OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

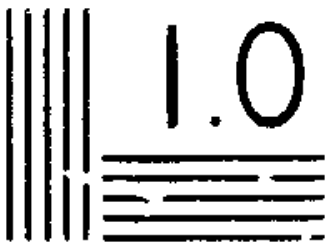
FAIR USE POLICY

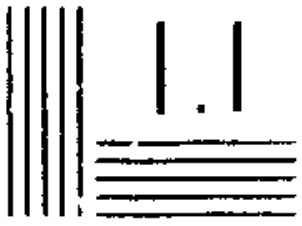
CONTACT

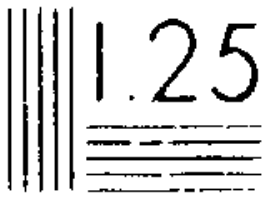
Please contact publications@unido.org for further information concerning UNIDO publications.

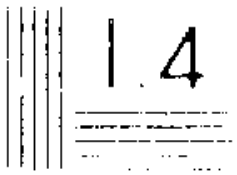
For more information about UNIDO, please visit us at www.unido.org

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


1.0


1.1


1.25


1.4


1.6

11969

30 September 1982

Restricted

English

Sudan.

CELLULOSE CHEMISTRY AND TECHNOLOGY RESEARCH UNIT

ST/ SUD/ 82/ 001

SUDAN

Interim Report

by

Dr. HASSAN IBRAHIM
Consultant of

The United Nations Industrial Development Organization

Vienna

TABLE OF CONTENTS

SUMMARY

This is the Interim Report of the Consultant at the end of his first mission (August - September 1982).

The Project Work Plan was discussed and reviewed with the representative of UNIFSTD, the NCR, CCTRU, SIDFA (UNDP, Khartoum) and the Pulp/Paper Expert (UNIDO). The discussion resulted in rescheduling of the Project to start from June 1982 to end of May 1984.

The equipment, apparatuses, glasswares, chemicals, books, and cars, etc. were specified and ordered.

The extension of the laboratories started in early August and is going on satisfactorily to be completed with all utilities before the end of November 1982 as planned.

Local training of the research personnel of the Unit has begun and a crash course was given by the Consultant. A programme for the study tours and fellowships training of the research personnel was put and will start in November 1982.

A research programme for the Unit was formulated and discussed in a Seminar with the Research Committee of the Unit. The result of the Seminar was a fruitful cooperation between the Unit and the National Research Institutions in conducting joint research projects in the field of pulp and paper, building boards, energy and animal feed from domestic raw materials.

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. Only 10% of the suitable land area is now being used.

Natural forests are only found in the Southern part 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 the 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 the GDP in 1981/82 and employed more than 200,000 people, about 3.5% of the economically active population.

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

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 products 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 plants and 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.

Since then, the NCR has adopted the idea of establishing a research unit for Cellulose Chemistry and Technology and set it up as an affiliate of its specialized CSTR. In this connection, the NCR has accomplished the following:

- The establishment needs of the Unit were defined and the project "Establishment of a Cellulose Chemistry and Technology Research Unit" was officially included as one of the Development Projects of NCR incorporated in the Six Years Plan for Economic and Social Development of the Sudan (1977/78-1982/83).

- A detailed study programme concerning the utilization of some Sudanese agricultural residues was prepared by the Unit in consultation with researchers from the Cellulose and Paper Laboratory of the National Research Center in Egypt. The programme was approved by the NCR of Sudan and the Egyptian Academy of Science and Technology within the general programme of Scientific and Technical Co-operation between the two institutions.

- The Director of the Unit has been appointed in 1981 and two other specialists have been sent on a 2-year mission to the U.K. for M.Sc. graduation in Cellulose Chemistry and Technology. A third researcher with a M.Sc. degree in Paper Technology is on the staff.

- A part of the necessary equipment and glasswares for conducting the research work at the Unit has already been purchased.

- Four temporary laboratory buildings have been established for the Unit to commence its research activities. Total area is 130 m^2 and an extension of at least 40 m^2 will be added in 1982.

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

The project was submitted to the UNIFSTD in 1980 requesting for financing and on 20 February 1982, the Project No. ST/SUD/82/001 "Cellulose Chemistry and Technology Research Unit" CCTRU was finally approved and signed by representatives of the Government of the Sudan, the Executing Agency (UNIDO) and the United Nations Financing System for Science and Technology for Development (UNIFSTD). The duration of the Project is 2 years from May 1982 to May 1984. The Government input is estimated at LS.264,404 while the UNIFSTD input will be US$ 647,000.

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 via support for the creation, adaptation or application of technology in the National Development Plan.

The main immediate objective of the project is the establishment of Cellulose Chemistry and Technology Research Unit and conducting scientific and technological research work on domestic fibrous raw materials with the aim of finding the best economic use of them. This would help in:

- assisting the Government in formulating its policies concerning the utilization of forest and agricultural residues in industry and agriculture.
- 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.
- making available to agricultural and industrial sectors pertinent information and findings of research of the Unit to promote and improve their development activities.

PROJECT WORK PLAN

On 5 and 7 August 1982, two meetings were held at the UNDP office and the NCR to discuss and review the project work plan in light of the prevailing conditions.

Present were:

Mr. A. A. El Agib	Director, CSTR
Mr. Abdel Magied Hassan	Principal Programme Adviser, UNIFSTD
Dr. Suleiman Gabir	Director, CCTRU
Dr. Paavo Harju	SIDFA, UNDP/UNIDO
Dr. Hassan Ibrahim	Consultant, UNIDO
Mr. Jey T. Jeyasingam	Pulp & Paper Expert, UNIDO

The outcome of the two meetings and the conclusions reached were as follows:

1. Project Schedule

As the first UNIDO Expert arrived in Khartoum in June, it was agreed to reschedule the entire project to start from 1 June (instead of May) 1982 and to end on 31 May 1984.

2. Ordering and Delivery of Equipment, Apparatuses, Glasswares, Chemicals and Books, etc.

In the original schedule, it was presumed the delivery of the above would be made on the basis of surface transport. It is considered this will delay the start of research work of the Unit. It has, therefore, been recommended that light and urgently needed equipment, test instrument, glasswares, chemicals and books should be shipped air

cargo to start the work early on the project.

The air cargo is justified on account of saving time and avoiding damage of such fragile items through surface transport. The heavy equipment such as briquetting machine, fiber board press, etc. could be delivered by surface transport.

3. Purchase of Vehicles

In the original work plan it was scheduled the purchase of vehicles would be completed within the first two months. It is now foreseen that the vehicles to be purchased through UNIDO would be available to the project in at least 6 months i.e. by end of November 1982.

Because of transport problems seriously affecting the project, it was agreed that a car from the UNDP or UNDP project will be made available for this project till the arrival of the vehicles of the project.

4. Study Tours

The original schedule shows there is a provision of 7 m/m for the study tours for the National Director and the Chief Investigator. The Chief Investigator is not presently available, and it is not expected that he will be appointed during the period when the full project programme is in effect. In consequence, the study tours will be available only to the National Director. It is also noted the budgetted amount of US $ 21,000 does not cover the expenses for study tours of 7 m/m. Accordingly, this should be adjusted to 2-3 m/m as shown in the revised bar chart.

5. Availability of Personnel and Followship Training

The original programme indicates four nationals are to be trained overseas for a 5-month period in the various specialized fields who will then form the basic structure of the research team of the Unit. It is recommended the said 4 nationals should have academic background as follows:

- 2 Chemists	: for pulp and paper and chemical products
- 1 Chemical engineer	: for energy
- 1 Agriculture engineer	: for animal feed and fertilizer

Due to the current difficulty in the recruitment of 4 nationals by the NCR, this recruitment will be spread out as two for 1982 and two for 1983. It is now planned to send the first batch of two research assistants for overseas training of 5 months as follows:

- Egypt	2 months	4 m/m
- USA & other	3 months	6 m/m

The second batch of research assistants that would be made available in 1983 would have reduced overseas training of 3 months because at this time the research facilities are expected to be available in Sudan and training would be split as follows:

- Egypt	1 month	2 m/m
- USA and other	2 months	4 m/m

As a result of the training indicated above, 16 m/m will be utilized leaving a surplus of 4 m/m overseas training for the two technicians who are already available now and have no laboratory facilities available for training. The training for these two technicians will be provided in Egypt for a period of two months. It is

therefore expected the entire 20 m/m overseas training as originally planned will be used up as indicated above. Prior to overseas training it is planned to provide the trainees with a theoretical local training on the scientific and technological aspects of cellulose chemistry and technology.

6. Extension of Laboratory Building

It is scheduled to complete the extension of the laboratory during the period July - November 1982. The actual work on the extension was started early August and it is now expected the building will be completed with the required facilities by the end of November 1982.

The existing laboratory has no adequate water supply and it is now planned to provide an underground tank and a lift pump within the next two months.

It is reported that there is no problem with electricity supply. Compressed air is needed but no provision has been made in the budget. Efforts will therefore be made to squeeze out some money for this purpose while evaluating offers received for non-expendable equipment.

7. Office Staff, Laboratory Attendants and Drivers

It has been agreed by the Directors of both CSTR and CCTRU that a suitable typist and secretary would be provided for the project as planned in about month time.

Provision is made for one laboratory attendant and it is now recommended that two are required.

The two drivers for the two project vehicles will be made available by the NCR as soon as the vehicles are made available to the Project.

8. Consultant

The Consultant started on the preparation of the revised programme on 1 August and his mission is expected to be completed by the end of September 1982. The return missions are now rescheduled for December 1982, July 1983 and April - May 1984.

9. Pulp and Paper Expert

It is noted that the work programme of the Pulp and Paper Expert extends to 24 months as per bar chart. However, the budget has been only for 18 m/m. Accordingly it was agreed that the work of the Pulp and Paper Expert will be for 18 m/m from June 1982 to November 1983 as shown in the revised chart.

10. Review Meeting

It is noted the review meeting originally scheduled for June 1983 could be rescheduled for July 1983 due to a one month delay in the start of the project.

11. Revised Work Plan

The revised work plan is as Annex II and the original work plan submitted with the project document is as per Annex I.

As a result of the above discussion, it is now planned as already stated above to start the research activities with 4 research assistants and 2 technicians. It is foreseen that the CCTRU of the NCR will keep on adding the required research personnel as planned in the original project document.

WORK PLAN AND ACTIVITIES OF THE CONSULTANT

After briefing in Vienna on 2 August and in Khartoum on 4 August, the Consultant put a work plan for his first mission (August - September 1982) consistent with the main duties of his job as follows:

1. Formulating a programme of action for the activities of the Unit.
2. Formulating detailed research programme on the utilization of wood and agricultural residues in the fields of:
   - pulp, paper and fiber board production
   - energy usage
   - animal feed
   - possible feed stocks for chemicals and ferilizer production.
3. Advising on the equipment and test instruments to be bought under the project.
4. Suggesting a programme for study tours and training of personnel.
5. When necessary organizing technical co-operation between the Unit and Research Units in Egypt.

In addition to the above-mentioned duties, the Consultant has found it useful to further his activities to include the following:

6. Visiting the National Research Institutions in Sudan to organize scientific and technological co-operation between the Unit (CCTRU) and the Research Institutions.
7. Visiting the Paper and Board and Sugar Mills in Sudan to organize technical co-operation between the Unit and the Mills.
8. A Crash Course for Training the research personnel at the Unit.
9. Seminar for the Research Committee of the Unit.

PROGRAMME OF ACTION FOR THE ACTIVITIES OF THE UNIT

The programme of action for the activities of the Unit through the two-year duration of the Project will comprise the following:

1. Specifying and procurement of the vehicles, equipment, apparatuses, glasswares, chemicals and books, etc.
2. Extension of the laboratories and furnishing them with the required utilities such as water, electricity, compressed air, etc.
3. Installation of the equipment and apparatuses, calibration and operation.
4. Training of the research personnel both locally and overseas.
5. Study tours for the Director of the Unit.
6. Conducting research work on the utilization of wood and agricultural residues for:
   - Pulp, paper, and board production
   - Energy
   - Animal feed
   - Feed stocks for chemicals and fertilizers.

These activities will be discussed in detail in the following pages.

EQUIPMENT AND APPARATUSES FOR CCTRU

Reviewing the Project activities and the research work needed as well as the equipment and apparatuses lists already ordered before his arrival in Khartoum, the Consultant has found it necessary to add some other equipment and apparatuses required for conducting the research work as stipulated in the Project.

Of these equipment and apparatuses are for instance:

- A chopping machine: for reducing the straws, canes, and stalks (agricultural residues) to short lengths suitable for pulping or chemical treatment
- A laboratory wood chipper: for reducing the wood to chips suitable for pulping
- A grinding machine: for grinding both wood and agricultural residues into small particles for animal feed trials and c' treatments
- A laboratory pulper: for defibration of pulp
- A laboratory strainer: for screening of pulp
- A sizing tester: for testing the water resistence of paper and paperboard
- Puncture tester and crush tester: for testing the paperboard, liner, fluting, corrugated board, small packages, etc.

A list of the main equipment and apparatuses to be ordered for CCTRU is given in Annex III.

CCTRU LABORATORIES

The existing four temporary buildings with a total area of approximately 122 m^2 established for the Unit to commence its research activities are not adequate for the research and testing facilities. Therefore, it was decided to add an extension of at least 40 m^2.

However, the minimum requirement for establishing a research unit to carry out the research work needed for the Project was defined by the Consultant to comprise:

- 1 Raw material preparation and storage room
- 1 Chemical laboratory: for chemical analysis of the raw materials, pulp, paper, and board,
- 1 Digester room: for cooking the raw materials and pulp treatment
- 1 Wet laboratory (Beater room): for beating the pulp and making hand sheets and fiber classification, etc.
- 1 Physical laboratory: for testing the pulp hand sheets, paper and board
- 2 Offices: for the research staff.

As a result, the NCR has agreed to extend the existing laboratory buildings by approximately 97 m^2. The new extension will comprise the raw material preparation room (49.5 m^2), the digester room (14.3 m^2) and the beater room (33.2 m^2) while the existing four buildings will be for the chemical laboratory (52.3 m^2), the physical laboratory (27.1 m^2) and two offices (42.4 m^2).

The total area of the laboratories and offices after extension will be approximately 220m^2 which is quite adequate for the research activities of the Unit.

The new arrangement of the laboratory buildings after extension is shown in Annex IV.

Actually, the extension of the laboratory buildings was started in early August and is going on actively to be completed before the end of November 1982 as planned in the Project.

STUDY TOURS AND FELLOWSHIPS TRAINING

A- Study Tours

It is recommended that the study tours for the Director of the Unit will be for 3 months splitted in 3 tours as follows:

1. First Study Tour (January 1983)

This tour will be for Egypt, India, and China (Developing Countries) to visit mills and research institutions working in the field of:

- Pulp, paper and fiber board from agricultural residues such as straws, bagasse, stalks and other nonwood plant fibers such as bamboo, reed, grasses, etc.
- Energy (biogas, ethanol).
- Animal feed from agricultural residues.
- Fertilizers from organic wastes.

2. Second Study Tour (August 1983)

The tour will cover visits to mills and research institutions in West Germany, Holland and the USA (Developed Countries) to study the various technologies and research activities in the field of:

- Pulp, paper, and paper board from wood (softwood and hardwood)
- Building boards (insulating board, medium-density board, hardboard and particle board, etc.).
- Energy (gasification, pyrolysis, liquefaction, briquetting, ethanol production, etc.)
- Animal feed from wood and agricultural residues
- Recovery of chemicals and energy from pulp mills waste liquors.

3. Third Study Tour (March 1984)

This tour will be for the Soviet Union, Romania, and U.K. to visit mills and research institutions for studying:

- Pulp, paper, paper board and building boards from cotton stalks, reeds, esparto, and others
- Feed stock for chemicals.
- Animal feed from wood and agricultural residues.

B- Fellowships Training

In the Project, there is a provision of 20 m/m fellowships training for the research personnel of the Unit. It is suggested to distribute the fellowships training as follows:

1. First Mission (4 m/m)

This will be for two technicians for 2-month training in Egypt through November - December 1982. The technicians will be mainly trained at the research laboratories and pilot plant of the General Company for Paper Industry "RAKTA", Tabia, Alexandria. The training will include all chemical analysis and physical testing of fibrous raw materials, pulp, paper, and paper board from agricultural residues such as rice straw, reed, bagasse, cotton stalks, etc. Pulping, bleaching and paper making will also be studied. In addition, there will be visits to other pulp, paper, paper board and building boards mills in the country such as:

- The National Paper Co., Alexandria (Industrial packaging paper and board from waste paper, straw pulp and wood pulp).
- Moharrem Pres Co., Alexandria (Converting Factory).
- Verta Co., Alexandria (Converting Factory).
- El Nasr Co. for Particle Board and Resins, Mansoura, (Board from flax shives)
- El Nasr Co. for Hardboard, Faraskour. (Board from rice straw).
- Sugar Co.
  - Pulp Mill, Edfu (pulp from bagasse)
  - Particle Board Mill, Kom Ombo (Board from bagasse)
  - Ethanol and Chemicals Factory, Hawamdia.
- Abis Experimental Station, Department of Animal Nutrition, Faculty of Agriculture, Alexandria University, Alexandria (Animal feed from agricultural residues).

2. Second Mission (10 m/m)

For two research assistants to be overseas trained for a 5-month period through March - July 1983. The mission will be splitted into 2-month training in Egypt and 3-months in the USA.

In Egypt, the training will be in the same above-mentioned mills and research institutions.

In the U S A, training of the research assistants will be mainly in the laboratories of " Fibrous Products Research, Northern Region Research Center, Agricultural Research Service", Peoria, Illinois with visits to the "Institute of Paper Chemistry", Appleton, Wisconsin and mills of pulp, paper, and board. Research institutions for energy, animal feed and feedstocks will be visited.

3. Third Mission (6 m/m)

This will be for the other two research assistants to be trained for 3-month period through September - November 1983. The same training course as mentioned above for the second mission will be followed but will be reduced to one month in Egypt and two months in U S A.

RESEARCH PROGRAMME FOR CCTRU

It is to be noted that the research programme of the Unit encompasses a wide range of research activities that would be difficult to achieve with the research facilities available for the Unit. The budget for the equipment is limited to US $ 397,000 which will hardly cover the expendable and non-expendable equipment required for the research work on pulp. paper and board. On the other hand, the research work needed for Energy Usage, Animal Feed and Fertilizers would require other specific equipment as for instance biogas digester, gasifier, pyrolyser, etc. which would not be available for the Unit at least in its first stage of activity.

It would, therefore, be suggested that the research work needed for energy, animal feed and fertilizer is to be done jointly with other specialized Research Institutions such as the Energy Research Institute (NCR), the Department of Chemical Engineering - Faculty of Engineering, The Department of Animal Production - Faculty of Agriculture, University of Khartoum, and the Industrial Research and Consultancy Institute, Ministry of Industry, etc. where there may be found the required research facilities and expertise.

In the following, the objectives and scope of the research programme will be discussed.

A- Fibrous Raw Materials in Sudan

1. Wood

Up to the present time there is not enough data available on the stock and stand of the forested area of Sudan.

Land use in Sudan is shown in Table I, Annex V and indicates that forest land was estimated in the FAO Production Year Book 1971, at 91,500,000 hectars and in the WFI, 1970, at 110,334,000 ha. It will be noted that the greatest area of productive forest lies in the high rainfall region of the woodland savanna which extends into most parts of Bahr El Ghazal and Equatoria in the extreme South-West of the country. The species encountered here are Khaya senegalensis (Mahogany), Isoberlinia doka (Vuba) and Anogeifsus leiocarpus (schalg) where the rainfall is under 1300 mm per year and Terminalia glaucescens, Alizia Zygia and Vitex doniana in areas having greater than 1300 mm of rainfall annually. The FWI 1970 indicates that approx. 10,600,000 ha have been inventories, the majority by aerial reconnaissance survey.

1.1. Sawn Timber

In FAO Report No. 1291, J.K. Jackson (1960) provides some very rough figures on the availability of sawn timber from all potential sources in Sudan. Table II, Annex VI shows the estimated annual yield of sawn timber and indicates that about 80% of the total volume of 155,000 m^3 annually is Isoberlinia spp. (Vuba) which is mainly suitable for railway sleepers but considered rather inferior for other purposes.

It is reported that investigations have not been made on any significant scale of the species occuring in Sudan. Even if such work is 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 obtained.

1.2. Afforestation in Sudan

The Forest Department of the Ministry of Agriculture of Sudan administers the afforestation programme of the country. Plantings have mainly consisted of Sunt (nilotica), Neem (Azadirachta indica), Inderab (Cordia Abyssinica), Eucalyptus umbelata and E. microthena, Mahogany (Khaya senegalensis) and two varieties of Bamboo (Oxytenanthera abyssinica) and (Bambusa vulgaris).

At Ed Damazin, near Roseires Dam, Blue Nile Province, 150,000 feddans are being planted in Eucalyptus and Bamboo. There are also plantations of Pinus varieties in the Emerson Mountains, in the South East Equatorial Province, on the border with Uganda. In Gebl Mara, in tne West, there is an afforested area of 3,500 feddans of Cypress and Pine of varieties both Radiata and Petula. The trial plantations in the South and South West Sudan are in areas of average annual rainfall of about 600 mm.

Because of the remoteness of these areas from the populated areas of Sudan, experimental plantations depending upon irrigation have been established in the Green Belt area near Khartoum. Irrigation water of 800 m^3/feddan/month is required.

2. Nonwood

Nonwoody plants comprise a wide variety of fibrous materials such as:

2.1. Bamboo, reed, papyrus, esparto, etc. and

2.2. Agricultural residues as straws, canes and stalks etc.

The quantity of agricultural residues available in Sudan are fairly well known. Table 3 shows the quantities of the main agricultural

residues for the year 1978/79. The data indicate that more than 10 million tons of agricultural residues are produced annually. The largest residues are those of sorghum and cotton stalks followed by groundnut shells and wheat straw. Rice straw is of less importance and bagasse is mostly used as fuel for sugar factories.

B. Pulp, Paper and Paperboard

The objectives and scope of the research work to be done in this field are:

1. Analytical Evaluation of Indigenous Fibrous Raw Materials

For their potential as a source of paper making pulp.

Included in the evaluation of the plants are their:

1.1. Botanical Characteristics (Morphological and Anatomical structure)

1.2. Density

1.3. Chemical Composition (ash, silica, extractives, lignin, hemicelluloses, and alpha-cellulose contents)

1.4. Dimensional Measurements of Fibrous Constituents (Fiber length and width and fiber wall thickness, etc.)

1.5. Yield after Sodium Chlorite Maceration.

2. Laboratory - Scale Pulping Studies

2.1. To evaluate the fibrous raw materials as pulp sources, the conventional pulping processes namely the Soda, the Sulfate (Kraft) and the Sulfite processes will be applied. The pulping variables (chemical ratio, liquor/solid ratio, temperature and time) will be studied in order to determine the optimum conditions

for pulping each raw material.

Thermomechanical and chemi-mechanical processes for the production of high-yield pulp will be investigated.

Non-conventional pulping processes such as the Soda-oxygen, the soda-anthraquinone and the nitric acid-alkali processes will also be tried.

2.2. Bleaching Characteristics of the obtained pulps will be studied using different bleaching chemicals and sequences.

2.3. Beating and Drainage Characteristics of Pulps (unbleached and bleached).

2.4. Physical - Strength Characteristics of Pulp Hand-sheets (unbeaten and beaten pulp) such as brightness, porosity, bulk / density, tensile strength, burst strength, tear resistance, folding endurance, stiffness, etc.

2.5. Evaluation of fibrous raw materials as pulp sources will be based on:

- Pulp yield
- Chemical consumption in cooking and bleaching
- Initial and beaten freeness and drainage characteristics
- Permanganate values
- Physical and strength characteristics.

3. Paper and Board Making

Pilot Plant trials for making different grades of paper and paperboard from the pulps obtained will be made for evaluating the quality of paper and paperboard in accordance with the international specifications of such grades.

C- Construction Boards (Building & Structural Boards)

These are products used both in building construction and for furniture and other manufactured items. They include:

1. Fibrous-Felted Boards, either homogenous or laminated

   1.1. Structural insulating boards: density 10 to 26 lb/ft^3 including boards with specially fabricated faces for sound reflectance suppression (acoustical boards)

   1.2. Medium - density building fiber-boards: density 26 to 50 lb/ft^3

   1.3. Hard board: density 50 to 80 lb/ft^3

2. Allied Board Materials

   2.1. Gypsum board, gypsum faced with paper

   2.2. Automotive panel boards

   2.3. Others, such as asbestos wall board, paper overlaid veneer, etc.

3. Particle Board

General properties required for these boards are permanence, structural stiffness and strength, and sometimes additional properties like heat insulation, sound insulation, resistance to flame spread or fire, and resistance to decay, fungi, insects and vermin.

They are generally preferred to solid sawn timber in that they are more uniform in structure, free from knots and pores, and can be made in any required size, thickness and density.

The objectives of the research work needed are:

1. To study the technical suitability of various indigenous wood species and agricultural residues for the manufacture of building and structural boards of different types.
2. To study the different variables affecting the quality of the board such as:
   - The particle geometry
   - The type of binder or glue
   - The ratio of binder / raw material
3. To 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 vermin.
4. Evaluation of the chemical and physical - mechanical properties of the boards.

D- Chemicals from Indigenous Wood and Agricultural Residues.

Wood and agricultural residues are rich sources of chemicals. Among the commodities that could be derived from wood and agricultural residues and which deserve study and investigation at the CCTRU are the following:

1. Extraction of gum for use as adhesive or binder in paper and board products.
2. Extraction of vegetable tannins for use as tanning agents for leather.

3. Prehydrolysis of hardwoods and agricultural residues to produce a pentose - rich fraction which could be concentrated to mollasses - like consistency (65% solids) to be used as animal feed.

4. Preparation of furfural by acid treatment of pentose sugars derived from agricultural wastes such as corn cobs, grain hulls or sugar cane bagasse.

5. Fermentation of hexoses to Ethanol.

6. Poly phenolics (Sulfonated) to be used as oil well drilling mud additives and as dispersants.

7. Phenolic adhesive components

8. Carboxymethyl cellulose and other cellulose derivatives.

E- Energy from Wood and Agricultural Residues

It is well known that with rising demand for fuels and reduced supplies, economic and social growth will depend on more efficient use of traditional fuels, better management of natural resources and wide-spread substitution of alternative fuels.

Sudan like most other developing countries rely on wood and agricultural residues and animal and human power to meet most of their basic energy needs. However, in Sudan the problem of fuel shortage is more acute and adversely effects its economic and social development. If additional energy sources were more readily available, agricultural and industrial output could be significantly increased.

Wood and agricultural residues as energy sources resemble conventional fuels in that they vary in chemical composition, density, heating value and other properties. The composition of certain agricultural wastes is similar in many respects to coal except that the wastes have a higher moisture content and oxygen content and lower sulfur level.

Gaseous, liquid and solid fuels can all be produced from organic wastes. The two general approaches available for the conversion of wastes to fuel are biological and thermochemical. Biological methods include the production of biogas and ethanol. Thermochemical methods involve combustion, gasification, pyrolysis to oil, char and gases and liquefaction to oils.

1. Biological Production of Methane (Biogas)

Methane (biogas) production from agricultural, animal and human wastes is well known and being practiced in several developing countries.

In Sudan, trials for biological production of biogas from water plants began in 1976 under the German Sudanese Friendship Programme for combating the River Nile water plants. The trials started with small batch biogas generating units and then developed into larger continuous units of the Indian and Chinese - style. It is claimed that the trials are promising. These trials are being followed-up and evaluated by specialists from the Plant Protection Department of the Ministry of Agriculture and the Energy Research Institute of the NCR.

2. Biological Production of Ethanol

The production of ethanol for fuel use is receiving much attention. Ethanol processing from sugar or starch-based wastes is simpler than from cellulose. In the conversion of cellulose to ethanol

the cellulose must first be hydrolyzed to glucose by either enzymatic or acid hydrolysis.

Whether the original waste contains starch or cellulose and requires conversion to sugar before fermentation, or whether it contains sugar to begin with, the final step in converting these materials to ethanol is essentially the same. This involves the dilution, acidification and fermentation of the material using a selected strain of yeast. After fermentation, the mixture is distilled into alcohol and stillage. The stillage could be used as cattle feed.

3. Gasification

Heating the wood and agricultural wastes with a limited amount of air (less than needed for complete combustion) can convert substantially all the organic matter into gas of a low heat value. This gas can be used for crop or lumber drying, firing boilers for steam and power generation or powering diesel or spark engines. Gasification is particularly suitable for agro-industrial use where relatively dry wastes (20% or less moisture content) are available.

Gas generators have been designed and operated with almost every conceivable form of waste cellulose including wood chips, saw dust, cocoanut husks, rice hulls, straw, dung, groundnut shells, and maize residues. Energy efficiency is about 85%, i.e. about 85% of the energy contained in the solid waste is recovered in the gas produced.

Gasification is particularly attractive as a power source for agro-industrial processing where the cellulose wastes are available and represent a disposal problem as in the case of cotton stalks in Sudan.

4. Pyrolysis

Pyrolysis is heating the organic wastes in the absence of air to produce mixtures of solid, liquid, and gaseous fuels.

In general, well over 80% of the heat value of the waste is retained in the gas, liquid and char obtained but in a more useful form.

A number of agricultural and forestry wastes have been tested in pyrolytic studies. It has been reported that 1 ton of sun-dried wheat straw, heated to 500-600 C^{o}, could yield about 300 kg of char, 38 litres of a tarry oil and 280 m^3 of gas. Cow manure, rice straw, pine bark, cotton stalks, sorghum and maize stalks, groundnut shells, etc. could be pyrolyzed as well.

In Sudan, at least 10 million tons of combustible wastes are produced each year. If pyrolyzed, considerable amounts of char, oils and gases could be produced. These could replace fuel oil currently used to power the domestic manufacturing equipment and agro-industrial complexes and help in solving the problem of fuel oil shortage.

5. Liquefaction

Liquefaction is the process of converting solid wastes to oils through heating the wastes at high temperature and pressure in the presence of a reactive gas such as hydrogen and carbon monoxide.

Liquefaction is still in the development stage and a number of research institutions in Europe and North America are studying the liquefaction of organic wastes. Some interesting results were attained as for example, manure reacts with carbon monoxide at 84 kg/cm^2 and

380 °C for 20 minutes to produce 570 litres of oil from 1 ton dry manure. In a process developed at the University of California, USA, an aqueous slurry containing 25% wood is acidified, and hydrolyzed at 80°C and 10 Kg/cm^2 to form an emulsion of wood sugars (hexoses and pentoses). This mixture is then reacted with a 50:50 mixture of carbon monoxide and hydrogen at 370°C and 210 Kg/cm^2 to give 30 -35 Kg of a 36,500 Kj/Kg oil from 100 Kg wood. For comparison, diesel oil is 45,600 KJ/KG.

However, although oil could be produced from all organic wastes by liquefaction, the raw materials differ in ease of conversion to oil. The most easily converted materials consisted of these forms of cellulose having xylose units like corn cobs or having undergone considerable biodegradation such as fermentation residues.

The research work needed for energy usage would involve:

1. Survey of the amount and locations of domestic wood and agricultural residues and agro-industrial wastes available for conversion to energy.

2. Characterisation of these raw materials by chemical analysis, elemental analysis, calorific value, benzene extract, etc.

3. For biogas systems, evaluation of the different types of digesters (gas generators) under prevailing local conditions to select the most appropriate, less costly and more durable system.

4. For alcohol production, more work is needed on simple systems to convert cellulose to sugars. Cellulose is the most abundant, lowest cost waste available in Sudan and in most parts of the world. The economical conversion of cellulose to sugar will have a profound impact on the type and amount of energy available from renewable sources.

5. For gasification and pyrolysis, evaluation of the various indigenous waste materials for their ease of conversion to gas, liquid and solid fuel, energy efficiency and the economy of the process is required.

F- Animal Feed

From Wood and Agricultural Residues

Domestic animals generally subsist on crops and crop residues. The systematic use of roughages in the diets of all ruminant animals is a percept of common multinational practice. High fiber feeds in the diets of cattle, sheep and goats and also in non-ruminants such as horses, swine and poultry is important.

The cost and availability of conventional roughage feeds are quite variable, with climatic upsets and planting practices yielding temporary or long-term shortages in many areas of the world. The pressure to put pasture and hay acreage into grain and other food crops promises an even more serious and longer term reduction in forage crop production.

For many years it has been common practice to replace conventional roughages with lower quality wood and agricultural residues. Generally, this practice has led to decreased production of meat, lower yields of milk and poorer animal health.

Therefore, it became necessary to develop methods and techniques of treating, preparing and feeding wood and agricultural residues so that acceptable animal performance is the normal consequence.

It has been found that the nutritional value of some of the residues, particularly straws, can be significantly improved through physical, chemical or biological treatment. For example, grinding is a valuable means of improving the efficiency of utilization, especially by growing and lactating animals, primarily through increasing their intake. Alkali treatment with sodium hydroxide, calcium hydroxide, or amonia was found to increase the digestibility of straw by 10 to 15 percentage point.

In the Sudan, about 92% of the animal wealth (Table 4, Annex VIII) is nomadic and depends mainly on natural vegetation. With climatic upsets, the natural vegetation varies in quantity and quality and consequently the animal productivity is seriously affected. Also shortage of pasture for prolonged periods and lack of other feed supplement often result in malnutrition and even starvation leading to high death rates.

Therefore, supplementation of nomadic animals is essential to secure and develop the animal wealth in Sudan. Efficient utilization of the available wood and agricultural residues and agro-industrial wastes would improve the animal productivity.

The objectives of the research work needed are:

1. To determine the chemical composition of various domestic wood and agricultural residues.
2. To assess the improvement of the feeding value of the residues through mechanical and chemical treatment.
3. To carry out digestion trials to determine the digestible nutrients and the useful energy of the residues.
4. To execute feeding trials to study the effect of varying levels of the residues on animal performance, milk yield and composition.

A CRASH COURSE FOR TRAINING OF RESEARCH PERSONNEL AT THE UNIT

A crash course for theoretical training of the two technicians of the Unit was given by the Consultant through his mission of August - September 1982.

The main topics of the course were:

1. Morphological and anatomical structure of wood and agricultural residues.
2. Chemical composition of wood and agricultural residues.
3. Preparation of fibrous raw materials for pulping.
4. Pulping methods: soda, sulfate (Kraft) and sulfite.
5. Pulp treatment.
6. Bleaching of pulp.
7. Pulp evaluation: chemical and physical.
8. Pulp hand sheets, paper and paper board testing.

SEMINAR

On 16 September 1982, a Seminar was held at the NCR for the Research Committee of the Unit.

Present were:

- Dr. Suleiman Gaber	Director of CCTRU
- Dr. Tag El Sir Mustafa	Department of Chemical Engineering, Faculty of Engineering, University of Khartoum.
- Dr. Abdel Shakour Awad El Karim	Dept. of Chemical Engineering.
- Dr. Tag El Dien Mussien Nasroun	Forest Research Institute, Soba, Khartoum.
- Dr. Mahmoud Abdel Magied Muglad	Dept. of Animal Production, Faculty of Agriculture, Univ. of Khartoum.
- Dr. Omar Fagiri	Director of Building & Road Research Institute, Univ. of Khartoum.
- Mr. Mohamed Ahmed Yousif	Industrial Research & Consultancy Institute, Ministry of Industry, Khartoum.

The purpose of the Seminar was to discuss the objectives of the Project and the research programme of the Unit. The discussions and exchange of views among the members of the Committee resulted in a fruitful cooperation between the Unit and the Research Institutions represnted by the members of the Committee.

As a result of this cooperation, it was agreed to formulate the research programme in defined Research Projects to be jointly executed by the Unit and the Research Institutions.

Of these research projects are the following:

- Energy from Wood and Agricultural Residues
- Building Boards from Wood and Agricultural Residues
- Animal Feed from Wood and Agricultural Residues.

RECOMMENDATIONS

1. Due to the wide range of research activities of the Unit in utilizing indigenous wood and agricultural residues for the production of pulp, paper, paperboard, building boards, energy, animal feed and fertilizers, cooperation between the Unit and the National Research Institutions in conducting research work in these fields is strongly recommended. This would help avoid duplication of research work in the same field and strengthen the capabilities and team work of the national researchers.

2. As the national paper and board and converting factories lack quality control facilities, the Unit could serve as a quality control laboratory for these factories by analyzing and testing their raw materials and end products to maintain and improve the quality of such products to the satisfaction of the customers.

In addition, the Unit could help the National printing and packaging industry in setting national specifications for the imported paper and board and testing it in accordance with these specifications. This would improve the performance of the printing and the packaging industry and protect them against defected goods.

PART II.H. ANNEX I

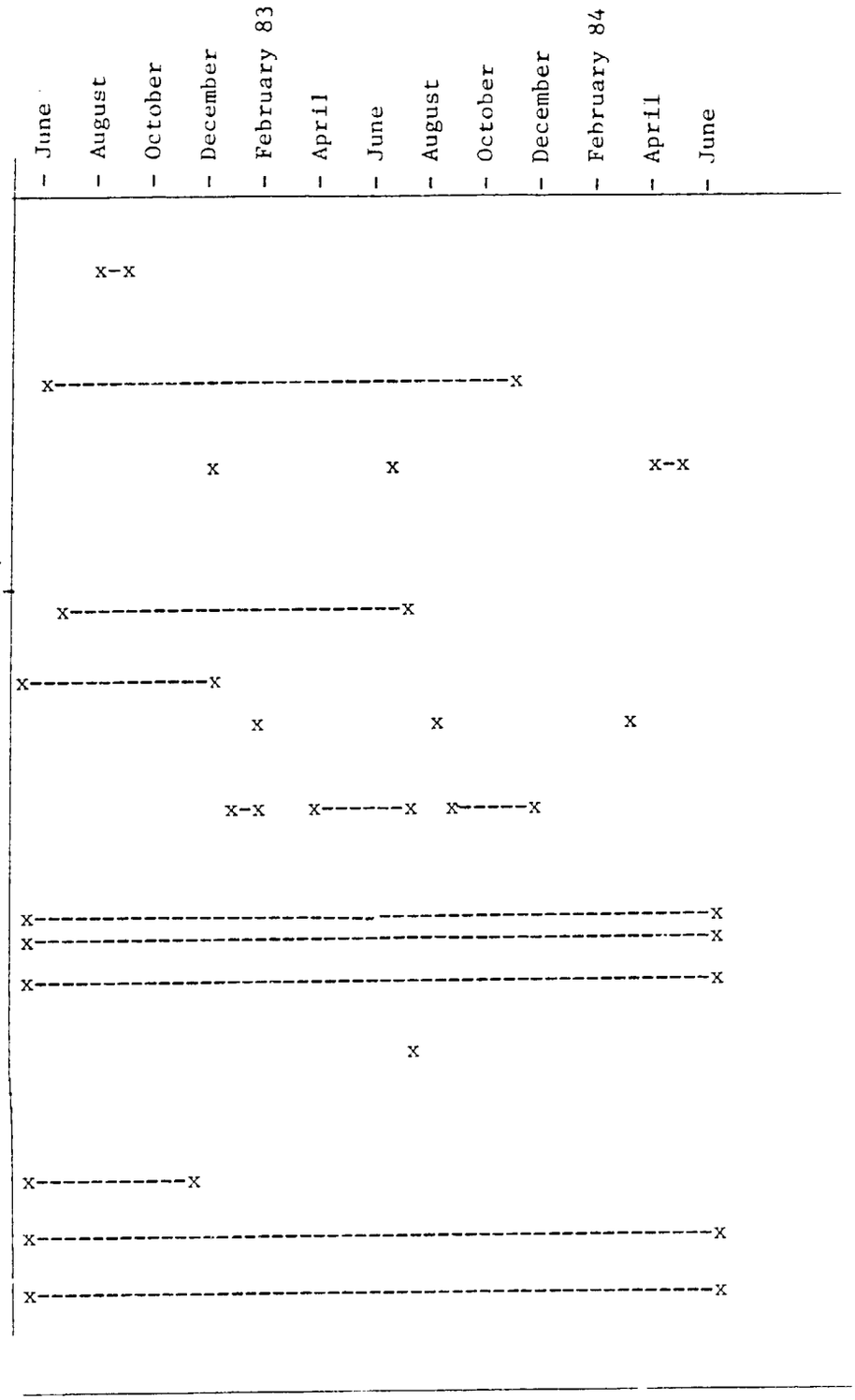
WORK PLAN (original)

1. Below is the envisaged bar-chart for the activities of the project.

	May 82	July	Sept.	Nov.	Jan.83	March	May	July	Sept.	Nov.	Jan.84	March	May
Preparation of detailed research programme by the consultant	x--x												
Work of the Pulp & Paper Expert with research teams	x												x
Return mission of consultant				x-x		x-x						x--x	
Ordering and delivery of equipment, apparatuses, chemicals, glassware, books, etc.	x						x						
Purchase of vehicles	x-x												
Study tours		x			x				x				
Fellowships training			x										x
Research activities:													
- Fibre board		x											x
- Animal feed		x											x
- Energy/Chemical feed stock			x										x
Review meeting							x-x						
General activities:													
Extension of laboratory building			x										
Availability of personnel	x												x
Availability of facilities	x												x

2. The General Work Plan for the activities in this project were prepared by the National Director, Mr. Gabir, and Mr. Judt, backstopping officer for the project from UNIDO, Vienna, in November 1981 in Khartoum. The existing four premises are small but sufficient in space to start with the research work as early as possible. But an extension of the main laboratory building is needed in early 1982.

PART II. H. WORK PLAN



ANNEX III

List of Main Equipment and Apparatuses for CCTRU

A- For Raw Material Preparation

1.	Chopping machine	;	for agricultural residues
2.	Wood chipper	:	for wood
3.	Grinding machine	:	for wood and agricultural residues
4.	Briquettor	:	for binderfree briquetting of wood and non wood.
5.	Technical balance	:	range 0-120 Kg.

B- For Digester Room

1. Laboratory rotary digester
2. Laboratory strainer

C- For Wet Laboratory (Beater Room)

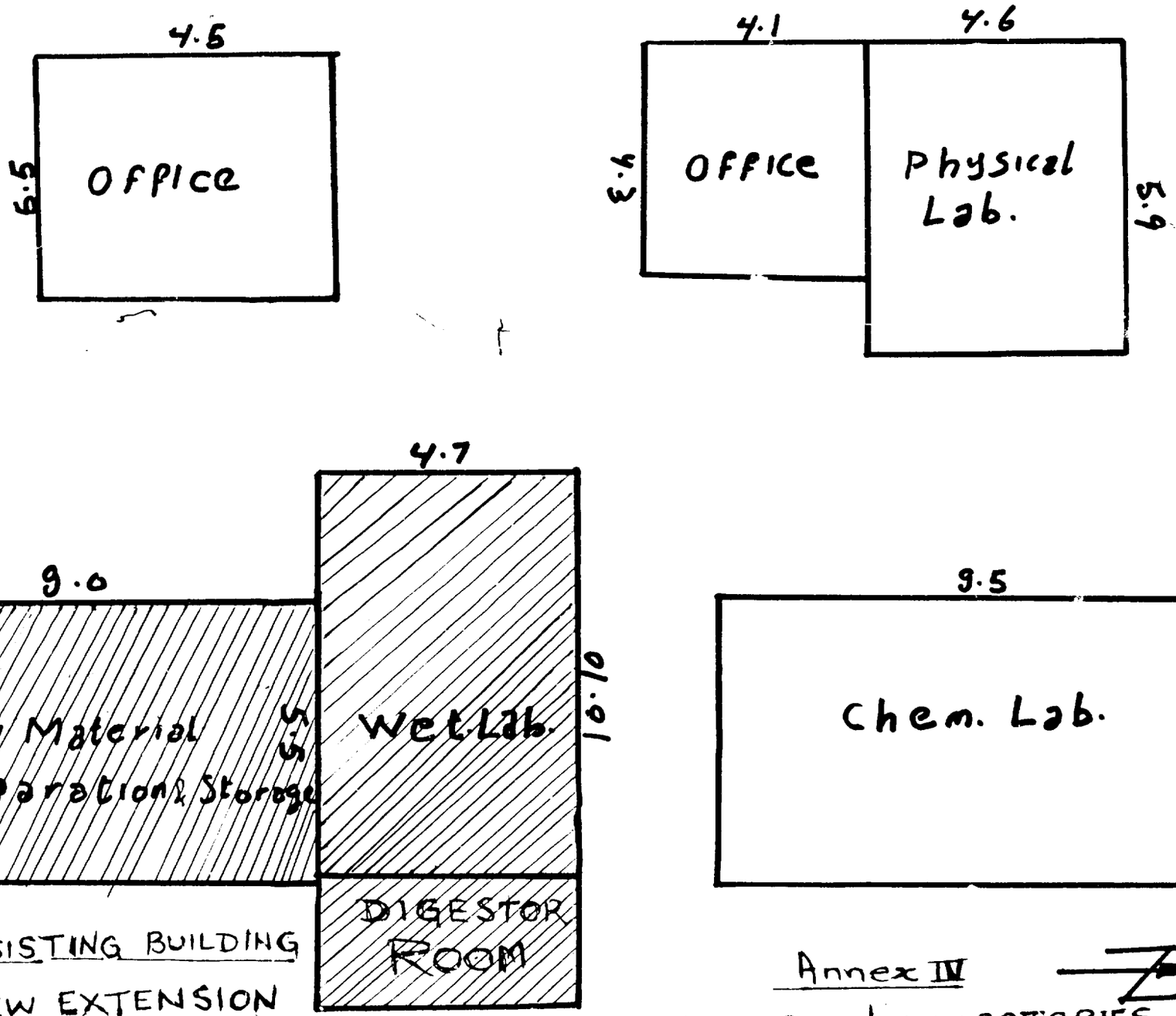
1. Laboratory Hydraulic Press : for fiberboard
2. Valley beater
3. Pulp disintegrator
4. Freeness tester
5. Pulp mixer and sampler
6. British handsheet machine with couch roll, drier plates, drier rings and blotting paper
7. Handsheet press
8. Drying oven
9. Fiber classifier
10. Technical balance

D- For Physical Laboratory

1. Strip cutter
2. Circular cutter
3. Quadrant scale : Range 0 - 120 g/m^2
4. Quadrant scale : range 0 - 500 g/m^2
5. Tearing Templates: sample size 10x10, 20x20, 20x25 cm
6. Electric balance : range 0.1 - 180 g., accuracy $\pm$ 1 mg
7. Air conditioner for constant temp. ($23^{o}C$) and relative humidity (50%).
8. Precision micrometer
9. Brightness tester (type Photovolt or Elrepho)
10. Sizing tester (type Cobb)
11. Bendsten smoothness and porosity tester with accessories
12. Folding endurance tester for paper (Type Schopper)
13. Tensile strength tester for paper and paperboard (Type Schopper) with attachment devices for wet strength tests and zero span tensile test
14. Bursting strength tester for paper and board (Type Mullen)
15. Tearing strength tester for paper (Type Elmendorf)
16. Puncture tester for board (Type TMI)
17. Crush tester for liner, fluting, corrugated board, etc.
18. Microscopic fiber projector

E- For Chemical Laboratory

1.	Vacuum drying-oven	:	40 - 180°C for cellulose drying
2.	Water distillation apparatus:		capacity 12 l/h
3.	Rotary vacuum pump	:	capacity 1.5 m^3/h, max. vacuum below 0.05 Torr
4.	Water bath unit	:	with temp. regulation and cooling and time switch
5.	Laboratory PH meter	:	range 0-14 PH, complete with buffer solu.
6.	Laboratory centrifuge	:	max. speed 5000 rpm, with speed control, tachometer, timer 0-60 min., electric brake, safety lid.
7.	Sieve shaker with wet screening	:	Electromagnetic drive, variable vibration, with 5 sieves and one pan, set of 5 sieves of mesh 14, 30, 100, 200, 300
8.	Bottle shaker		
9.	Viscosimeter (Type Hoppler - falling ball)		
10.	Viscosimeter (Type Ostwald)		
11.	Analytical balance	:	0-160 g. - 0.05 mg, single pan, digital
12.	Technical balance	:	Top pan weighing, range 0-1300 g. precision _ 0.05 g.
13.	Muffle furnace	:	1000°C
14.	Platinum cruciable (2)	:	capacity 35 cm^3
15.	Platinum dishes (2)	:	capacity 50 cm^3
16.	Calorimeter	:	for determining calorific value of wood and agricultural residues.



Annex IV

CCTRU LABORATORIES

ANNEX V

Table 1

Land Use in the Sudan

Land Use	Area, 1000 ha	
	FAO Production Year book 1971[1]	WFI 1970[2]
Arable land and land under permanent crop	7,000	7,700
Permanent meadows and pastures	24,000[3]	
Forest and other wooded areas (Forest land)	91,500	110,334[4]
Forest		28,749
Open woodland		58,534
Scrub and brush land		23,051
Other land	127,981	119,399
Land area	237,600	237,503
Total area	250,581	250,453

1. Information from 1968
2. Information from 1970
3. Acacia short grass scrub
4. Forest area include pastural land as the mode on animal tenure is nomadic.

ANNEX VI

Table 2

Estimated Annual Yield of Sawn Timber

in Sudan

Species	Estimated annual yield m^3
North Sudan	
Acacia nilotica	7,200
Acacia albida	5,000
Anogeissus leiocarpus, Khaya senegalensis, Cordia africana, etc	5,500
South Sudan	
Khaya senegalansis (Mahogany)	2,500
Daniella oliveri	1,250
Isoberlinia spp. (Vuba)	128,000
Khaya grandifoliola, etc	800
Montana forests	1,000
Other species (approx)	4,000
Grand Total	154,760

ANNEX VII

Table 3

Main Agricultural Residues Available in Sudan
Crop 1978/79

Crop	Planted area feddan	Production ton	Agriculture residue	Quantity ton
Sorghum	7,202,000	2,408,000	Stalks	8,283,520
Cotton	1,036,000	407,000	Stalks	1,036,000
Groundnuts	2,328,000	798,000	Shells	279,300
Wheat	586,000	177,000	Straw	244,260
Rice	20,000	10,000	Straw	15,000
Sugar cane				
- Geneid Factory	12,498	36,097	Bagasse	43,316
- N. Halfa "	20,383	64,850	Bagasse	77,820
- Sennar "	6,000	18,177	Bagasse	21,812
- Kenana "	27,660	-	Bagasse	-
Grand total				10,001,028

Source: Current Agricultural Statistics Vol. I No. 3

ANNEX VIII

Table 4

Animal Wealth in Sudan
in 1000 heads

Year	Cattle	Sheep	Goats	Camels
1974	14,720	13,775	10,707	2,750
1975	15,281	14,494	11,254	2,782
1976	15,367	16,222	11,300	2,361
1977	16,305	16,676	11,763	2,441
1978	17,299	17,143	12,246	2,524

Source: Department of Agric. Economics,
Ministry of Agriculture, Food and Natural Resources.