presently produced.

  If direct consumption sugar is produced, the steam consumption in processing will be reduced from 700-750 kg/ton cane to 550 - 600 Kg/ton cane. In this case, surplus bagasse will rise up to 60 000 ton/year for each factory (at full capacity).

- Meanwhile, there is an idea to utilize surplus bagasse at these facteries in generating electricity for irrigation purposes. In this case, it is estimated that an amount of about 18 000 tons bagasse will be consumed leaving a net surplus of 42 000 tons ovendry bagasse per year at each factory (at full capacity utilization).

- Summing up, there is presently surplus bagasse available at sennar and Assalaya sugar factories which may create problems if it is not used for generating electricity and/or the manufacture of particle board, pulp and paper and animal fodder.

  The quantity of surplus bagasse that could be made available for the pulp, paper and board industry would be dependent on :
  - Sugarcane variety and its fiber content.
  - Capacity utilization of the sugar factory.
  - Improvement in fuel efficiency in sugar operations.
  - Sugar grade produced.
  - The Government's policy regarding the utilization of surplus bagasse in electricity generation.

Molasses

In addition to bagasse, molasses is another primary by - product of the sugar industry. Molasses is the

Condensed residue which remains after removal of most of the sugar from the concentrated sugar juice.

Molasses has many uses. It is most extensively used in the manufacture of yeast and in the fermentation industry to produce potable alcohol and alcohol for fuel and as a chemical feedstock. Molosses is also used in animal feeds basically as an energy source.

Molasses is produced at a rate of about 4 % by weight of the cane crushed. A total of 150 000 to 200 000 tons molasses is presently being produced at the sugar factories in Sudan.

Unfortunately, this valuable source of energy is almost entirely exported at a very low net profit of about US dollars 2 - 3 /ton molasses.

It is strongly recommended to use molasses locally in the animal feed and the production of alcohol for fuel and chemicals.

Another alternative propsed by the writer is to use molasses in the boilers (direct combustion) to partially replace fuel oil and bagasse in generating steam and electric energy for the sugar factories. This would save fuel oil and provide more surplus bagasse for the paper and board industry. However, this proposal should be first techically and economically studied by the research institutes and the industry.

3. Cotton Stalks

There is about one million feddans under cotton cultivation of which about 500 000feddans are found in the Gezira area (Annex XVII).

The yield of cotton stalks is considered to be one ton per feddan. Consequently, total tonnage of cotton stalks produced is about one million ton per year.

According to Sudan cotton hygienee regulations and Gezira Board rules, it is illegal to remove or store cotton stalks. It is the duty of the farmer to destory by fire all cotton residues before the 31 st of May. These regulations were mainly introduced to safeguard the crop against plant diseases.

As the Sudan Government is interested and keen to make use of cotton stalks as a source for energy and industrial products, a committee from the Agricultural Research Corporation and Sudan Gezira Board was formed to look into the problems of pest and diseases. The committee has recommended the following precautions and measures in case cotton stalks are considered for industrial utilization :

- It is advisable to collect cotton stalks for industrial uses from grazing areas to eliminate future build - up of pests.
- The proposed factory should be at a reasonable distance from nearby cotton fields to avoid plant debris from being blown back.
- The area surrounding the factory should be free from host plants e.g. hambouk and bambia to avoid possible build - up of pink bollworms;
- Exposure of the cotton stalks to a dry hot air over 60 ^{o}C or treatment with insecticide to kill the insects and inhibit their developmeut stages.

Accordingly, cotton stalks could be considered available for industrial uses should the above - mentioned precautions and measures be taken.

Cotton stalks would offer economic advantages to the Sudan where wood and wood wastes are costly and not readily available for industrial uses.

In conjunction with the industrial utilization of cotton stalks, it is advisable to consider the fact that cotton stalks are bulky seasonal product, only available during a short period of the year. Therefore, harvesting must be accomplished in a period from one to three months, necessitating high labor, high transportation costs and large storage facilities to serve the year - round needs of a factory.

4. Other Agricultural Residues

In addition to cotton stalks, there are other agricultural residues produced in large quantities in the country (Annex XVII).

The most important of these residues are sorghum stalks (9 million tons / year), millet stalks (3 million tons / year), wheat straw (322 000 tons / year) and groundnut shells (156 000 tons / year).

These residues are largely used in rural areas as animal fodder, fuel, etc.

In view of the present socio - economic and infrastructure conditions as well as high transportation costs, it is advisable that for a pulp and paper or particle board mill to be based on one of these residues, the raw material requirement would be in the order of 5 - 6 % of the residue produced. Besides, the mill should be

located as near as possible to the raw material source. This is to ensure continuous supply of the raw material to the mill at reasonable cost.

5. Wastepaper

Wastepaper is also available in Sudan for the paper and board industry.

Actually, the three paper and board mills existing in Khartoum area namely the Blue Nile Packing Mill, Apex Paper Mill and the Sudanese Paper Mill are based on wastepaper.

However, the wastepaper that could be presently collected from the converting factories, printing houses, etc. is limited to 3000 - 4000 tons / year. This amount could hardly cover the present needs of the two currently operating mills (Blue Nile and Apex mills).

With the expansion of these two mills (under study) and the operation of the Sudanese Paper Mill, there will be an acute shortage of wastepaper. This would call for either importing wastepaper or installation of a pulp mill to satisfy the requirements of the paper and board industry.

Annex I

Training Programme

(Based on TAPPI Home Study Course)

Vol. 1 : Introduction to Papermaking Technology

The course is divided into 15 chapters as follows :

1. Introduction to papermaking - history, economic factors, product variety, a process overview.
2. Paper property assessment.
3. Fibrous raw material.
4. Non-fibrous raw material.
5. Refining - stock preparation.
6. Pulper to head box - flow systems equipment.
7. Head box.
8. Paper formation.
9. Water and fiber use and reuse.
10. Fourdrinier Machine Wet End.
11. Cylinder and other wet ends.
12. Pressing.
13. Drying.
14. Surface coating.
15. Surface finishing - Roll and sheet converting.

Annex I (Cont.)

Vol. 2 : Introduction to Pulping Technology

The course is presented in 20 chapters as follows:

1. Introduction and History.
2. Wood Structure and Anatomy.
3. Chemical Composition of Wood.
4. Wood Preparation.
5. Wood Deterioration and Storage.
6. General Principles of Pulping.
7. Evaluation and Properties of Pulp.
8. Mechanical Pulping - Groundwood.
9. Refiner and Thermomechanical Pulping.
10. Acid Pulping - Sulfite.
11. Acid Recovery and By-Products.
12. Alkaline Pulping - Kraft.
13. Alkaline Recovery and By - Products.
14. Semichemical and High Yield Pulping.
15. Bleaching.
16. Other Pulping Processes.
17. Recycling of Paper and Board.
18. Pollution Problems and Abatement.
19. Pulp Treatments.
20. Uses of Pulps.

Annex I (Cont.)

Vol. 3 : Introduction to Paper Properties

The course is presented in 10 chapters as follows :

1. Introduction to Paper Properties.
2. The Structural Properties of Paper.
3. The Mechanical Properties of Paper.
4. The Appearance Properties of Paper.
5. The Influence of the Environment on Paper Properties.
6. The Barrier and Resistance Properties of Paper.
7. The Fundamental Aspects of Paper Properties: I. Interrelationships Between Paper Properties: II.
8. A Discussion of Printing Processes and Printing and Writing Papers.
9. The Properties of Paperboard Used in Packing.
10. The Properties of Creped Tissue Papers.

Annex II

Fellowship Training of CCTRU Personnel

Name	Job	Field	Place	Duration
1. Seif El Faki	Senior Technician.	Pulp & Paper	Egypt	2 Months (1983)
2. Ali Osman	Technician	Pulp & Paper	Egypt	2 Months (1983)
3. Omer El Assum	Research Assistant	Pulp & Paper	Egypt	2 Months (1983)
		" "	U.S.A	4 Months (1983)
4. Eisa El Hilo	Research assistant	Pulp & Paper	Egypt	2 Months (1983)
		" "	U.S.A	4 Months (1983)
5. Farid Rizgallah	Research assistant	Particle Board	Egypt	1 Month (1984)
6. Asem Lutfi	Research assistant	Animal Feed	Egypt	1 Month (1984)

Annex III

Major Items of Equipment and Supplies Delivered
By UNIDO to the Project No.: ST/SUD/82/001-CCTRU

Qty	Description	US Dollar Equivalent
1	Vehicle: Peugeot Annee Model 1983	5,481.-
1	Vehicle: Toyota Pick-up	10,700.-
1	Universal Mill, Star Beater	871.-
1	Spot Test Moisture Meter	980.-
1	Diaphram Compressor	823.-
1	RSN Brikettier Press 150 M	22,408.-
1	Photocopier Mod. 213 Complete	1,889.-
1	Overhead Projector	300.-
1	Electric Sand Bath	388.-
1	Thickness Micrometer, Toyo	1,375.-
1	Schoper Folding Endurance Tester Kumagai	6,500.-
1	Taber Type Stiffness Tester, Toyo	2,917.-
1	Bendtsen Smoothness + Porosity Tester	1,713.-
1	Laboratory Strainer Code 216	4,520.-
1	Extra Strainer Plates	853.-
1	Microscope Fiber Projector	1,820.-
1	Camera Olympus CM 10 with Adaptor	939.-
1	Dial Platform Scale, cap. 20 Kgs	204.-
1	Dial Platform Scale, cap. 100 Kgs.	208.-
1	Lab. Stirrer, Yamato	325.-
1	Hammer Crusher, Ushida Mod. 1018 - A	1,833.-
1	Gurley Type Sizing Tester, Toyo	479.-
1	Vacuum Pump, F.G. BODE & Co.	398.-
1	Puncture Tester, Toyo Type TMI	5,512.-
1	Ring Crush Tester, Toyo Mod. S	3,558.-
1	Vacuum Pump, Yamato Mod. PD-51	354.-
2	Platinum Dishes	1,937.-
1	Lab. Turbo - Pulper, Type LP_3, Compl.	2,644.-
1	Quadrant Balance No. 102/23 Compl.	296.-

Annex III(Cont.)

Qty	Description	US Dollar Equiv.
1	Pulp Mixer with Agitator	1,588.-
1	Top Pan Weighing Balance, Electronical	738.-
2	Platinum Dishes	782.-
1	Vacuum Drying Oven, Labsco	810.-
1	Water Still, Labsco	944.-
1	Rotary Vacuum Evaporator, Labsco	540.-
1	Quick Lifting Stand for Above, Labsco	177.-
1	Universal Heating Bath for Flasks, Labsco	192.-
1	Refrigerator Bosch	433.-
1	Midget Shaker Model KS. 10/B	633.-
1	Quadrant Balance QW 201, Labsco	261.-
1	Sample Drying Oven, Labsco	221.-
1	Freeness Tester Schopper, Labsco	1,037.-
1	Stereo scopic Microscope STE10, Zoom 0.7-2.4	1,175.-
1	Mullen Tester (Bursting Tester), Labsco	1,750.-
1	Bauer McNett Classifier	7,622.-
1	Hydraulic Heating - Plate - Press Type LZT-S 60 complete	13,554.-
1	Circular cutter for Paper Specimen, L & W	176.-
1	Hollander Beater TMI	
1	Precision Adjustable Cutter for Paper Strips	
1	Machine for Preparing Specimen	
1	Brightness Tester	
1	Concora Medium Fluter	
1	Air Conditioner	
1	Chopping Machine	
1	Disc Refiner	
1	Portable pH Meter	
1	Elmendorf Tear Tester	
1	Tensile Strength Tester	

Annex III (Cont.)

Qty	Description	US Dollars Equiv.
1	Fire Extinguisher for Lab. Chemicals	
1	Rotronic Hygroscope BT Portable	
10	Bunsen Burner	
1	Canon - Fenske - Routine Viscosimeter Type T-230	
1	pH- Meter, Schott Portable Type CG 817/88	
1	Hygrometer and Climate- meter Model 5004	
1	Electrical Muffle Furnace, Heraeus Type K 1150/1	
1	Basket Type Centrifuge, Runne RS 101 E	
1	Dial Brookfield Viscometer for Medium Viscosity Model RVT	
1	Mettler Electronic Top Pan Analytical Blance, Model AE 160	
1	Automatic Burette MEHTROM dosimat.	

Annex IV

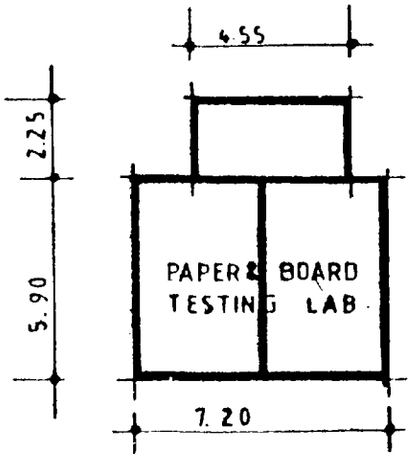
List of Equipment and Supplies Requisitioned and Not Yet Received Until 31.7.1984

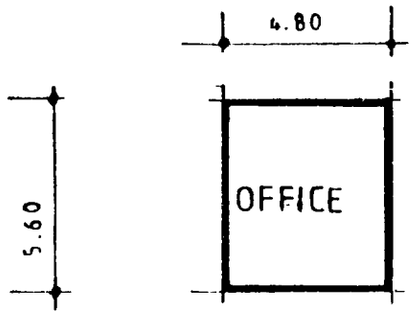
Qty :	Description
1	Universal Testing Machine for Testing Particleboard and Fiber board
1	Lab Saw for cutting Particleboard Specimens for Testing
3	Pendulums for, Tear Tester
2	Tearing Templates for 20 x 20 cm and 20 x 25 cm
1	Concora folding Gluer
2	Sheet Dryers - Type Emerson, size 24"x24" 750 watt with automatic and reliable thermostat control
1	Calorimeter for determining the calorific value of agricultural residues and wood.
1	Mixing Unit, cap. 50 - 75 litres for mixing pulp slurries at various capacities
1	Hercules sizing tester for paper and board testing
1	Lab Beater (Type Valley) for beating of pulp under standardized conditions according to TAPPI Methods
25	Drying Rings for Pulp Handsheets
25	Drying Plates for Pulp Handsheets
	Cutting Tools for Paper Samples Preparation:
1	Punch for strips 15 x 300 mm
1	Punch for strips ½ x 6 inch
1	Strip sampler (Jumbo - Cut) for cutting a sample strip of paper or board across the roll.
1	Precision Micrometer for rapid and accurate measurement of the thickness of paper and board
1	Crude Fibre Apparatus
1	Goldfich Fat/Oil Extractor.

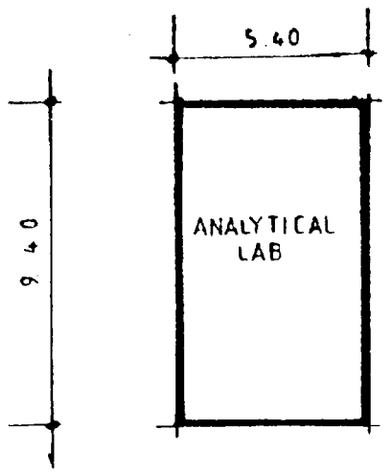
Annex V

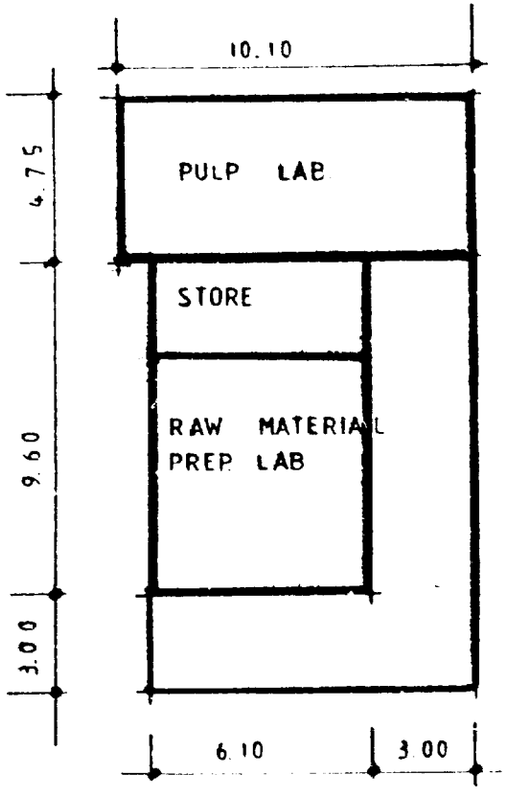
C.C.T.R.U. LAB BUILDINGS

SCALE 1:200









Annex VI

Work Plan of the Consultant

for 6 Months (March - August 1984)

Project No.: ST/SUD/82 /001 - CCTRU.

	. M . A . M . J . J . A
- Supplies & Equipment Ordering & operation	----------
- Research Projects :	
Pulp & Paper	----------
Construction Boards	----------
Animal Feed	----------
- Quality Control for Industry	
Raw Materials &	----------
End Products	----------
- Trouble Shooting for Existing Paper Mills	----------
- Training for Mill Personnel	
& Students	----------
- Updating Annual Statistics	
of Available Agricultural Residues	--------
- Mill Visits:	
Aroma Board Mill	
Sugar Mills	x x
Saw Mills	x
Kenaf Mill	x
- Work Plan for Project	
(Extension period June 84	
- May 85)	x
- Review Meeting	x
- Evaluation Mission	
(American Chemical Scciety)	x
- Reports	x

Annex VII

RESEARCH PROJECT PROPOSAL

NO. 1

1. Subject: Pulp, Paper and Paperboard from Indigenous Fibrous Raw Materials :

2. Objective:

To evaluate the indigenous fibrous raw materials (wood and agricultural residues) for their potential as a source of fibers for pulp, paper and paperboard making.

3. Justification :

The forest land in Sudan is estimated at 100,000,000 ha. with an annual yield of sawn timber of 155,000 m^3 of tropical hardwoods. Furthermore, an afforestation programme is being administered by the Forest Department of the Ministry of Agriculture of Sudan, Plantings have mainly consisted of Eucalyptus and Bamboo. In addition, about 10 million tons of agricultural residues are annually produced mainly sorghum stalks, cotton stalks, groundnut shells, wheat and rice straws and sugar cane bagasse.

It is reported that complete evaluation has not been made on any significant scale of the species occuring in Sudan. Even if such work was carried out on samples of individual species, it is also necessary to determine the mixture of these species in the forest and to pulp samples of the mixtures to determine the characteristics of the hardwood pulp attained.

The analysis, testing, pulping and paper making would follow known technology and would require equipment available at the " Cellulose Chemistry and Technology Research Unit, CCTRU". A new laboratory disc refiner is required for the defibration of thermomechanical, chemimechanical and semichemical pulp.

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Present total domestic consumption of paper and paperboard is about 20,000 ton/yr selling at Ls. 1500 per ton, total value Ls. 30,000,000. Almost all the paper and paperboard is imported. If 80 % of this paper and paperboard could be produced locally, this would save the hard currency and make use of the available raw materials and alleviate the problem of their disposal as in the case of cotton stalks.

4. Programme :

Representative samples of the wood and non-wood species will be collected in the field for analysis and testing and used as raw material in the investigation.

Analytical evaluation will include morphological and anatomical structure, density, chemical composition, dimensional measurement of fibers, and yield after sodium chlorite maceration.

Pulping process would follow the conventional methods namely soda, sulfate (Kraft) and sulfite methods. In a later stage, non-conventional methods such as soda-anthraquinone, soda-oxygen and nitric acid-alkali may be applied.

Bleaching of pulp would be carried out by conventional methods and sequences. New methods may be applied later.

The obtained pulps (unbleached and bleached) will be evaluated for : pulp yield, chemical compostion, freeness, drainage time, beating characteristics, physical and strength properties of handsheets.

If evaluation is satisfactory, a quantity of 10 kg ovendry pulp will be prepared for test runs on the pilot plant papermachine at the General Co. for Paper Industry "RAKTA", Alexandria, Egypt. The paper and board obtained will be evaluated for physical and strength properties.

5. Personnel Requirement :

Project Leader	:	Dr. Suleiman Gabir
2 Research Assistants	:	Mr. Salah El Siddique
		Mr. Omer El Sheikh
2 Technicians.		

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6. Time Schedule :

	Month	Completion Date
Sample collection	1	Apr. 1983
Analysis	3	July 1983
Pulping	3	Oct. 1983
Bleaching	2	Dec. 1983
Evaluation of Pulp	2	Feb. 1984
Preparation of large samples for pilot plant tests	2	Apr. 1984
Evaluation of Paper & Board	2	June 1984
Reporting	2	Aug. 1984

7. Costs :

	Ls.
Technical manpower	2,000
Supplies, travel, etc.	5,000
New equipment	100,000
Total	107,000

8. Future Work :

If the pilot plant test results are positive, commercial - (mill)-scale test run would be conducted for studying the performance of the material through the different stages of the process and evaluating the end products. This would form the basis for an efficient design of a plant appropriate for processing the local raw materials into pulp, paper and paperboard.

The costs for this phase could be estimated later.

9. Reporting :

Progress reports and a terminal report will be submitted by the Project Leader to the Directors of C S T R and N C R.

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Annex VIII

RESEARCH PROJECT PROPOSAL

No. 2

1. Subject : Construction Boards From Local Fibrous Raw Materials :

2. Objective :

To investigate the technical suitability of local fibrous raw materials (wood and non-wood) for the manufacture of construction boards namely structural insulating board, medium-density building fiberboard, hardboard and particle board.

3. Justification :

The availablility of tremendous amounts of wood and agricultural residues (cotton stalks, sorghum stalks, groundnut shells, sugarcane bagasse and Kenaf pith, etc.) and the urgent need for construction boards for the reconstruction and development programmes in Sudan, calls for the industrial utilization of these raw materials.

Furthermore, the relatively low yield in domestic saw milling and the resulting high percentage of wood waste (50-70 %) makes the integration of saw mills with building and structural boards manufacture most economically attractive.

However, efficient utilization of local raw materials requires thorough investigation and information especially for dense hardwoods, low-quality savanna wood and some agricultural residues such as cotton stalks and groundnut shells.

The investigation of local fibrous raw materials for making construction boards will be carried out according to current techniques and methods which would require equipment and testing instruments available at the " Cellulose Chemistry & Technology Research Unit-CCTRU " and the " Forest Research Institute ",

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Soba, Khartoum, but some new equipment such as a lab. defibrator, Instron testing equipment (for bending, tensile and compression tests) and glue spray are required.

4. Programme:

- Literature survey and collection of information on the available fibrous raw materials and methods and methods and techniques of the manufacture and testing of construction boards,

- Collection of representative samples of the available wood and agricultural residues for analytical evaluation, morphological and anatomical structure as well as chemical composition and physical properties.

(this infomation could be obtained from Project No.1)

- Preparation of laboratory samples of various types of construction boards like insulating board, medium-density building fiberboard, hardboard and particle board.

- Study of the different variables affecting the physical and strength properties of the board such as particle geometry, type and ratio of binder, pressure and thermal treatment of the board.

- Study the effect of other additives and treatments imparting specific properties to the boards like resistance to flame spread or fire or resistance to decay, fungi, insects and vermins.

- Testing and evaluation of the chemical and physical-strength properties of the board.

- Analysis of the results and reporting.

5. Personnel Requirement :

Project Leader	:	Dr. Tageldin Nasroun, Forest Research Institute
2 Research Ass.	:	Mr. Ahmed Hamdan, Forest Research Institute.
		Mr. Omer El Sheikh, CCTRU
2 Technicians.		

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6. Time Schedule :

	Month	Completion Date
Literature Survey	1	Apr. 1983
Sample collection	1	May 1983
Preparation of particle board samples	3	Aug. 1983
Evaluation of product	2	Oct. 1983
Preparation of hardboard	3	Jan. 1984
Evaluation of product	2	Mar. 1984
Preparation of insulating board & medium-density building board	3	June 1984
Evaluation of product	2	Aug. 1984
Investigation of additives	3	Nov. 1984
Evaluation of product	2	Jan. 1985
Reporting	2	Mar. 1985

7. Costs :

	Ls.
Technical manpower	3,000
Supplies, travel, etc.	10,000
New equipment	15,000

8. Future Work:

- If the test results are promising, a mill-scale test run could be carried out for studying the performance of the material through processing and evaluating the end products. This will help design an appropriate plant for the manufacture of building and structural boards from local raw materials.

- Market testing of the products and market survey would be carried out.

9. Reporting :

Progress reports and a terminal report will be submitted by the project leader to the Directors of CSTR and NCR.

Annex IX

RESEARCH PROJECT PROPOSAL

No. 3

1. Subject: Animal Feed from Agricultural Residues and Agro-Industrial By-products

2. Objective:

To evaluate the feeding value of some local agricultural residues and agro-industrial by-products and to develop a method for treatment of these residues for the production of higher quality animal feed to supplement and develop the animal wealth in Sudan.

3. Justification :

- One consequence of the emphasis on cropping in Sudan is the availability of large quantities of agricultural residues and agro-industrial by-products which could constitute an important resource for feeding farm animals.

- The need for increased use of agricultural residues is motivated by increasing feed costs. Cereal grains can no longer be relied upon as a source of energy to farm animals because of their increased consumption by humans which led to exaggerated prices.

- Forage production is limited because the land suitable for arable farming is used for cash and food crops.

- The importance of the agricultural residues and agro-industrial by-products can be seen from the increaing animal resources in Sudan.

4. Programme :

- Literature survey and collection of representative samples of agricultural residues for analysis, treatment and feeding trials.

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- Chemical analysis of raw materials.

- Treatment of raw materials :

  - Mechanical treatment :

    It is well known that the voluntary feed intake of poor quality roughages is usually low and is limited by gut fill. The processing through chopping, grinding and pelletizing which reduces the particle size increases the feed intake.

  - Chemical treatment:

    The interest stems from the fact that treatment of low quality roughage with alkali or ammonia increases the carbohydrate digestibility and improves feed intake and animal performance.

- Estimation of the digestibility of the untreated and treated raw materials both in vitro and in vivo to arrive at the total digestible nutrients.

- Feeding Trials :

Group of animals will be fed increasing quantities of the treated material to relate the level of the material with the animal performance. First, the value of animal feed will be assessed in sheep and perhaps goats and at a later stage in the dairy cows.

Available equipment and apparatus at the Cellulose Chemistry and Technology Research Unit - CCTRU and the Animal Production Department, Faculty of Agriculture, University of Khartoum will be used in the investigation but a new van Soest apparatus would be required for the determination of various components of the crude fiber.

5. Personnel Requirements :

Project Leader	:	Dr. Mahmoud Maglad (Animal Production Dept., University of Khartoum).
2 Research Asst.	:	Mr. Asim Lutfi, CCTRU. Mr. Eisa Elhilo, CCTRU.
2 Technicians		
1 Animal Attendant.		

..

6. Time Schedule :

	Month	Completion date
Sample collection	1	Apr. 1983
Analysis	3	July 1983
Treatment of raw material(mechanical & chemical) - sample A	3	Oct. 1983
Field trial (feeding digestibility)	4	Feb. 1984
Evaluation	2	Apr. 1984
Treatment - Sample B	3	July 1984
Feeding trials	4	Nov. 1984
Evaluation	2	Jan. 1985
Reporting	2	Mar. 1985

7. Costs :

	Ls
Technical manpower	4,500
Supplies, travel, etc.	15,000
New equipment	3,000
Total	22,500

8 Future Work :

After arriving at the best combination between the treated agricultural residues and good quality concentrates feed, the mixture will be applied on a large scale.

An appropriate design for processing the agricultural residues including a pelletizing system would be prepared for commercial production of animal feed.

9. Reporting :

Progress reports as well as a terminal report will be submitted by the Project Leader to the Directors of CSTR and NCR.

Annex x

Soda Pulping of Whole Cotton Stalks

Cooking conditions :

Liquor - to - solid ratio = 6 : 1 - Max. temp. = 170 °C

Time to max. temp = 1 ½ h - Time at max. temp = 2 h

Cook No.	1	2	3	4	5
Added NaOH on o.d. stalks, %	18.0	20.0	22.0	24.0	26.0
Chemical consumption					
NaOH consumed on o.d.stalks%	-	16.7	16.9	18.1	19.2
Defibration time, min.	60	20	10	5	2.5
Yield of pulp					
Unscreened pulp on o.d.stalks,%	50.4	46.0	43.5	42.0	39.4
Screened pulp on o.d. stalks, %	42.9	44.9	43.3	41.7	39.2
Screenings on o.d. pulp %	31.7	2.4	2.4	2.3	0.4
Pulp evaluation					
Kappa No.	104	85.1	58.3	37.3	20.7
Hypo No.	8.7	6.5	5.2	3.9	2.8
Disintegration time , min.	5 25	5 25	5 25	5 25	5 25
Freeness degree, °SR	65 70	40 44	36 40	30 34	28 32
Drainage time,S	17.8 19.3	9.0 10.5	8.5 10.0	8.0 8.5	7.5 8.0

Annex XI

Bleaching Conditions and Bleached Pulp Evaluation of Cotton Stalks Soda Pulp

Cook No.	C - 4	C - 5
Yield of unbl. scr. pulp on o.d. stalks%	41.7	39.2
Kappa No.	37.3	20.7
Bleaching conditions :		
1. Chlorination for 1 h at 30 °C, cons.3%		
Cl_2 applied on.o.d. unbl.pulp, %	6.0	4.0
Cl_2 consumed on o.d. unbl. pulp, %	4.9	3.0
2. Alkali extraction for 1 h at 60°C cons.6%		
NaOH on o.d. unbl. pulp, %	2.0	2.0
3. Hypochlorite for 2h at 40°C, cons. 6 %		
Available Cl_2 applied on o.d.unbl.pulp,%	13.0	12.0
Available Cl_2 consumed on o.d.unbl.pulp%	12.0	11.9
Total Cl_2 consumption on o.d.unbl.pulp,%	16.9	14.9
Yield of bleached pulp		
on o.d. unbl. scr. pulp, %	85.0	87.4
on o.d. stalks, %	35.5	34.3
Bleached pulp evaluation		
Brightness %	69.2	76.4
Disintegration time, min.	5 25	5 25
Freeness , °SR	34 38	28 32
Drainage time, S	10 11	8 9

Annex XII

Soda Pulping of Whole Sorghum Stalks

Cooking conditions :

Liquor - to - solid ratio : 5 : 1 - Max. temp. = 170 °C
Time to max. temp. : 2 h - Time at max.temp.: 2 h

Cook No.	1	2	3	4	5
Added NaOH on o.d. stalks, %	12	14	16	18	20
Defibration time, min.	20	5	5	5	5
Yield of pulp :					
Unscr.pulp on o.d.stalks, %	57.8	55.8	54.9	49.7	48.7
Scr.pulp on o.d. stalks, %	53.6	54.5	53.5	48.8	48.1
Screenings on o.d. pulp, %	7.6	2.3	2.1	1.8	1.2
Pulp evaluation :					
Kappa No.	21.3	16.8	15.9	14.2	10.8
Hypo No.	6.04	4.57	3.64	1.98	1.7
Disintegration time,min	5 25	5 25	5 25	5 25	5 25
Freeness degree, °SR	53.5 56	38 48	47.5 52	39.5 41.5	41 44
Drainage time, S	50 55		36 45	8 11	14 15

Annex XIII

Bleaching conditions and Bleached Pulp Evaluation of Whole Sorghum Stalks Soda Pulp

Cook No.	2	3
Yield of unbl.scr.pulp/o.d.stalks, %	54.5	53.5
Kappa No.	16.8	15.9
Bleaching conditions :		
1. Chlorination for 1 h at 30°C, cons. 3 %		
Cl_2 applied on o.d.unbl. pulp, %	4.6	3.7
Cl_2 consumed on o.d.unbl.pulp, %	3.7	3.3
2. Alkali extraction for 1h at60°C,cons.6 %		
NaOH on o.d. unbl. pulp %	2.0	2.0
3. Hypochlorite for 2h at 40°C,cons. 6 %		
Available Cl_2 applied on o.d. unbl. pulp, %	4.6	5.0
Available Cl_2 consumed on o.d.unbl. pulp, %	2.5	2.9
Total Cl_2 applied on o.d. unbl. pulp, %	9.2	8.7
Total Cl_2 consumed on o.d.unbl. pulp, %	6.2	6.2
Yield of bleached pulp		
- on o.d. unbl. scr. pulp, %	85.1	84.0
- on o.d. stalks, %	46.4	44.9
Bleached pulp evaluation		
Brightness , %	79.0	80.0
Disintegration time, min.	5 25	5 25
Freeness degree, °SR	44 47	41 46
Drainage time, S	29 43	34 44

Annex XIV

Soda Pulping of Depithed Bagasse

Cooking conditions :

Liquor - to - solid ratio : 5 : 1 - Max. temp. 170 °C

Time to max. temp : 2 h - Time at Max. temp. 2 h

Cook No.	1	2	3	4	5
Added NaOH on o.d. bagasse , %	14	16	18	20	22
Defibration time, min.	10	10	10	5	5
Yield of pulp					
Unscr.pulp on o.d.depithed bag.%	50.1	49.8	49.6	49.4	48.0
Scr.pulp on o.d.depithed bag. %	47.8	47.7	47.3	46.3	42.4
Screenings on o.d. pulp, %	1.04	1.00	0.84	0.40	0.36
Pulp evaluation					
Kappa No.	30.8	21.3	19.4	16.2	10.6
Hypo No.	7.8	5.2	3.4	2.0	1.0
Disintegration time, min.	5 25	5 25	5 25	5 25	5 25
Freeness, °SR	23 26	29 33.5	32 38	24.5 26.5	21.5 24.5
Drainage time, S	6.0 8.0	5.0 6.0	5.5 6.0	5.5 6.0	6.0 6.0

Annex XV

Bleaching Conditions and Bleached Pulp Evaluation of Depithed Bagasse Soda Pulp

Cook No.	2	3
Yield of unbl. scr. pulp on o.d. %	47.7	47.3
Kappa No.	21.3	19.4
Bleaching conditions :		
1. Chlorination for 1 h at 30 °C, cons.3%		
Cl_2 applied on o.d. unbl. pulp, %	5.2	3.4
Cl_2 consumed on o.d. unbl. pulp,%	4.8	3.2
2. Alkali - extraction for 1 h at60°C,cons.6%		
NaOH on o.d. unbl. pulp, %	2.0	2.0
3. Hypochlorite for 2h at 40°C, cons. 6 %		
Available Cl_2 applied on o.d.unbl.pulp,%	5.2	3.0
Available Cl_2 consumed on o.d.unbl.pulp,%	4.4	2.9
Total Cl_2 applied on o.d. unbl. pulp,%	10.4	6.4
Total Cl_2 consumed on o.d.unbl.pulp, %	9.2	6.1
Yield of bleached pulp		
on o.d. unbl. pulp, %	88.8	89.0
on o.d. depithed bagasse, %	42.4	42.1
Bleached pulp evaluation :		
Brightness , %	80.0	
Disintegration time, min.	5 25	5 25
Freeness degree, °SR	26.5 27.5	
Drainage time, S	9 9.5	

Annex XVI

Sugarcane Bagasse in Sudan

1. Guneid Sugar Factory (Capacity 60 000 t/a Sugar)

Season	Cane Crushed (ton)	Sugar (ton)	Molasses (ton)	Bagasse (ton)
1979/80	318 618	N.A.	11 309	131 844
1980/81	346 248	29 591	12 747	149 033
1981/82	185 796	15 743	8 218	141 646
1982/83	221 656	20 308	8 545	96 952
1983/84	N.A.	22 699	N.A.	N.A.

2. New Halfa Sugar Factory (Capacity 90 000 t/a Sugar)

1979/80	483 131	N.A.	20 545	212 279
1980/81	439 393	36 122	16 501	204 010
1981/82	432 816	35 796	15 566	179 402
1982/83	476 536	38 018	16 460	224 925
1983/84	595 309	47 885	N.A.	N.A.

3. Sennar Sugar Factory (Capacity 110 000 t/a Sugar)

1979/80	386 175	N.A.	18 355	185 054
1980/81	385 155	26 115	15 417	163 372
1981/82	313 795	22 315	11 815	140 078
1982/83	463 962	41 313	15 300	224 368
1983/84	702 837	57 690	N.A.	N.A.

4. Assalaya Sugar Factory (Capacity 110 000 t/a Sugar)

1979/80	54 882	N.A.	6 934	38 522
1980/81	93 003	8 385	4 395	44 037
1981/82	-	-	-	-
1982/83	297 709	31 580	13 970	106 077
1983/84	500 000	41 101	N.A.	N.A.

5. Kenana Sugar Factory (Capacity 330 000 t/a Sugar)

1980/81		Start-up		
1981/82	N.A.	165 000	N .A.	N.A.
1982/83	2 118 000	230 000	92 000	840 000
1983/84	2 567 000	250 000	100 000	1040 000

- Source : Sugar Corporation, Khartoum, Sudan.
- Bagasse : with about 50 % moisture content.
- N.A. : Not Available

Annex XVII

Agricultural Residues of the Main Crops Grown in the Sudan through 1980 - 1984

Year	Sorghum			Millet		
	Cultivated area 1000 fed.	Production 1000 ton	Residue 1000 ton	Cultivated area 1000 fed.	Production 1000 ton	Residue 1000 ton
1980/81	6,955	2,068	6,955	2,598	491	2,598
1981/82	9,231	3,277	9,231	2,925	509	2,925
1982/83	8,664	1,938	8,664	2,784	341	2,784
1983/84	9,060	1,819	9,060	3,025	314	3,025
Year	Wheat			Cotton		
1980/81	437	218	437	964	287	964
1981/82	329	122	329	947	465	947
1982/83	233	141	233	988	583	988
1983/84	322	162	322	1,028	593	1,028
Year	Groundnuts					
1980/81	2,129	707	247			
1981/82	2,376	838	293			
1982/83	1,862	492	172			
1983/84	1,859	445	156			

Source : Statistics Section, Department of Agricultural Economics, Ministry of Agriculture, Sudan.

Note : Agricultural residues were roughly estimated at 1 ton/ feddan for sorghum stalks, millet stalks, wheat straw and cotton stalks. Groundnut shells were estimated at 35 % by weight of the groundnuts.

1 Feddan: 0.420 Hectare

Annex XVIII

Project Work Plan

(For the Extension Period June 1984-May 1985)

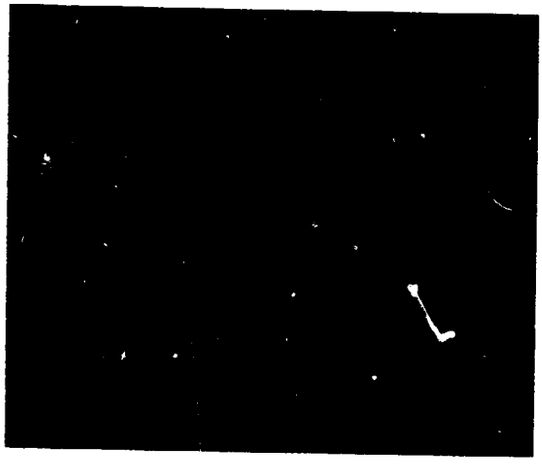
Projest No . : ST / SUD / 82/001

	. J . J . A . S . O . N . D . J . F . M . A . M .
Consultant	x---------- x
Equipment & Supplies :	
Ordering, delivery & installation	x--------------x
Study Tours	x---x x---x
Fellowships	x-------x
Research Activities:	
- Pulp & Paper	x----------x
- Construction Boards	x----------x
- Animal Feed	x----------x
Technical Services to the Industry	x----------x
General Activities:	
- Extension of lab building	x----------x
- Recruitment of Technicians	x-------x
Review Meetings	x x

Annex XIX

Pulp Handsheets

From Sudanese Cotton Stalks



Annex XX

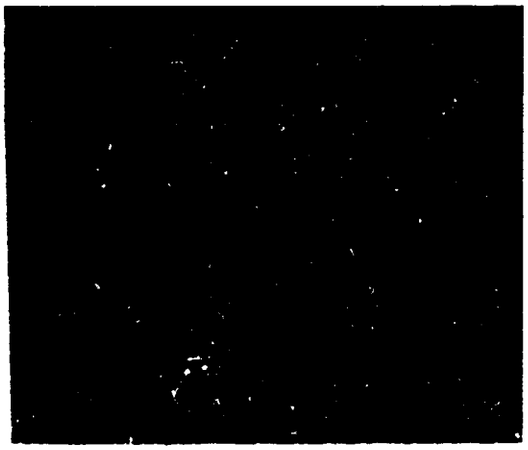
Pulp Handsheets

From Sudanese Sorghum Stalks

Annex XXI

Pulp Handsheets

From Sudanese Sugarcane Bagasse



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Dr.	Suleiman Gabir	- Director
Mr.	Abdalla El Magli	- Researcher
Mr.	Salah El Din El Siddique	- Researcher
Mr.	Eisa El Hilo	- Rasearch Assistant
Mr.	Omar El Assum	- Research Assistant
Mr.	Faread Rizgalla	- Research Assistant
Mr.	Asim Lutfi	- Research Assistant
Mr.	Seif El Dawla El Faki	- Senior Technician
Mr.	Ali Ibrahim Osman	- Technician

Forest Research Institute

Dr.	Tag El Din Nasroon	- Research Leader, Construction Board

Animal Production Dept., University of Khartoum

Dr.	Mahmoud Maglad	- Research Leader, Animal Feed

Forestry Dept., University of Khartoum

Dr.	Palmina Khristova	- Professor

Energy Research Institute

Dr.	Ahmed Hassan Hood	

Industrial Research and Consultation Institute

Dr.	Farouk El Tayeb El Hadi	- Director

Ministry of Industry

Mr.	Awad El Karim Idris	- Special Adviser to the Minister
Mr.	Abd El Gader Suleiman	- Under Secretary
Mr.	M. George	- Assistant Under Secretary
Dr.	Salah El Din Hussein	- Head of Wood and cellulose Section

Blue Nile Packing Corporation

Mr.	Gaddal	- General Manager
Mr.	El Tayeb Karar	- Mill Manager

Apex Pulp and Paper Company

Mr.	Raymond Benezra	- Managing Director
Mr.	Ahmed Shebeika	- Director
Mr.	Snehab Shebeika	- Assistant Mill Manager

Sennar Sugar Factory

Mr.	Gaafar Hussein Saleh	- General Manager
Mr.	Mahdi Bashir	- Chief Chemist
Mr.	Awad El Karim Hussein	- Assistant Chief Chemist

Assalaya Sugar Factory

Mr.	Mohamed El Hassan Taha	- Production Manager

Kenana Sugar Factory

Dr.	Ahmed El Fadil	- General Manager

Sennar Forest Department

Mr. El Sheikh Idris	- Conservator

Singa Forest Department

Mr. Mohamed El Tayeb	- Conservator

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Mr. Arthur Holcombe	- Resident Representative
Dr. Paavo Harju	- Deputy Res. Rep.
Mr. Ismail Mohamed	- A., JPO

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Mr. Rustam Lalkaka	- Deputy Director
Mr. Munir Allahwerdi	- Senior Regional Adviser
Mr. A. Magied Ali Hassan	- Ex. Prinicipal Program Adviser

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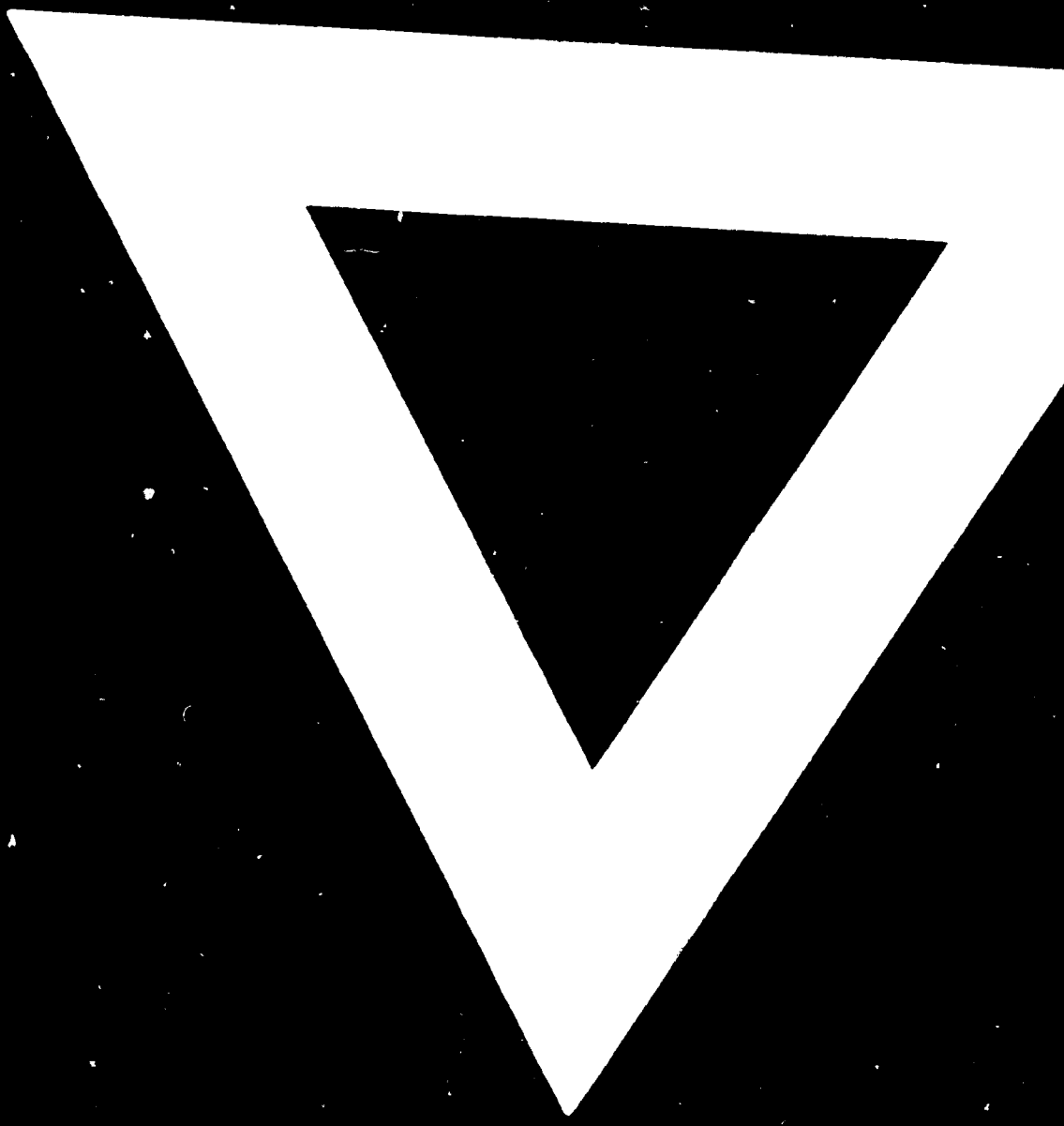

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